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

Interactive systems for digital television distribution

Access systems for interactive services on SMATV/MATV networks

ITU-T Recommendation J.118

(Formerly CCITT Recommendation)

ITU-T J-SERIES RECOMMENDATIONS

TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

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ITU-T Recommendation J.118

Access systems for interactive services on SMATV/MATV networks

Summary

This Recommendation "Access systems for interactive services on SMATV/MATV networks" covers the definition of the framing structure, channel coding and modulation for the provision of an Interaction channel throughout SMATV/MATV networks from the user to the SMATV/MATV Head-end.

This Recommendation defines two current technological alternatives for the interactive service provision in SMATV/MATV networks according to a bandwidth dependent classification. In particular, the cable based solution is fitted when broadband applications are concerned while the Master Link Low Rate TDMA is suited for narrow-band applications.

Source

ITU-T Recommendation J.118 was prepared by ITU-T Study Group 9 (1997-2000) and approved under the WTSC Resolution 1 procedure on 18 May 2000.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. 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 turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSC Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

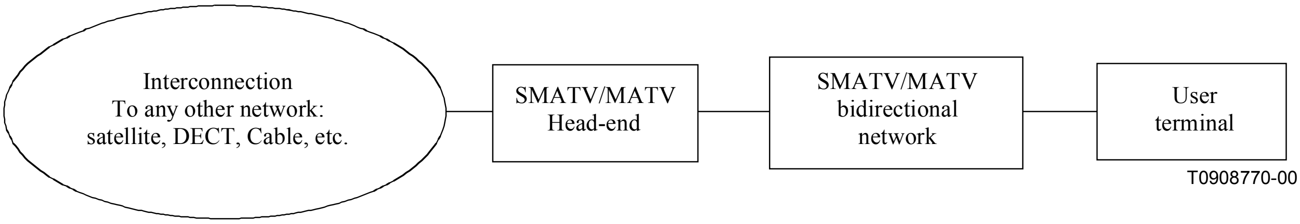
ITU-T Recommendation J.118

Access systems for interactive services on SMATV/MATV networks

1 Scope

This Recommendation extends the scope of the ITU-T J.84 "Distribution of digital multiprogramme signals for television, sound and data services through SMATV/MATV networks" to make provision for bidirectional data over SMATV/MATV coaxial networks for interactive services.

The scope of this Recommendation is the definition of the framing structure, channel coding and modulation for the interactive service provision in SMATV/MATV networks. This Recommendation provides the necessary elements for the implementation of an interaction channel between the user terminal and the SMATV/MATV head-end equipments. Other sort of connections between the SMATV/MATV head-end and the Service Provider can be implemented in a seamless fashion. The system architecture followed in this Recommendation is depicted in the following figure:



This Recommendation describes two different technological possibilities providing the specifications for the systems to be used in SMATV/MATV for interactive purposes.

In particular, the two technological alternatives for the interactive service provision in SMATV/MATV networks have been classified according to a bandwidth dependent criteria. The cable based solution is fitted when broadband applications are concerned (see 6.2) while the Master Link Low Rate TDMA is suited for narrow-band applications (see 6.3).

Alternative Interaction channel systems may be also used by SMATV/MATV users, as for example the PSTN/ISDN and the wireless DECT solutions.

Research and Development activities carried out in the frame of the ACTS[1] European Research Programs have demonstrated the feasibility of the Interaction Channel for SMATV/MATV. Tests and demonstrations have shown that this concept is a short term reality and that preliminary prototypes are available supported by the industry.

This Recommendation is intended to ensure that designers and installers of SMATV networks carrying interactive services 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 interactive signals throughout SMATV networks.

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[1] Advanced Communications, Technologies and Services (ACTS) is the European Commission Research and Development Programme. One of its Projects is DIGISAT, which has significantly contributed to the solutions of the Interaction channel for SMATV/MATV networks. S3M Project is also contributing with the Master Link solution for the Interaction channel in the SMATV/MATV environment, in particular, for small SMATV/MATV networks although with the possibility to be used in bigger SMATV/MATV networks due to the modular characteristics of this solution.

This Recommendation contains two informative appendices (I and II) with useful information for the implementation of the interactive system in SMATV/MATV installations.

2 Normative 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 J.84 (1997), *Distribution of digital multi-programme signals for television, sound and data services through SMATV networks.*

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

[4] ITU-T J.112 (1998), *Transmission systems for interactive cable television services.*

[5] ITU-T J.111 (1998), *Network independent protocols for interactive systems.*

[6] ITU-T V.24 (2000), *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE).*

[7] ITU-T V.28 (1993), *Electrical characteristics for unbalanced double-current interchange circuits.*

[8] ITU-T X.25 (1996), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

[9] ISO 2110:1989, *Information Technology – Data communication – 25-pole DTE/DCE interface connector and contact number assignments.*

[10] ETSI EN 50201 (1998), *Interfaces for DVB-IRD.*

3 Abbreviations and relevant definitions

3.1 This Recommendation uses the following abbreviations:

BC Broadcast Channel

BIM Broadcast Interface Module

CATV Cable TV distribution system

CDM Code Division Multiplex

CTS Clear To Send

DCE Data Communications Equipment

DTE Data Terminal Equipment

DVB Digital Video Broadcasting

ETS European Telecommunications Standard

IB In-Band

IC	Interaction Channel
IIM	Interactive Interface Module
INA	Interactive Network Adapter
IRD	Integrated Receiver Decoder
ISCM	Interactive Services Commercial Module (DVB)
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union – Radiocommunication Sector
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
MAC	Media Access Control
MATV	Master Antenna Television
MMDS	Microwave Multipoint Distribution System
MTU	Maximum Transfer Unit
NIU	Network Interface Unit
OOB	Out of Band
OSI	Open Systems Interconnection
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QPSK	Quaternary Phase Shift Keying
RTS	Request to Send
SLIP	Serial Line Interconnection Protocol
SMATV	Satellite Master Antenna Television
STB	Set Top Box
STU	Set Top Unit
TDM	Time Division Multiplex
TDMA	Time Division Multiplex Access
TS	Transport Stream

3.2 The following relevant definitions are provided:

3.2.1 SMATV system A (SMATV-DTM): This system approach consists of the transmodulation from satellite Quaternary Phase Keying (QPSK) signals as defined in [2] to a Quadrature Amplitude Modulation (QAM) scheme as defined in [3]. The process of transmodulation without baseband interfacing is also known as Transparent Transmodulation and the head-end unit performing this function is known as Transparent Digital Transmodulator (TDT).

3.2.2 SMATV system B: This system is based on the use of QPSK modulation. The SMATV system B concept allows a direct reception of digital satellite signals using frequency conversion of the received satellite signal to a frequency band appropriate to the characteristics of the SMATV distribution network. The functional elements of this system are given in the baseline satellite specification provided in [2]. Two configurations of SMATV system B are considered as follows:

– **SMATV-IF**: which uses the Intermediate Frequency (IF) as delivered by the Low Noise Block (LNB) (e.g. 950-2150 MHz)

– **SMATV-S**: which uses a conversion to the extended S band (e.g. 230-470 MHz).

3.2.3 SMATV grouping terminal or interactive head-end: The Grouping Terminal at the SMATV performs the collection and the distribution of information coming from and going to the user terminals. It is composed by the Grouping Terminal Interactive Network Adapter (INA), the MAC functions and the interfaces with the other networks in order to collect/distribute the information in the SMATV coax network related to each user terminal (Interactive Interface Module – IIM).

4 SMATV/MATV Interactive system concepts

The Satellite Master Antenna Television (SMATV/MATV) system was previously intended for distribution of television and sound signals to households located in one or more adjacent buildings. However, the advent of new digital interactive services implies that the SMATV/MATV networks should be equipped with a return channel allowing the introduction of digital interactive services. This kind of network is also known as community antenna installations or domestic TV cable networks. A SMATV system represents a mean of sharing the same resources among several users for the Transmission/reception of contents.

This Recommendation provides reference examples for the implementation of an interaction channel system to cope with two different scenarios.

Scenario A) An environment of ***asymmetric interactive services supporting broadcast to home with narrowband return channel.*** This is the typical broadcasting scenario enhanced with low capacity interactive services, the implementation of which is foreseen to be widespread within a short period of time.

Scenario B) An environment oriented towards ***wideband Multimedia services*** where the SMATV/MATV interconnection infrastructure can play a very effective role.

The generic ITU Reference model for interactive systems described in ITU-T J.110 has been followed by the system described in this Recommendation. The Interaction Network is split into a supporting network, a coaxial section and an interface in-between. The SMATV/MATV section provides the two-way communications between each user Terminal and the SMATV/MATV head-end, which is located on the roof of each building.

The interactive SMATV/MATV systems described in this Recommendation propose solutions for bidirectional communications between the user and the SMATV/MATV head-end. The system consists of two main components: the Interactive Head-end or Grouping Terminal and the SMATV/MATV Interactive Interface Module or user terminal. Freedom is given for any further network connection at the head-end to link with the Service Provider. Solutions for the interconnection are being developed by other ITU Study Groups assuming either a wireless or wired solutions (satellite, terrestrial, CATV, etc.)

The Interactive SMATV/MATV head-end performs the collection and the distribution of information coming from and going to the user terminals. It is composed of the Grouping Terminal Interactive Network Adapter or Interactive Head-end Network Adapter (INA), the MAC functions and the interfaces with other networks in order to collect/distribute the information in the SMATV/MATV coaxial network related to each user terminal (Interactive Interface Module – IIM).

For the SMATV/MATV section two approaches are proposed according to a bandwidth dependent classification. For wideband applications, a subset of the options provided for cable systems [4] is recommended (see 6.2) allowing a system simpler than the CATV one, thus matching the requirements of the SMATV/MATV scenario. One of the key aspects of the SMATV/MATV scenario with respect to the CATV one is that the Grouping Terminal at the SMATV/MATV head-end should be a consumer equipment in a similar way as the Set Top Box, although the SMATV/MATV head-end cost is shared among the users connected to the same SMATV/MATV network. For narrowband applications the approach based on the Master Link system is recommended (see 6.3).

The system described here is compatible with the ITU-T Network Independent Protocols specification for Interactive services [5].

The system described in this Recommendation is an open system allowing the interoperability with other networks irrespective of the technology supported. Guidelines are provided in this sense, allowing the use of alternative technologies with the aim to allow the users or operators to select the technology best suited for each situation depending on the type of network, required services, quality of services, number of users, traffic requirements, etc.

The interface between the Coaxial section and the other networks is defined with the aim of facilitating the interoperability between subsystems from different vendors and technologies. In principle a very low cost interface, RS-232 based, is recommended although alternative interfaces are identified in order to allow the use of existing equipment as well as to facilitate the provision of multimedia broadband applications as identified in scenario B above.

