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

Switched digital video over cable networks

Requirement for in-band full-duplex in a HFC based network

Recommendation ITU-T J.1109

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Summary

Recommendation ITU-T J.1109 describes the high level general and system requirements for in-band full-duplex in a hybrid fibre coaxial (HFC) based network.

Keywords such as ultra-high-resolution content delivery, end-to-end access service proliferation, high-speed transmission and broadband transmission are becoming the basic requirements for network providers who are responsible for data transmission and reception.

In particular, as various IoT services, personal media and cloud-based services gradually become common, there is a demand for high data rate for subscribers.

Cable networks are also undergoing various network evolution processes to develop and apply technologies that satisfy the requirements of the service ecosystem.

Currently, cable broadcasting networks have limited upstream frequency bands that can transmit data.

In order to overcome these limitations and enable symmetric upstream and downstream transmission, in-band full-duplex (IFDX) transmission technology that enables simultaneous transmission and reception in the same band is being developed.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T J.1109	2019-01-13	9	11.1002/1000/13839

Keywords

IFDX, in-band full-duplex.

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Requirement for in-band full-duplex in a HFC based network

1 Scope

This Recommendation describes the high level general and system requirements for in-band full-duplex in a HFC based network. The purpose of an in-band full duplex in a hybrid fibre coaxial (HFC) based network is to develop simultaneous transmission and reception in the same band using HFC based cable TV network.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CM	Cable Modem
CMTS	Cable Modem Termination System
DS	Down Stream
FDD	Frequency Division Duplex
HFC	Hybrid Fibre Coaxial
IFDX	In-band Full Duplex
RF	Radio Frequency
SO	Service Operator
STB	Set-Top Box
US	Up Stream

5 Conventions

In this Recommendation:

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

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The keywords "**can optionally**" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

In the body of this document and its annexes, the words *shall*, *shall not*, *should*, and *may* sometimes appear, in which case they are to be interpreted, respectively, as *is required to*, *is prohibited from*, *is recommended*, and *can optionally*. The appearance of such phrases or keywords in an appendix or in material explicitly marked as *informative* are to be interpreted as having no normative intent.

6 Overview

In-band full duplex (IFDX) transmission technology is proposed to accommodate the increasing subscribers' upstream traffic over the cable broadcasting networks. IFDX allows simultaneous allocation of downstream and upstream channels over the usable frequency band (5 MHz to 1 GHz), which can allocate the additional bandwidth to the upstream transmission channel while maintaining the available bandwidth for the downstream transmission channel.

In addition, it is possible to improve the frequency utilization efficiency using IFDX transmission technology compared to the conventional transmission technologies.

For applying IFDX technology to the existing cable broadcasting network, the following factors should be considered; the backward compatibility, performance, scalability and device complexity.

In order for an IFDX device to be backward compatible with an existing cable broadcast network device, it should not affect the operation of the devices that are already in use in the same network.

Frequency band in the cable broadcasting network for providing IFDX technology may be divided into two types of the shared spectrum or dedicated spectrum section.

The section of the shared spectrum means a band in which downstream and upstream transmission are simultaneously performed and the dedicated spectrum means a band allocated only for downstream or upstream transmission.

In the section of the shared spectrum, an upstream signal transmitted from a specific IFDX device may give rise to interference with a downstream signal received by other adjacent devices and a scheme capable of eliminating such an influence is needed in the IFDX devices.

At present, the cable broadcasting network can support up to 10 Gbps downstream transmission, so it has to support up to 10 Gbps to provide symmetric service for the upstream transmission.

The effect of the IFDX technology should be closely considered for existing subscribers.

As the demand for transmission capacity grows on the network, the solution provided must be able to scale efficiently to accommodate the size of the subscribers and the service requirements, while at the same time maintaining backwards compatibility.

Management of device complexity is also important to manage the cost of device deployment. In a cable broadcasting network, the cable modem termination system (CMTS) is a common resource

shared by many users, so it is desirable to provide CMTS with additional functionality to minimize cable modem (CM) complexity.

Figure 1 and Figure 2 show the transmission scheme used in an existing cable network and IFDX transmission scheme that will be used in a cable network. The frequency band is divided into the upstream band and the downstream band by the FDD.