5 Reference Model for system architecture of narrowband interaction channels in a broadcasting scenario (asymmetric interactive services)

A reference model for the system architecture of narrowband interaction channels in a broadcasting scenario (asymmetric interactive services) is presented in this clause.

5.1 Protocol Stack Model

For asymmetric interactive services supporting broadcast to the home with narrowband return channel, a simple communications model consists of the following layers (the layers do not coincide exactly with the OSI layers).

– **Physical layer**: where all the physical (electrical) transmission parameters are defined.

– **Transport layer**: defines all the relevant data structures and communication protocols like data containers, etc.

– **Application layer**: is the interactive application software and runtime environments (e.g. home shopping application, script interpreter, etc.).

This Recommendation addresses the lower two layers (the physical and transport) leaving the application layer open to competitive market forces.

A simplified model of the OSI layers was adopted to facilitate the production of specifications for these nodes. Figure 1 points out the lower layers of the simplified model and identifies some of the key parameters for the lower tow layers.

Layer Structure for Generic System Reference Mode

Proprietary layers	
Higher medium layers	Network Independent Protocols
Access mechanism Packet structure	(Network Dependent Protocols)
Modulation Channel coding Freq. range Filtering Equalization Power	

Figure 1/J.118 – Layer Structure for Generic System Reference Model

This Recommendation addresses network specific aspects only. The network independent protocols are specified separately in ITU-T J.111.

5.2 System Model

Figure 2 shows the system model, which is to be used for interactive services. In the system model, two channels are established between the service provider and the user:

– **Broadcast channel (BC)**: A unidirectional broadband Broadcast Channel including video, audio and data is established from the service provider to the users. It may include the Forward Interaction path.

– **Interaction channel (IC)**: A bidirectional Interaction Channel is established between the service provider and the user for interaction purposes. It is formed by:

  - **Return Interaction path** (Return Channel): from the user to the service provider. It is frequently used to make requests to the service provider or to answer questions. It is a narrowband channel. Also commonly known as return channel.
  - **Forward Interaction path**: from the service provider to the user. It is used to provide some sort of information from the service provider to the user and any other required communication for the interactive service provision. It may be embedded into the broadcast channel. It is possible that this channel is not required in some simple implementations, which make use of the Broadcast Channel for the carriage of data to the user.

The user terminal is formed by the Network Interface Unit (NIU), consisting of the Broadcast Interface Module (BIM) and the Interactive Interface Module (IIM) and the Set Top Unit (STU). The terminal provides interface for both broadcast and interaction channels. The interface between the user terminal and the interaction network is via the interactive interface Module.

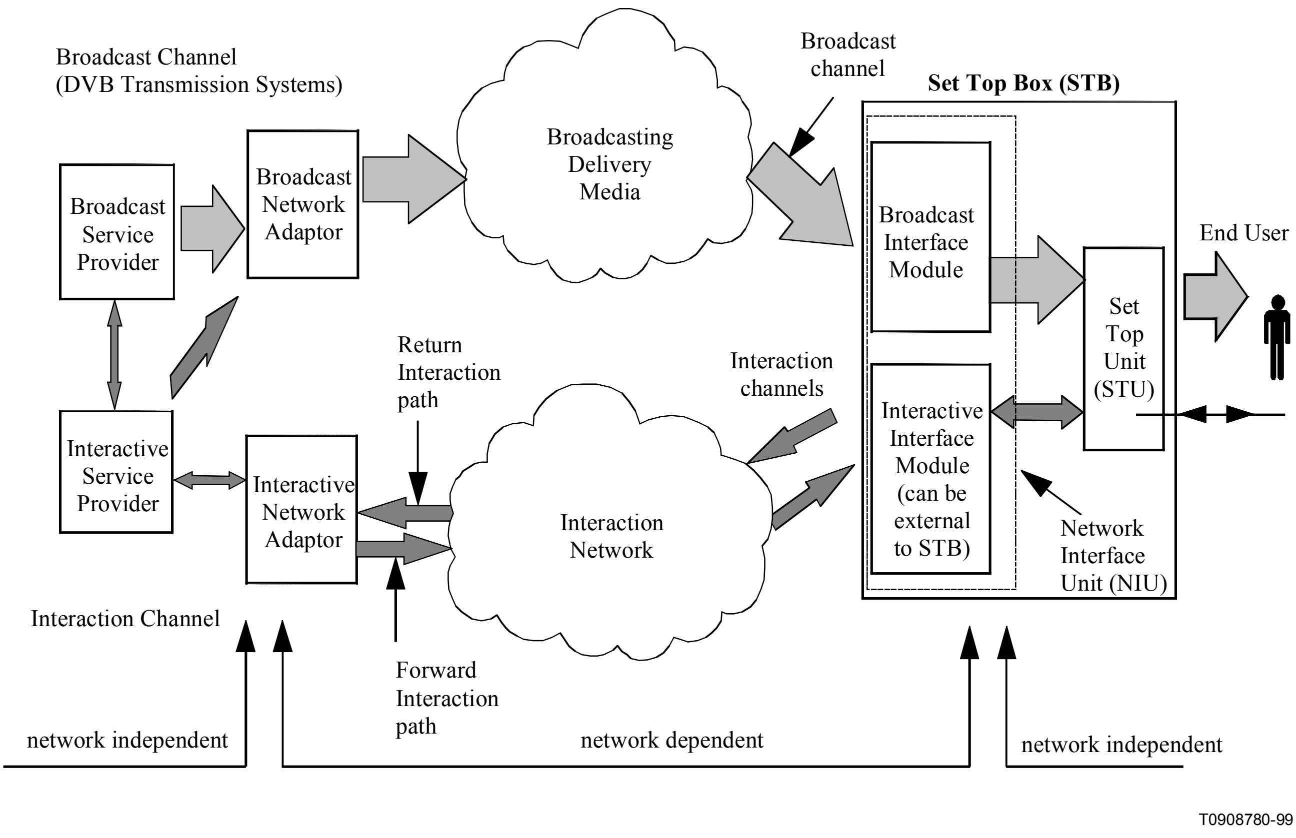

Figure 2/J.118 – A generic system Reference Model for Interactive Systems

5.3 Application of the Reference Model to the SMATV Interaction Channel

In Figure 3 the reference model for the particular case of the SMATV/MATV Interaction Channel based on the concatenation of any other network and the SMATV/MATV network is presented.

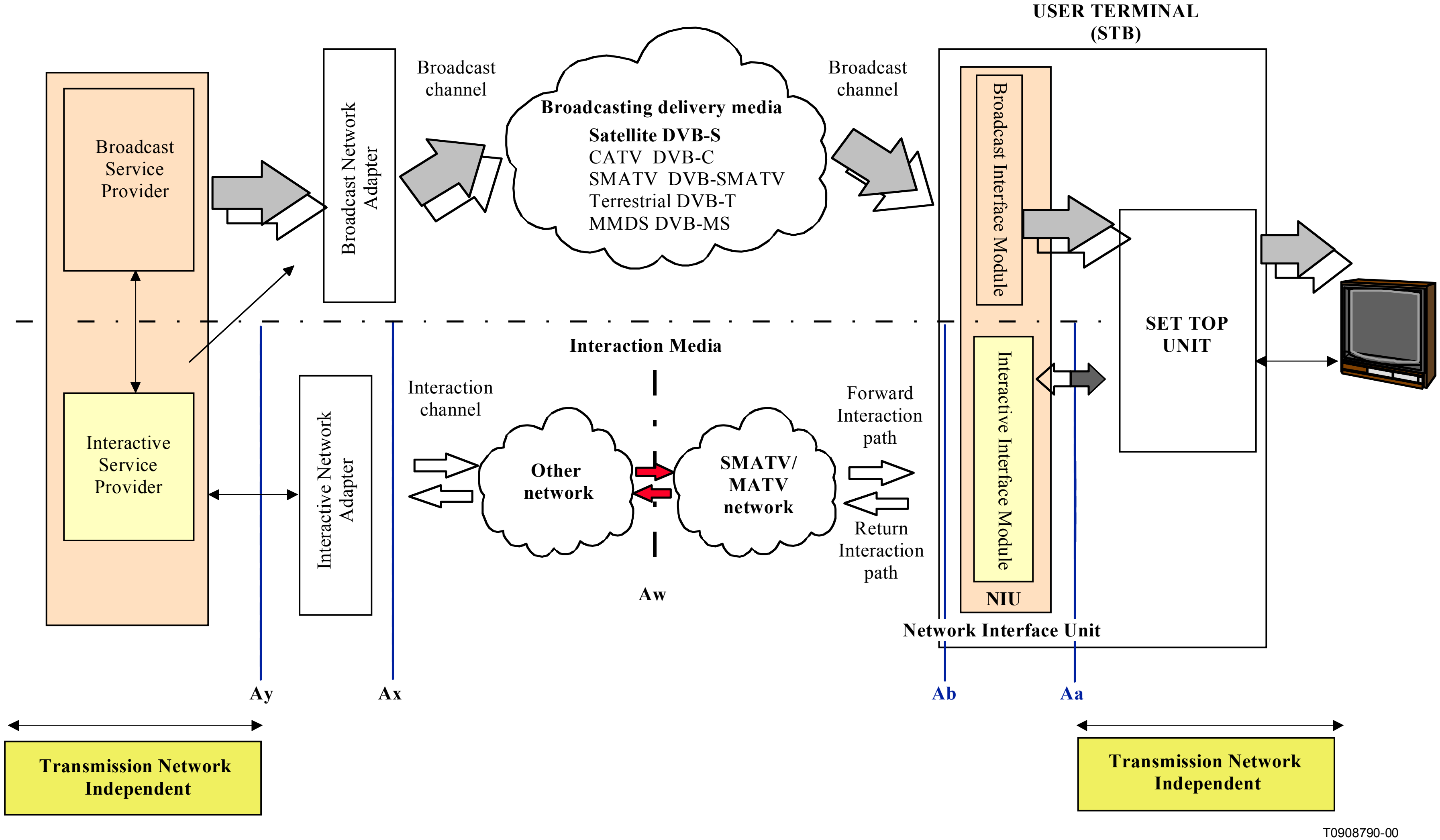

Figure 3/J.118 – Reference Model for the SMATV/MATV Interaction Channel

6 Interaction Channel for SMATV/MATV systems

6.1 System description

The SMATV/MATV infrastructures can support the implementation of the Interaction Channel for interactive services suitable for broadcasting systems. Therefore, SMATV/MATV systems can be used to implement interactive services in the digital video broadcasting environment, providing a bi-directional communication path between the user terminal and the service provider.

The Interaction Channel links the SMATV/MATV interactive head-end with the User Terminal. For the Return Interaction path (upstream), the interactive traffic from the users is transmitted in the lower part of the frequency band of the bidirectional (passive) coaxial distribution network and is collected by the SMATV/MATV interactive head-end, then it is transported to the service provider through other network. For the Forward Interaction path (downstream) the responses from the service provider are distributed through a bidirectional network to the SMATV/MATV interactive head-ends and then, inside each building, the distribution is performed through the Interactive Head-ends to each user using the lower part of the frequency band of the bidirectional (passive) coaxial distribution network.

Alternatively, or in parallel, the Forward Interaction path (downstream) could be embedded into the Broadcast Channel in the MPEG-2 Multiplex, when the capacity required in the Forward Interaction path or the type of applications required it.

The Broadcast Channel is transmitted as specified by [1].

In Figure 4a the functional block diagram of the system described for SMATV/MATV Interaction Channel system is provided for both the whole SMATV/MATV Interactive Head-end (Figure 4a) and the SMATV/MATV Interactive User Terminal (Figure 4b).

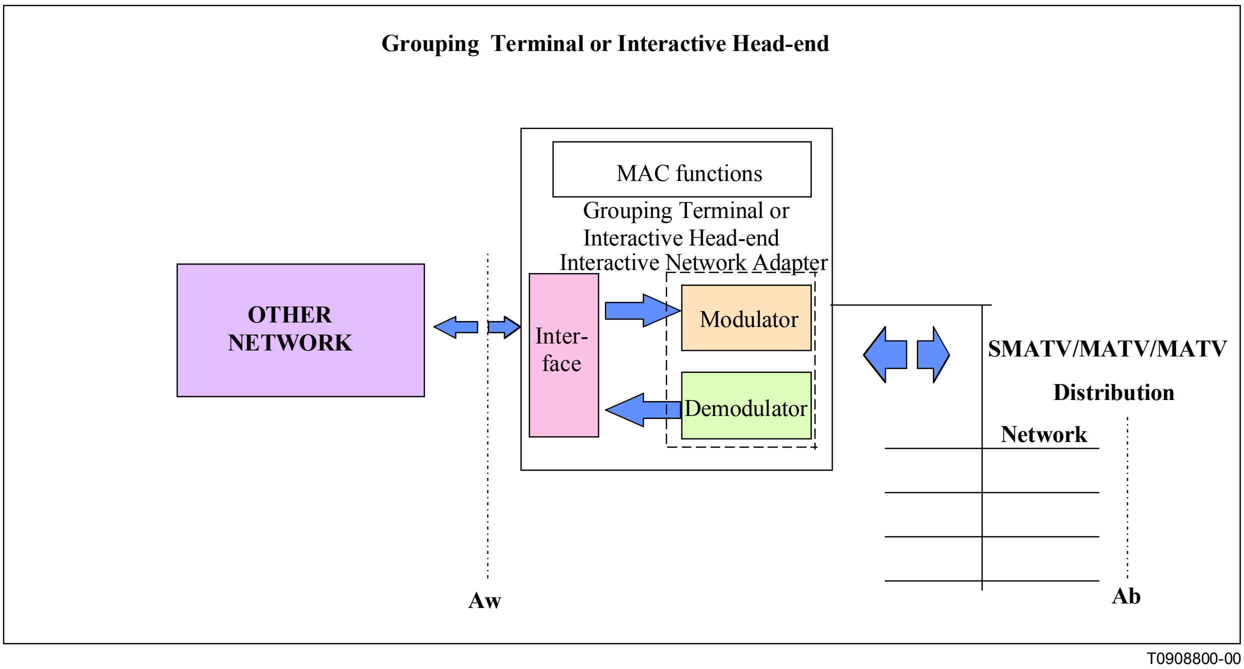

Figure 4a/J.118 – Functional block diagram for the SMATV/MATV Interactive Head-end

SMATV Interactive User Terminal (Set Top Box)

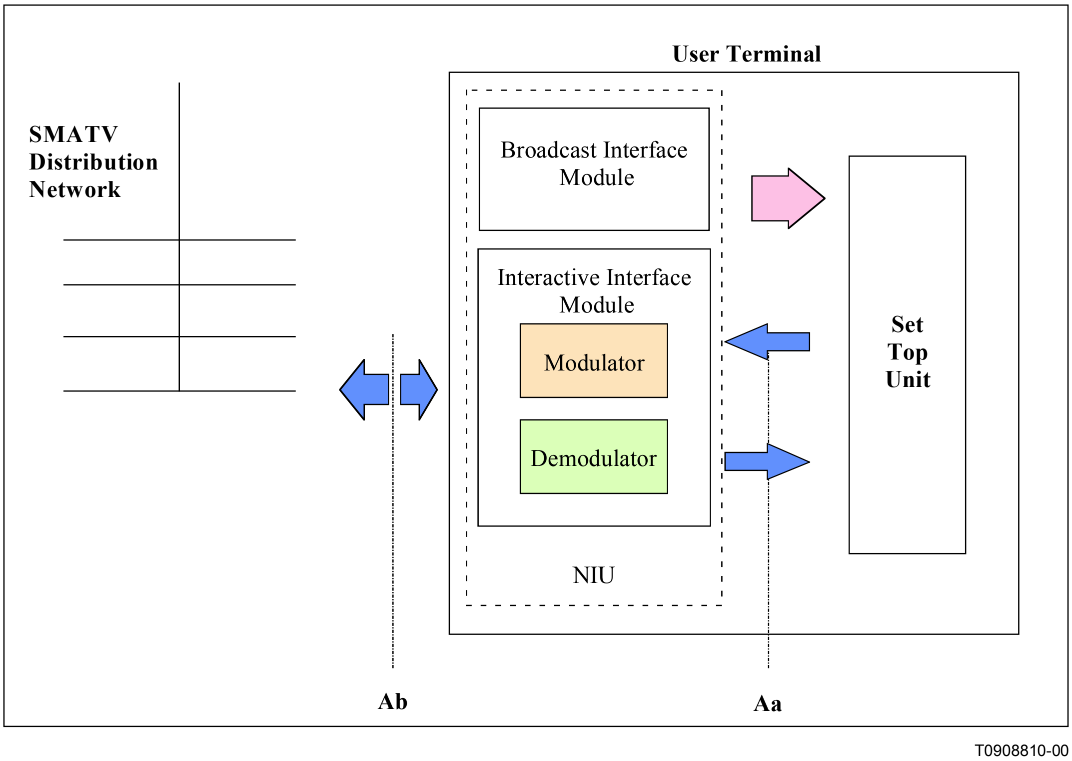

Figure 4b/J.118 – Functional block diagram for the SMATV/MATV Interactive User Terminal

The coaxial section supports the bidirectional communications between the User Terminal and the Interactive Head-end. The Interaction Channel is based on the same SMATV/MATV coaxial distribution network as the Broadcast Channel but uses the lower frequency range (15-35 MHz). The Network Interface Unit, which is located at the user side, provides the performance required for signal transmission (modulation, demodulation, channel coding, network access, etc.) through its interface and channel adapter called Interactive Interface Module or SMATV/MATV modem. See block diagram provided in Figure 5. The SMATV/MATV interactive head-end collects/distributes the interaction traffic related to the users connected to one or more independent SMATV/MATV networks.

This Recommendation defines two current technological alternatives for the interactive service provision in SMATV/MATV networks according to a bandwidth dependent classification. In particular, the cable based solution is fitted when broadband applications are concerned (see 6.2) while the Master Link Low Rate TDMA is suited for narrowband applications (see 6.3).

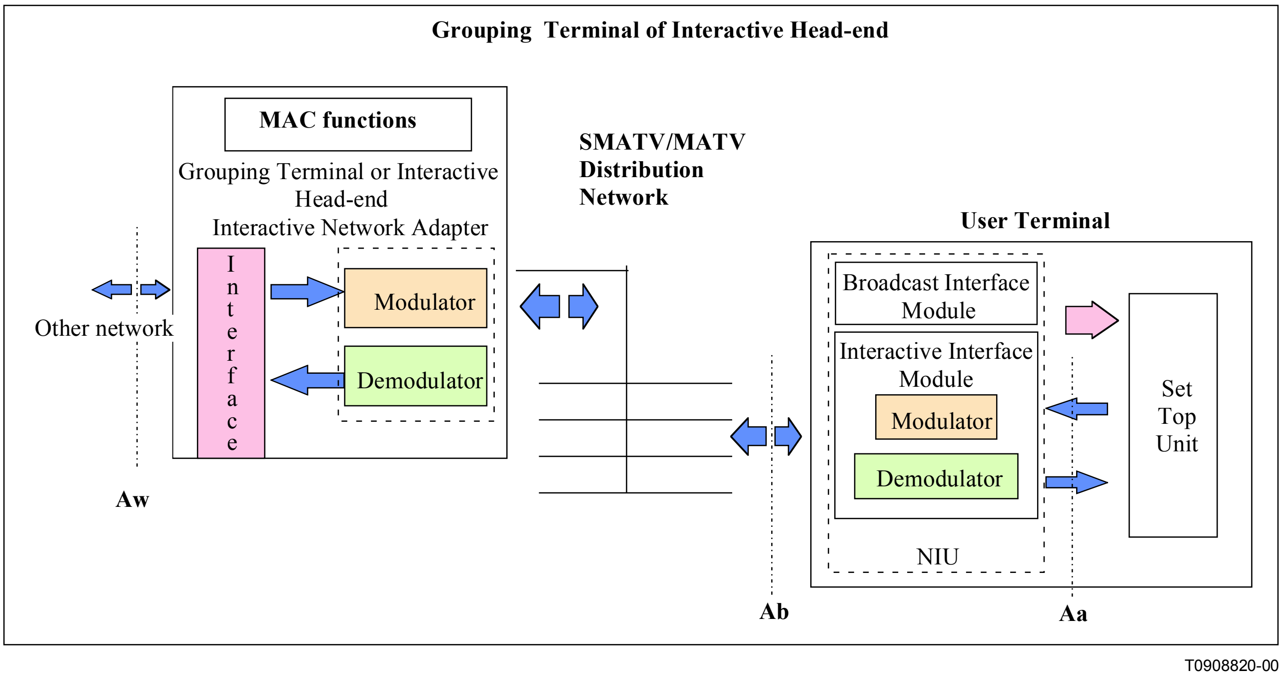

Figure 5/J.118 – SMATV/MATV Coaxial Section Block diagram

6.2 Approach based on the "Cable solution"

This solution consists of a subset of the options provided in [4] allowing a system simpler than the CATV one, thus matching the requirements of the SMATV scenario. One of the key elements of the SMATV/MATV scenario referring to the CATV one is that the Grouping Terminal at the SMATV/MATV head-end is an equipment of a consumer type in a similar way as the Set Top Box, although the SMATV head-end cost is shared among the users connected to the SMATV, which could be those of a single building or a group of buildings.

Due to the specific cost requirements of the SMATV, and taking into account the reduced number of users in SMATV (typically 5 to 300 users) in comparison with typical CATV networks, an appropriate subset of the cable system options is recommended in order to minimize the complexity and the cost of the Grouping Terminal. In principle it is intended that the SMATV Interactive Interface Module at the user terminal should be identical to the one needed for CATV system taking advantage in this way, for both scenarios CATV and SMATV, of the economies of scale of the Interactive Interface Module at the user terminal. In summary, the Interactive Interface Module at the user terminal will be the same, either for SMATV users or CATV users, but the Grouping Terminal at the SMATV interactive head-end will be much simpler than the CATV interactive head-end.

The interaction channel for CATV networks described in [4] system presents an advantage in terms of cost for rather big SMATV where the cost of the head-end is distributed among the users. It is also noted that this option for the coaxial section allows for a higher capacity allowing a better migration to wideband multimedia services as well as a greater flexibility to share the coaxial media among different users working with different type of applications with very different traffic patterns.

Below is a description of the coaxial section system concept. SMATV coaxial section solution is based on the CATV system. Therefore, the full detailed description of the physical layer parameters, access modes, MAC functions, etc., is provided in [4].

The Coaxial Section allows the transmission of Interaction Channel signals through the Forward Interaction path (downstream) and Return Interaction path (upstream). The general concept is to use the Forward Interaction path from the Grouping Terminal to the Interactive Interface Modules (IIMs) to provide synchronization and information to all IIMs. This allows the IIMs to adapt itself to the network and send synchronized information in the Return Interaction path. Return Interaction path carriers are divided into time slots, which can be used by different users, using the technique of Time Division Multiple Access (TDMA). One Forward Interaction carrier is used to synchronize up to 8 Return Interaction path carriers, which are all divided into time slots. A counter at the Grouping Terminal is sent periodically to the IIMs, so that all IIMs in the same SMATV network work with the same clock. This gives the opportunity to the Grouping Terminal to assign time slots to different users.

Three major access modes are provided with this system. The first one is based on contention access, which allows users to send information at any time with the risk of having a collision with other user's transmissions. The second and third modes are contentionless based, where the Grouping Terminal either provides a finite amount of slots to a specific IIM, or a given bit rate requested by an IIM until the Grouping Terminal stops the connection on IIMs demand. These access modes are dynamically shared among time slots, which allow IIMs to know when contention based transmission is or is not allowed. Periodically, the Grouping Terminal will indicate to new users that they have the possibility to go through sign-on procedure, in order to give them the opportunity to synchronize their clock to the network clock, without risking collisions with already active users. This is done by leaving a larger time interval for new users to send their information, taking into account the propagation time required from the Grouping Terminal to the IIMs and back.

Several simplifications of the head-end as specified for the CATV system in [4] can be applied to the SMATV scenario in order to allow for a simple Grouping Terminal with a lower processing capability. These simplifications can be done for the SMATV systems because the lower number of users and the smaller distance that separates the head-end and the users with respect to the CATV networks. In any case the IRDs based on [4] would apply for SMATV taking advantage of the expected economy of scale. The options recommended for the SMATV scenario are:

- Use the Out of Band (OOB) option with a unique carrier in each direction. Alternatively, or in parallel, the Forward Interaction path could be embedded into the Broadcast Channel in the MPEG-2 Multiplex, when the capacity required in the downstream or the type of applications requires it.
- Use of a single 3.088 Mbit/s carrier for the Return Interaction path to be shared among the number of users in the SMATV network.
- Use of a single 3.088 Mbit/s carrier for the Forward Interaction path to be shared among the number of users in the SMATV network.
- Reduced frequency ranges (15-35 MHz).
- No power or timing ranging (simplified MAC protocol).
- In some cases, fixed rate assignment to each user could be used in accordance with the total capacity assigned to the further network connected at the head-end to link with the Service Provider.

The IIM could also be external to the User Terminal, the interfaces defined in [10] should be used.

6.2.1 Spectrum allocation

Figure 6 indicates a possible spectrum allocation. Although not mandatory, a guideline is provided to use the following preferred frequency ranges, 70-130 MHz for the Forward Interaction path (downstream OOB) and 15-35 MHz for the Return Interaction path (upstream), or parts thereof. The use of limited frequency ranges simplifies the tuner complexity (filtering) and does not mean any capacity constraint. A Recommendation is done to use just one carrier for Forward Interaction Path and another for Return Interaction path.

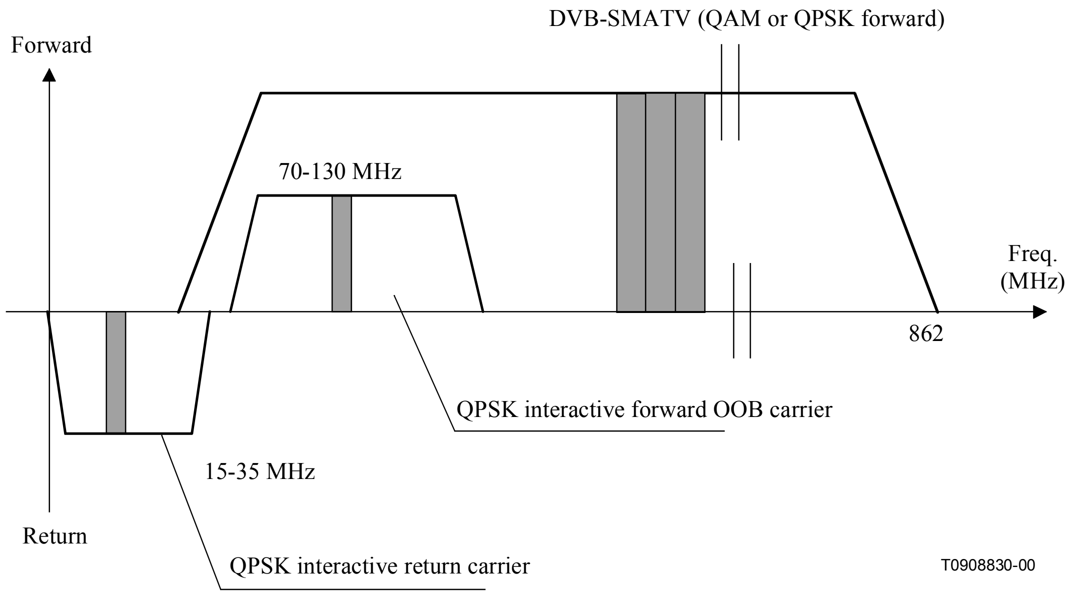

Figure 6/J.118 – Preferred frequency ranges for SMATV interactive systems

6.2.2 FDM/TDMA Multiple Access

A multiple access scheme is defined in order to allow different users sharing the same transmission media. Forward information is sent broadcast to all users of the networks. Thus, an address assignment exists for each user which allows the Grouping Terminal to send information singlecast to one particular user. Two addresses are stored in the set top boxes in order to identify users on the network:

- MAC addresses. That is a 48-bit value representing the unique MAC address of the NIU. This MAC address may be hard-coded in the NIU or be provided by external source.
- NSAP address which is a 160-bit value, representing a network address. Higher layers during communication provide this address.

Return information may come from any user in the network and therefore it has to be also differentiated at the Grouping Terminal using the set of addresses defined above. Each Forward Interaction path carrier contains a synchronization frame used by up to 8 different Return Interaction path carriers, whose frequencies are indicated by the Media Access Control (MAC) protocol. In any case, for most cases one carrier for Return Interaction path and another for Forward Interaction path is enough for providing the capacity required by most SMATV systems.

Within Return Interaction path carriers, users send packets with TDMA scheme. This means that each channel is shared by many different users, who can either send packets with a possibility of collisions when this is allowed by the Grouping Terminal, or request transmission and use the packets assigned by the Grouping Terminal to each user specifically. Assuming each channel can accommodate up to thousands of users at the same time, the Return bandwidth can easily be used by all users present on the SMATV network at the same time (as a reference, the typical number of users in SMATV networks could vary from 5 to 300 users).

The TDMA technique utilizes a slotting methodology which allows the transmit start times to be synchronized to a common clock source. Synchronizing the start times increases message throughput of the signalling channel since the message packets do not overlap during transmission. The periods between sequential start times are identified as slots. Each slot is a point in time when a message packet can be transmitted over the signalling link.

The time reference for slot location is received via the Forward Interaction path carrier generated at the Grouping Terminal and received simultaneously by all IIMs attached to the SMATV network.

Since the TDMA signalling link is used by IIMs that are engaged in interactive sessions, the number of available message slots in this channel is dependent on the number of simultaneous users. When messaging slots are not in use multiple message slots may be assigned to an IIM to increase messaging throughput. Additional slot assignments are provided to the IIM from the downstream signalling information flow.

There are different access modes for the Return Interaction path slots:

- Reserved slots with fixed rate reservation (Fixed rate Access: the user has a reservation of one or several time slots in each frame enabling, e.g. for voice or audio).
- Reserved slots with dynamic reservation (Reservation Access: the user sends control information announcing his demand for transmission capacity. He gets grants for the use of slots).
- Contention based slots (these slots are accessible for every user. Collision is possible and solved by a contention resolution protocol).
- Ranging slots (these slots are used to measure and adjust the time delay and the power).

These slots may be mixed on a single carrier to enable different services on one carrier only. If one carrier is assigned to one specific service, only those slot types will be used which are needed for this service. Therefore a terminal can be simplified to respond to only those slot types assigned to the service.

6.2.3 Bit rates and Framing

For the Forward Interaction path in SMATV, a rate of 3.088 Mbit/s is recommended in consistency with the appropriate bit rate for the further transmission media at the Head-end (as for example LMDS).

The Forward Interaction path carrier continuously transmits a frame based on T1 type framing, where some information is provided for synchronization of Return Interaction path slots.

For the Return Interaction path, the Grouping Terminal can indicate the transmission rate to users. Specifically 3.088 Mbit/s is recommended for SMATV following the same rationale as for the Forward Interaction path.

Figures 7 and 8 show the conceptual block diagrams for implementation of the coaxial section.

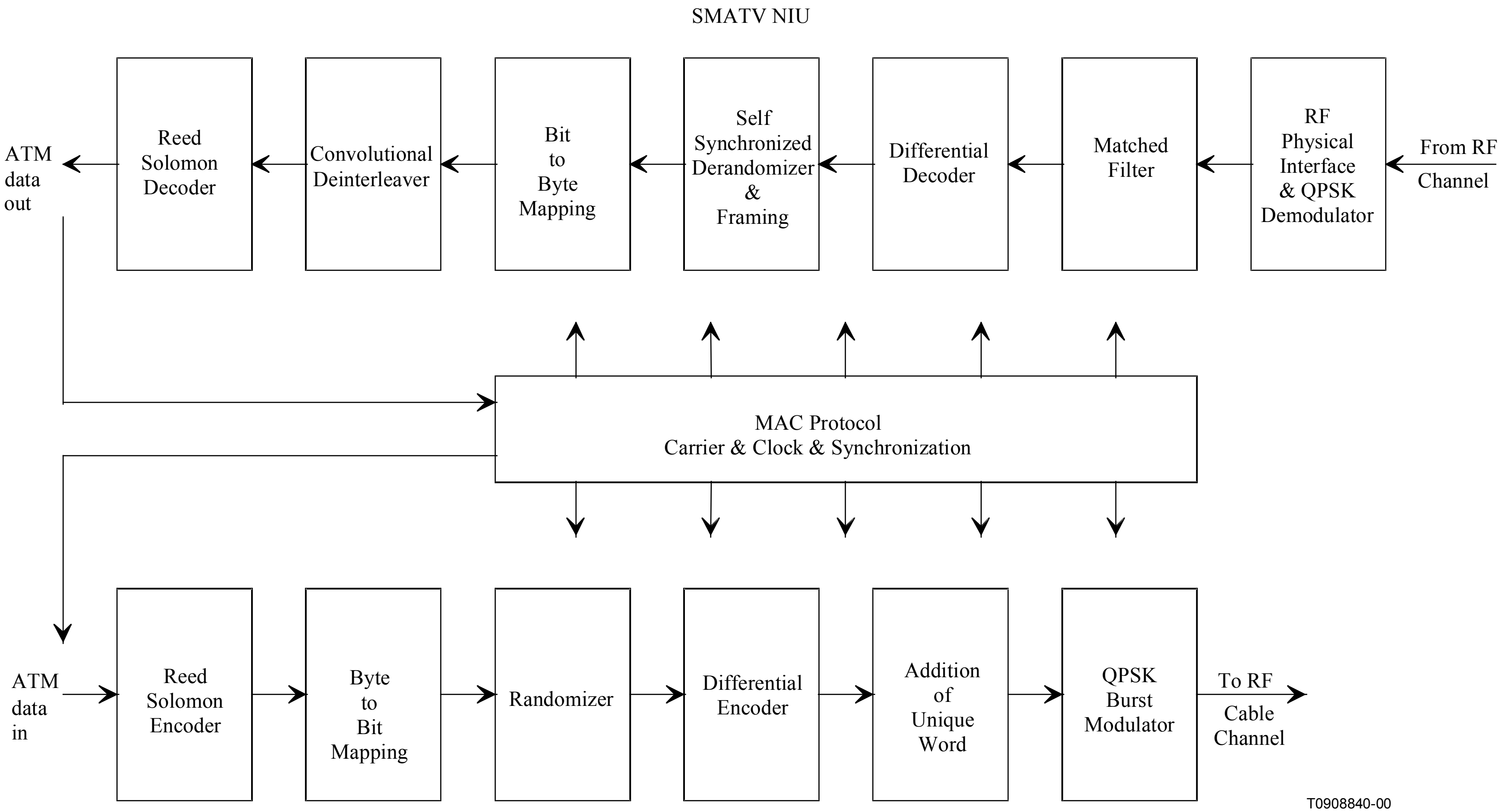

Figure 7/J.118 – Conceptual Block Diagram for the NIU OOB Transceiver

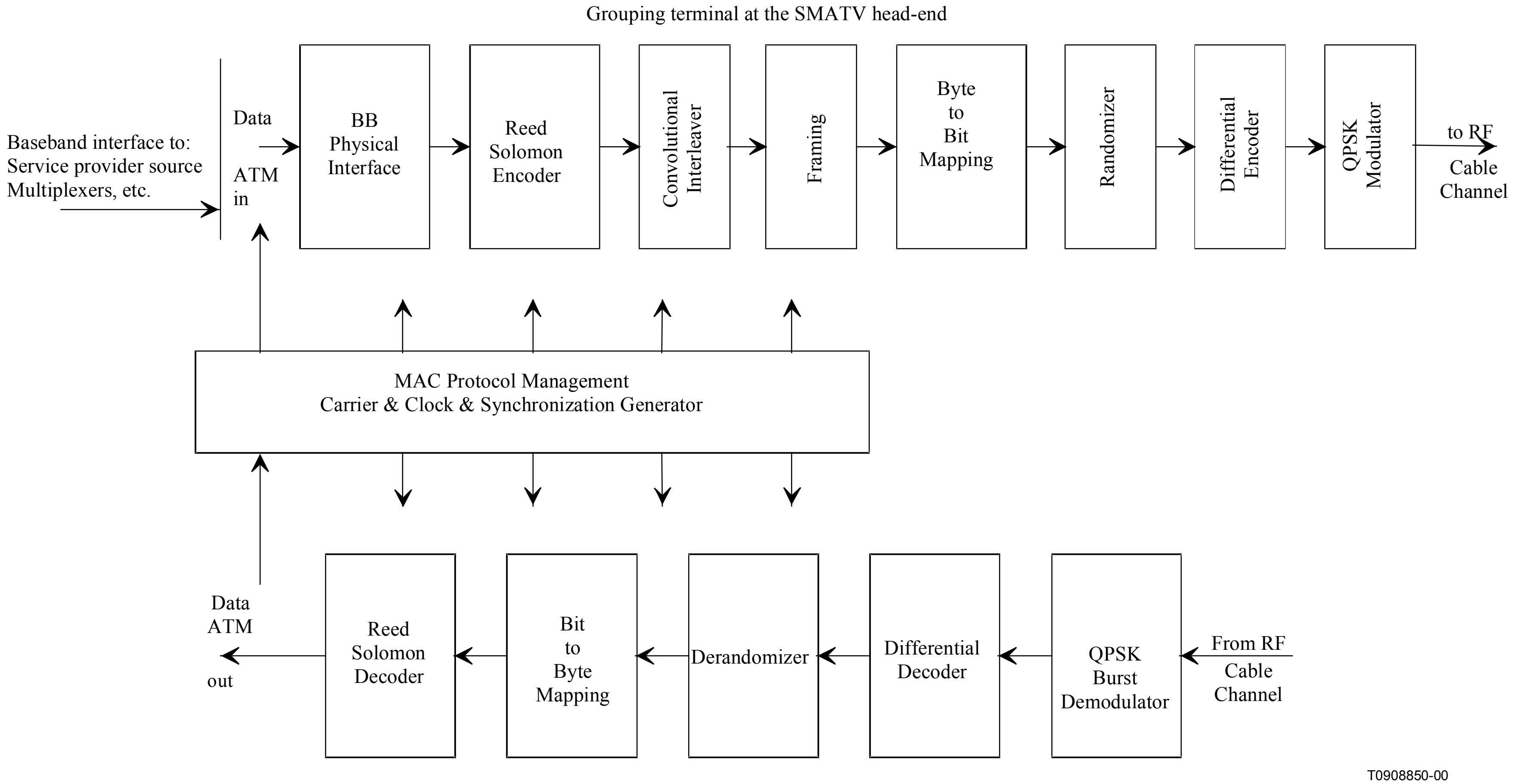

Figure 8/J.118 – Conceptual Block Diagram for the OOB Head-End Transceiver

6.3 Approach based on the "Master Link Solution or Low rate TDMA"

This clause specifies the Master Link solution or Low Rate TDMA (LRTDMA) solution developed by S3M Project. This section (which includes the Interactive Head-end or Grouping Terminal, the cable and the IIM-Interactive Interface Module) allows for a full-duplex interactive communication between the Set Top Box and the Interactive Head-end. This coaxial section solution is an interoperable one with the network alternatives further the Interactive Head-end such as Satellite, ISDN, terrestrial, wireless, etc.

It has been designed and optimized for small SMATV networks (up to 40 users, and consequently is fitted for more than 80% of users in Southern European Countries). From the cost point of view this is the most optimized solution for small SMATV networks. Anyway, this system is a modular system and then more users and/or more capabilities could be supported with more Interactive Head-ends. In any case, it has first been classified as a solution for narrowband applications (using just one head-end).

The Master Link Modem is simpler than other cable modems that were designed for bigger networks. It is expected that the Master Link could be less expensive than those ones. Towards this end, two points have been taken into account.

The Grouping Terminal or Interactive Head-end has an important influence on the system price per user, for these kinds of small SMATV systems, especially in a first introductory period. So, an important requirement for this User Section is that the Interactive Head-end must not be too much more expensive than the IIM. For this reason, this specification has been developed with a lot of similarities between the Interactive Head-end and IIM operation. In particular, the hardware that supports the Interactive Head-end and IIM is the same. Functional differences could be supported by software.

The Master Link is composed of several IIMs at the user side, and the Grouping Terminal or Interactive head-end.

The global Interactive System is intended for low rate interactive applications. This user section allows for full duplex transmission between users with a global bit rate of 271 kbit/s.

6.3.1 Main characteristics

The Master Link system has been designed for Small SMATV Systems (up to 40 users), and provides for full duplex communication between users and the Grouping Terminal. The system is modular in the sense that multiple Grouping Terminals can be chained together, allowing more than 40 users in the same building. The frequencies used by the system are in the range between 15-35 MHz. The full duplex scheme is achieved by time division on a single carrier frequency.

The Interactive system is composed of a Forward interaction Path (downstream) and a return interaction Path (upstream). The general concept is to use the downstream transmission from the Interactive head-end to the IIMs to provide synchronization and information to all IIMs. This allows the IIMs to adapt to the network and send synchronized information upstream.

The modulation scheme (GMSK) and bit rate are based on GSM standard (GSM 5.04). The global bit rate is 271 kbit/s.

The grouping terminal is in charge of controlling the traffic from the different users. The protocols considered are bit map protocols with simple access techniques. The error control considered for upstream traffic is based on ACK protocol and forward error control for downstream traffic.

6.3.2 Physical Layer

Modulation Scheme and bit rate are based on GSM standard (GSM 05.04). But the RF, the burst length, the frame structure, or MAC are different from the GSM standard. In fact this system has packet oriented switching, while GSM is a circuit oriented switching system. Another great difference is that the GSM is full duplex by frequency division, while this system is full duplex by time division. This characteristic makes the physical layer quite symmetric: both upstream and downstream transmissions are discontinuous (burst). In both directions, only two types of burst are used, called Long and Short Bursts respectively.

Some of the physical layers characteristics of the GSM standard have also been adopted in order to facilitate the use of available components of GSM mobile terminals. These components are characterized both by their low price and high level of integration (A/D and D/A conversion subsystem, and also IF components are susceptible to be used).

Most of the defined standards for cable transmission are based on QPSK modulation; but also GMSK as defined in DECT standard has been proposed. In all cases, GMSK and QPSK have very similar performances. In fact, the use of a linear receiver, identical to those used for OQPSK modulation is a good detection alternative for GMSK modulation.

A summary of the physical layer is presented below:

General

Bit Rate:	270.833 kbit/s
Frequency stability:	± 50 ppm
Symbol Rate Accuracy:	± 50 ppm

Transmitter

Long Burst:

Scrambling ($x^6 + x^5 + 1$). Self Initialized every burst.

Differential Coding.

GMSK Modulation.

Burst Transmission (both upstream & downstream).

Short Burst:

Bipolar orthogonal signalling, based on GMSK modulator.

Receiver

Long Burst:

- Linear Receiver (Offset QPSK type).
- Receiver Filter: Adapted filter + Equalizer.
- Coherent Detection. Training sequence used.
- Differential Decoding.
- De-scrambler. Self Initialized every burst.

Short Burst:

- Incoherent Detection.

6.3.3 Frequency Range

A single carrier will be used on the range of 15 to 35 MHz.

At power on, the Set Top Box IIM will search which frequency is actually used by Grouping Terminal.

6.3.4 Power Budget & Power Ranging

Before any power ranging procedure it is not expected to have more than 30 dB of power variations on the upstream direction. After power ranging procedure, less than 1 dB (TBC) power margin must be obtained in upstream direction.

6.3.5 MAC layer

As multiple users share the same channel, an access protocol must be implemented. While defining it, we have tried to exploit the fact that the number of users is not big (in fact, restricted to less than 40). The procedure is as follows: to transmit any information, an IIM must transmit in advance an access request. This request is transmitted on a specific time slot, when the Grouping Terminal allows it.

6.3.6 MAC address

After initialization and sign on procedure, the grouping terminal gives a MAC address to each IIM.

These addresses are used by the MAC layer to facilitate the multiple access mechanism.

6.3.7 TDMA scheme

The TDMA scheme is based on a basic time interval of 336 bits length, that we call **Period**. There are two types of Periods:

The **Normal Period** is composed of 2 time slots: One downstream slot composed by a short burst appended to a long burst, and one upstream slot consisting only of a long burst. A Normal Period Diagram is shown below.

The **Request Period** is similar to the normal period, but the time slot assigned to the upstream long burst is now divided on 6 time slots assigned to upstream short burst. A diagram with the details of this division is shown below. See Figure 9.

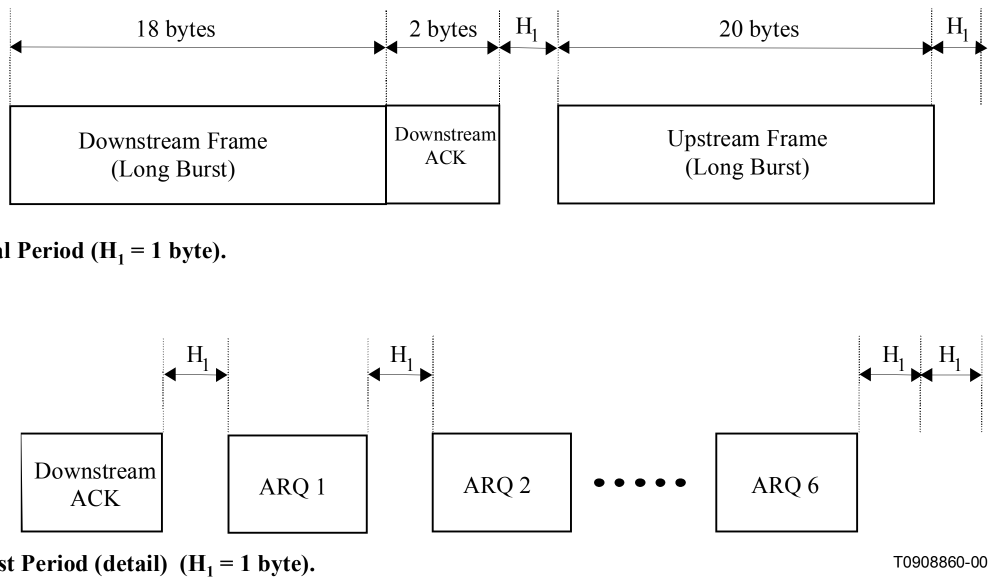

Figure 9/J.118 – TDMA Scheme

6.3.8 Framing

Short Burst Acknowledges: These short bursts are transmitted only by GROUPING TERMINAL on the ACK slot of Normal or Request periods, as an acknowledgement of the previously received frame, as part of the error control procedure.

Short Burst Access Request: These short bursts are transmitted by IIMs on Access Request slots of Request periods. These bursts inform the GROUPING TERMINAL which IIMs need to transmit something.

Normal Frame: Normal Frames are transmitted on a single long burst, so they are 20 bytes long. They carry user data or signalling. They have the following four field:

- TS: **Training Sequence** is a predefined bit sequence, 4 bytes long, used by the receiver on synchronization acquisition procedures.
- CTR: **Control Field** has two functions. It has information on the type of data carried by the Data Field. It also defines the type of the following period (Normal or Request), and the IIM that can use the upstream time slot of this following period.
- DF: **Data Field** is 13 bytes long, and contents User Data or Signalling.
- RS: Two bytes **Reed Solomon** parity field are included for error control procedure. Both Control and Data Field are protected.

TS: 4 bytes. Training sequence.

CTR: 1 byte. Control field.

DF: 13 bytes. Data Field.

RS: 2 bytes. Reed Solomon parity field.

TOTAL: 20 bytes.

Sign On Frame: It is 20 bytes long, and transmitted as a long burst. It is used only by IIMs during initialization procedure. The only difference with normal frame is that the training sequence is longer (13 bytes) and the Data Field shorter (4 bytes). It only carries signalling Data.

TS: 13 bytes. Training sequence.

CTR: 1 byte. Control field.

DF: 4 bytes. Data Field.

RS: 2 bytes. Reed Solomon parity field.

TOTAL: 20 bytes.

6.3.9 Error Control Procedure

Error control is based on an ACK protocol. Frames are protected by Reed Solomon parity bits. Because of the fact that Downstream frames are always broadcasted, we are only considering downstream ACK slots. The GROUPING TERMINAL checks the validity of the received frame and sends an acknowledge (ACK or NACK) to the IIM. When NACK signal is detected, the IIM will retransmit the same frame.

6.4 SMATV/MATV Head-End Interface with other networks

In order to allow an open and interoperable system, a specification for the interface between other networks and SMATV/MATV network is given. The complete definition of this interface allows for the use of alternative technologies with the aim to facilitate the interoperability between subsystems from different vendors and technologies.

Also the definition of this interface allows the reuse of the coaxial section for establishing the Interaction Channel through different transmission media (Satellite, DECT, CATV, etc.).

A very low cost interface, RS-232 based, is the baseline recommended solution although alternative interfaces are identified in order to allow the reuse of existing terminals.

6.4.1 RS-232 serial Interface

Mechanical and electrical characteristics

The interface will comply with EIA 232-D, more specifically:

- Logical: ITU-T V.24 [6].
- Electrical: ITU-T V.28 [7].
- Mechanical: ISO 2110 standard (25 pin connector) [9].

working with the following basic parameters:

- Speed: configurable up to 115 200 bit/s;
- 8 data bit;
- no parity;
- 1 stop bit.

The coax section will act as the DTE (Data Terminal Equipment), and so its connector will have male contacts (female shell). The Satellite Interactive Terminal will play the role of DCE (Data Communications Equipment), so its connector will have female contacts (male shell).

Framing

The Maximum Transfer Unit (MTU) is defined as 1024 bytes[2] for this interface. It means that any data packet longer than the MTU defined should be segmented before transmission through this interface.

Flow control mechanisms

Flow control may be implemented using the Clear To Send/Request To Send (CTS/RTS) signals (hardware flow control) or the XON/XOFF protocol (software flow control).

Data flow from the coax section towards the Satellite section will be limited according to the following rules, when using the CTS/RTS flow mechanism:

- The coax section equipment will make sure the CTS signal is LOW before starting transmission of a new data packet.
- Satellite Interactive Terminal will set CTS LOW as soon as free space in its internal buffers allows for a whole maximum-size data packet. CTS will be set back HIGH when there is space for a new packet.
- It is up to the Satellite Interactive Terminal implementors to choose when the CTS signal must be set HIGH as buffers are emptied. It is the responsibility of the Satellite Interactive Terminal equipment to ensure that no data is lost as long as the coax section complies with the first rule.
- The coax section must propagate data flow limitations towards the user equipment to avoid packet losses.

Data flow towards the coax section has no flow mechanism.

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[2] The size of 1024 bytes for the MTU has been chosen, because it is an adequate value to be used with the SLIP protocol which can be implemented for this interface.

6.4.2 Alternative Interfaces

6.4.2.1 LAN based interfaces

In order to facilitate the evolution towards multimedia broadband applications, alternative interfaces based on LAN technology are identified in order to provide solutions to the potential barriers that the RS-232 may present in terms of maximum bit rate. For that purpose a typical Ethernet interface is proposed which is very extended and facilitates the interconnections to LAN for any other kind of needs.

For the mechanical and electrical characteristics the interface will comply with EIA 568-A, that is: it will be an IEEE 10 Base-T Ethernet (IEEE 802-3 standard) with RJ-45 connectors. With respect to the framing and error control a standard for framing of data packets into Ethernet is described in IEEE 802.3.

6.4.2.2 X.25 communications interfaces

Most of the existing networks implement in their terminals the protocols and physical interfaces used for X.25 communications. Therefore these kinds of connections might have to be considered when reusing already operating networks which are currently installed in a number of buildings.

APPENDIX I

Report on measurements of the master link system for SMATV/MATV networks

I.1 Introduction

This appendix reports on the measurements of the "Master Link" system carried out at the RAI Research Centre in the context of the S3M Project[3].

The aim of the measurements was to test the performance of the "Master Link" System in SMATV/MATV networks. For this purpose, three laboratory implemented SMATV/MATV networks were used.

I.2 Description of the Test-Bed

The laboratory implemented distribution networks used in the trials are completely similar to real installations as far as components and cable lengths are concerned. They use active and passive components available on the market and they are thought to represent the most common community installations ("old" and new installations).

All the networks measured had a parallel topology. The networks analysed were resistive (worst) and inductive.

The Grouping Terminal was connected to the SMATV/MATV network input, while the Interactive Interface Module (User modem) was connected to different user outlets. Both were connected to Pentium II PC's with Linux OS, through RS-232 interface with SLIP on-line protocol. A variable attenuator was included to vary the signal level at the input of the SMATV/MATV network to measure the performance of the system at different SNR. The SNR is referred to the GMSK base-band analogue signal in the receiver modem, before A/D conversion.

[3] S3M Project is an Advance Communications Technologies and Services Project of the EC Programme mainly contributing with Interactive channel solutions for SMATV/MATV networks.

I.3 Measurements

Different measurements were carried out during the trials:

- Bit error rate of the GMSK signal.
- Attenuation range.
- IF spectrum.
- Performance in the presence of linear distortions.

I.3.1 Bit Error Rate of the GMSK signal

The BER of the GMSK signal was measured in a network which represents "old" installations and it is implemented with resistive taps. This network is very sensitive to the conditions of outlet termination. The measurements were carried out in the worst case of outlet termination, that is all the user outlets left open except the one under measurement. The measured BER was about 10^{-7} for all the outlets of the network. The measured SNR was about 25 dB. This SNR was measured before A/D conversion in the receiving modem, and the measurement was made by comparing the peak-to-peak amplitude of the GMSK signal and the peak-to-peak background noise, both in time domain, with the oscilloscope. The measured BER did not change and the System worked correctly in the presence of ten 64-QAM signals transmitted in the S-band.

I.3.2 Maximum allowable attenuation

The purpose of this measurement is to find out the power of the signal to be injected at the input of the network to obtain a given performance (BER $\leq 10^{-6}$, corresponding to SNR $\geq$ 20dB) at every outlet. The attenuation of the network depends on the frequency range used. In the "Master Link" system prototypes the frequency is fixed to 25 MHz. In this band the attenuation has important differences depending on the network used. Considering the networks tested, resistive networks, which correspond to "old" installations and for a limited number of outlets, have low attenuation at this frequency (20-25 dB), while inductive networks, corresponding to "modern" installations, can have a higher attenuation, up to 60 dB.

The Automatic Gain Control (AGC) margin of the "Master Link" prototypes supports up to 40 dB of attenuation. This was verified using a variable attenuator and increasing the attenuation until the condition of loss of packets was reached. The tests were carried out in the presence and absence of the SMATV/MATV networks obtaining in the two cases similar results and verifying the 40 dB of attenuation range. The measurements were carried out for every outlet in every Network. The outlets whose attenuation lower than 40 dB did not introduce any impairment on the performance of System with respect to the attenuator.

I.3.3 IF spectrum

Figure I.1 Shows spectrum of the GMSK signal at the carrier frequency of 25 MHz.

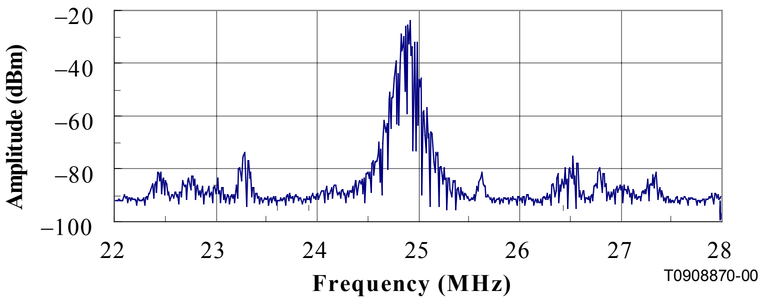

Figure I.1/J.118 – Power spectrum of the GMSK signal (Band 22-28 MHz)

I.3.4 Performance in the presence of linear distortions

Having verified that the network did not introduce linear distortions in the frequency range used by the "Master Link" system, a variable filter was added to the test bed, in order to simulate linear distortion introduced by the distribution network.

The filter was a low pass filter having a cut-off frequency of about 30 MHz, and it was adjusted varying the cut-off frequency around 25 MHz.

Figures I.2, I.3 and I.4 show the amplitude and group delay responses of the filter in three different cases. In these conditions the system worked correctly.

Figure I.5 shows the only case in which the system did not work correctly, having moved the notch of the filter exactly at the frequency of 25 MHz. In this case the attenuation introduced by the filter is very close to the maximum attenuation the system can tolerate.

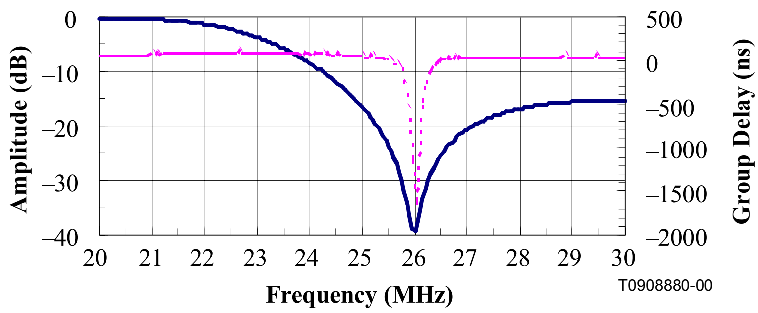

Figure I.2/J.118 – Amplitude and group delay responses of the filter, case I

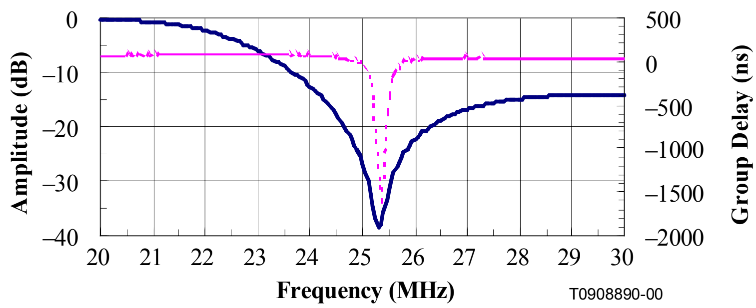

Figure I.3/J.118 – Amplitude and group delay responses of the filter, case II

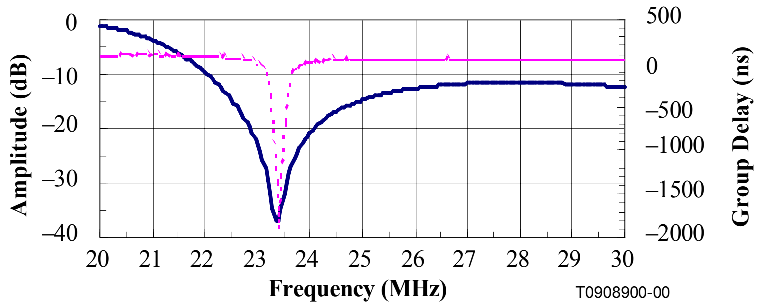

Figure I.4/J.118 – Amplitude and group delay responses of the filter, case III

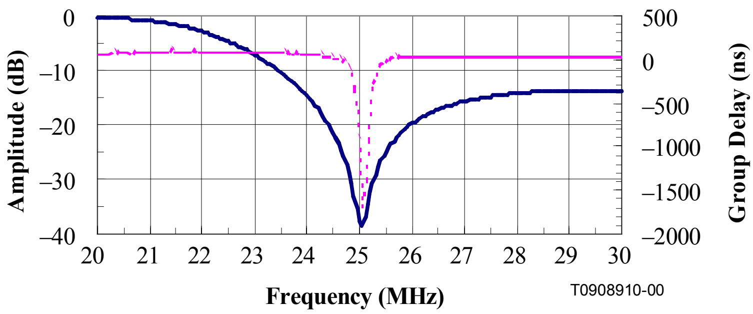

Figure I.5/J.118 – Amplitude and group delay responses of the filter, case IV

I.5 Conclusions

The main conclusions are summarized herein:

- "Master Link" system showed good performance for the networks tested (representing both resistive, corresponding to old installations, and inductive networks, being representative of modern installations).
- The "Master Link" prototypes allow a maximum attenuation of 40 dB (from output of the transmitting modem to input of the receiving modem) in the band of interest 25 MHZ. Measurements with the tested SMATV/MATV networks confirmed this value, below which signal reception proved to be successful.
- The effects of linear distortions have been evaluated adding a variable filter to the test bed. The "out-of-service" condition is reached in the case of attenuation close to the maximum value of 40 dB, indicating good system performance in the presence of linear distortions in the band of interest.

APPENDIX II

Report on Simulation of the behavior of the GMSK signal used by the Master Link System in SMATV/MATV networks

II.1 Introduction

This report shows the results obtained by the simulations made of a GMSK signal, used by the Master Link Solution, without coding going through the coaxial channels. Different coaxial channels were simulated based on the most representative types of SMATV/MATV networks with several topologies, number of users, floors, etc., installed in West Europe. Two scenarios could be considered, networks up to 40 users which represent more than 80% of SMATV users in Southern European countries (networks from A to E and H) and networks with more than 40 users (networks F and G). This work has been done in the scope of S3M Project.

The main objective of the simulations was to analyse the expected degradation of the signal, the most affected range of frequencies and the order of magnitude of this degradation in the presence of white noise.

The transfer functions of the coaxial networks were characterized in the frequency range 5-50 MHz by the RACE DIGISMATV Project.

II.2 Description of the Simulation

The block diagram used at the simulation is shown in Figure II.1.

The GMSK signal without coding simulated is the one used for the return channel. The frequency band used in the simulations is from 15 to 35 MHz assigned to the return channel. The signal was passed to a filter that reproduced the coaxial channel, before the white noise was added at the front of the receptor.

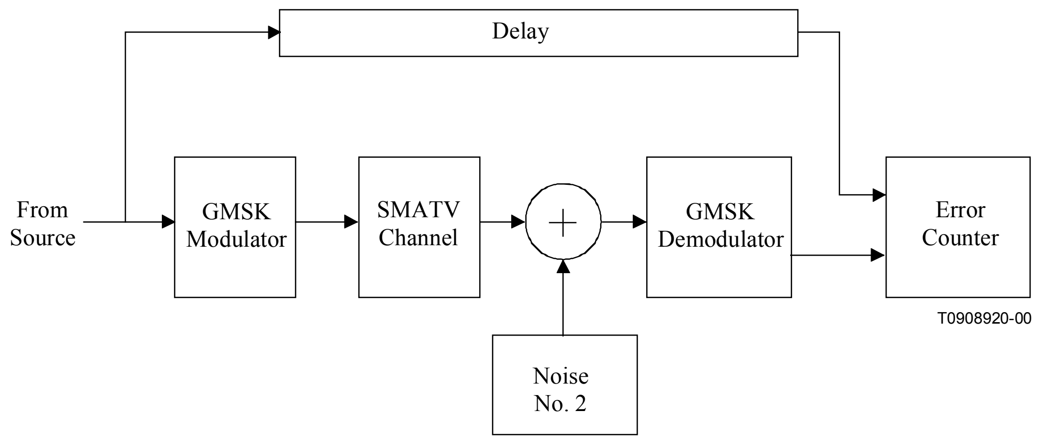

Figure II.1/J.118 – Transmission chain adopted at the simulation

The transmission chain adopted for the whole system was conformed to a uniform random bit generator, a GMSK modulator with $B_{Tx}T$ equal to 0.3, a FIR filter of the coaxial channel, a White noise generator, a GMSK demodulator and a BER counter.

The modulator that was built is a FM modulator with a gaussian filter for pulse shaping and a deviation ratio h equal to 0.5 [5]. In the receptor the demodulator used is a coherent orthogonal I&Q (in-phase and quadrature) designed by Buda [6] with the same predetection optimum filter done by Murota [2], keeping in mind the characteristics of the real I&Q representation of a MSK signal [5].

This is an efficient and simple model to simulate GMSK, in a non-temporal fading environment as the coaxial channel is. It will only show the degradation obtained because of the coaxial channel but not from the receptor performance, due to the exact phase and frequency synchronization at the receptor in the presence of white noise. It will show a minimum value that the real demodulators will get on the channel.

The binary rate is 270.833 kbit/s. The transmission filter bandwidth is B_{tx} = 81.250 kHz to comply with $B_{Tx}T = 0.3$. The assigned bandwidth per carrier is 200 kHz.

The BER estimation method is Monte Carlo [1].

II.3 Transfer function analyses of the networks considered

The transfer functions used at the simulations represent the different resistive and inductive topologies of the coaxial medium at the SMATV systems.

The maximum amplitude and group delay variations that the transfer function graphs show for GMSK narrow-band carrier between 15 to 35 MHz are presented in Table II.1.

The value of the bandwidth equal to 247.5 kHz chosen to measure the maximum amplitude and group delay variations from the graphs is due to their minimum resolution.

Table II.1/J.118 – Maximum amplitude and group delay variations at a 247.5 bandwidth of network A to H [5]

Network	Maximum amplitude variation at a 247.5 kHz bandwidth (dB)	Maximum group delay variation at a 247.5 kHz bandwidth(ns)
A	0.09	2.32
B	0.07	1.71
C	0.17	3.61
D	0.09	2.96
E	0.77	38.68
F	0.21	7.76
G	7.34	539
H	0.06	2.48

From the table, it is clear that the group delay distortion is not important for most of the simulated networks. It is because the bit period is around 1000 times higher than the maximum group delay variations.

Network G shows a very high mismatching among the components in the network (outlets, splitters, tap-offs, etc.) representing a very rare case. Then it could be interpreted as the worst-case situation when the SMATV network has not been properly built up.

For that network G, the group delay variation will be 436 ns in a 200 kHz bandwidth, which is around 12% of the bit period. It means low degradation due to group delay distortion on network G. The final results obtained with the simulations proved that the degradation obtained by the group delay distortion is minimum in the presence of white noise.

Resistive networks A, B and E have attenuation from 20 to 35 dB, while inductive networks C, D, F, G and H have attenuation form 20 to 52 dB in the 15 to 35 MHz bandwidth. For networks up to 40 users the attenuation is always less than 40 dB in the 15-35 MHz band being higher for bigger networks.

Network G has 4 notch that reach 10 dB of amplitude variation and 600 ns group delay variation, when the neighbour outlet of the same floor is not correctly terminated in 75 Ω [6]. Because the GMSK signal is a narrowband signal, from Table II.1 the maximum amplitude variation on 247.5 kHz is 7.34 dB. This is a very high change in the amplitude that will cause degradation on the signal in the presence of white noise at the receiver. The 4 notch were defined as 4 critical points A, B, C and D.

Network E presents high ripples of 5 dB in the amplitude response, but in the GMSK bandwidth the amplitude variation does not go beyond 1 dB. The degradation obtained in the simulations was almost null in the presence of white noise.

II.4 Simulation results

In Figure II.2 there appears places 1, 2 and 3. These points were the places where the GMSK carrier was located to do the simulation. Because the 4 critical points of network G are notches, the highest degradation on the presence of white noise was expected at place 2. Place 3 is not the worst case for the signal because of its symmetric form.

The highest degradation obtained in the presence of white noise was obtained using a carrier 20 kHz from the notch for critical points A, B and C.

The highest degradation for point D was obtained with the carrier in place 1 because the carrier in place 3 does not see a notch.

The degradation obtained by the group delay distortion was minimum in the presence of white noise. Simulations were done with filters with amplitude and delay response and with amplitude response only for the critical points of network G. Both simulations showed the same results.

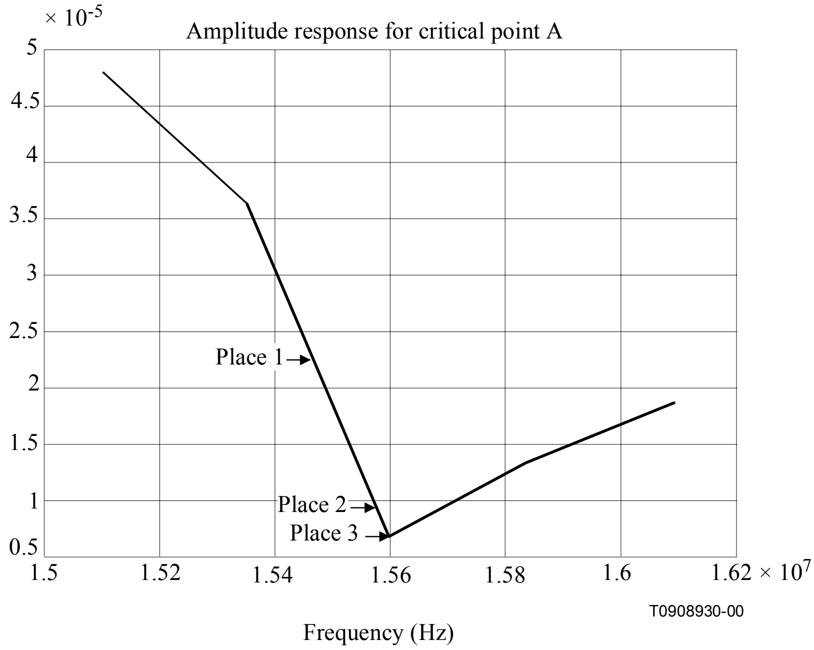

Figure II.2/J.118 – Critical point A of network G. Amplitude response vs. frequency

Figure II.3 shows the degradations of the E_b/N_o ratio of the GMSK signal in the presence of white noise due to the distortion of the amplitude response in the transfer function of the coaxial channel for the 4 critical points of network G.

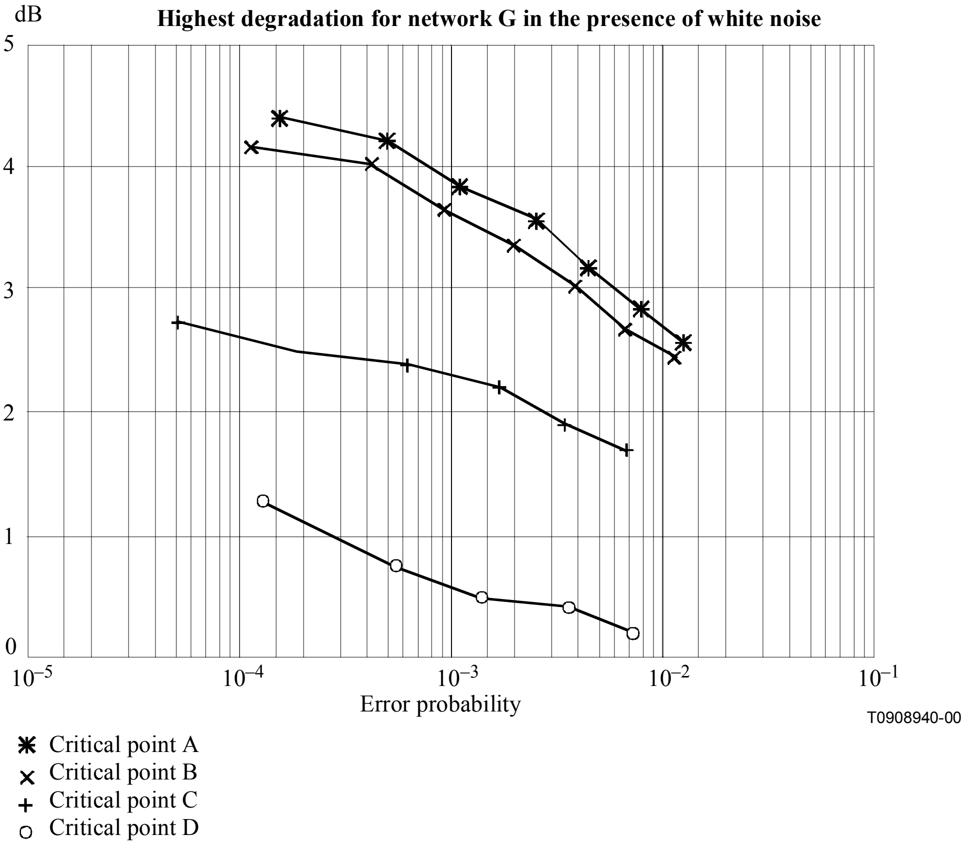

Figure II.3/J.118 – Highest degradation in the presence of white noise due to the coaxial channel

II.5 Conclusions

The results of the simulations show the minimum value of degradation of the E_b/N_o ratio for the GMSK signal in the presence of white noise for the worst and atypical case if a SMATV network has not been properly built up (high mismatching among components, splitters, tap-offs, outlets, and/or it is not properly terminated).

As an example, if the receiver for network G (worst case and network up to 80 users) works with error probabilities near but less than 0.05, there will be at least 2 dB of degradation for GMSK carriers around 15.59 and 21.53 MHz if the neighbour 's outlet is not correctly terminated with 75 Ω (0.05 is the limited value for the Reed-Solomon coding to correct errors). This degradation value should be considered as part of the noise sensibility of the receivers if the SMATV networks are not properly built up or terminated and the GSMK carrier to be used will be around the frequencies with high attenuation variation.

On the other hand, if the communication system for network G works with error probabilities much less than 0.05, there will be also degradations at frequencies 27.47 and 33.29 MHz.

However if the SMATV network is correctly terminated on the outlet on the same floor it will prevent the degradation in the network.

Networks A, B, C, D, E, F and H do not seriously impact the GMSK signal.

Particularly, for networks with up to 40 users the behaviour is quite good, and the GMSK signal is not seriously degraded. Also, the attenuation is always less than 40 dB. For networks up to 80 users the maximun attenuation will be 52 dB (worst atypical case). Consequently, a feature to be taken into account in the implementation of the receivers is the dynamic margin to be considered with an amplitude attenuation from 20 dB to 52 dB (worst case atypical situation) depending also on the type of SMATV network.

Finally, the manufacturers of receivers should take into account in some cases the possible although atypical worst case degradation and the dynamic margin.

II.6 Bibliography

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