Figure 1 shows the transmission scheme used in an existing cable network. The frequency band is divided into the upstream band and the downstream band by the frequency division duplex (FDD). Figure 1 includes four bands as follows; upstream data band, downstream data band, analogue broadcasting band and digital broadcasting band. It is possible to use up to 6.4 MHz a channel in the upstream data band.

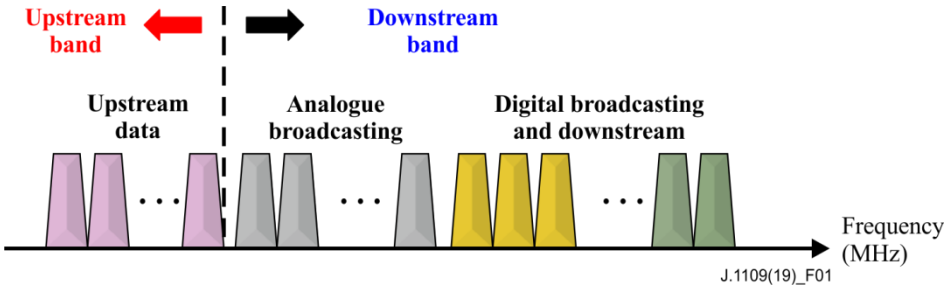

Figure 1 – Example of the transmission scheme in current cable TV network

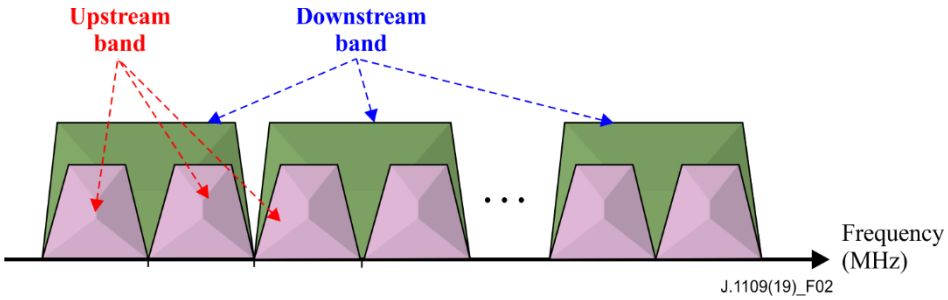

Figure 2 – Example of the IFDX transmission scheme in a shared spectrum range

Figure 2 shows the IFDX transmission scheme that will be used in a cable network. In the shared spectrum range, the frequency band is not divided into the upstream transmission band and the downstream transmission band and is used at the same time. The upstream signaling channel uses up to 96 MHz and the downstream signaling channel uses up to 192 MHz wideband signal.

7 Requirements

7.1 General requirements

IFDX-GenReq-01: The IFDX transmission system is required to support multi-Gigabit bidirectional data transmission using existing cable broadcasting network.

IFDX-GenReq-02: The IFDX transmission system is recommended to adopt new transmission technologies in existing cable network without additional installation of network equipment and replacement of operating system.

IFDX-GenReq-03: The IFDX transmission system is required to support upstream data transmission capability similar to downstream data transmission capability.

IFDX-GenReq-04: The IFDX transmission system is required to maximize the utilization efficiency of the using frequency resources in the cable broadcasting network.

IFDX-GenReq-05: The IFDX transmission system is required to cause no degradation of existing service quality in the cable broadcasting network.

7.2 System requirements

IFDX-SYSReq-01: The IFDX transmission system is required to transmit and receive upstream and downstream signals in two directions simultaneously within the same shared frequency band.

IFDX-SYSReq-02: The IFDX transmission system is required to sufficiently remove the self-interference that is arisen from the downstream signal transmitting over the same frequency band when the headend receives the upstream signal.

IFDX-SYSReq-03: The IFDX transmission system is required to make terminal (i.e., cable modem) groups with radio frequency (RF) isolation from each other.

IFDX-SYSReq-04: The IFDX transmission system is required to transmit and receive upstream and downstream signals using different frequency bands within a terminal group.

IFDX-SYSReq-05: The IFDX transmission system is required to cross-allocate upstream and downstream bands for each terminal group.

IFDX-SYSReq-06: The IFDX transmission system is required to operate in a coaxial network without amplifiers (i.e., fibre deep, N+0 network) in order for simultaneous transmission of the upstream and downstream signals within the same shared frequency band.

IFDX-SYSReq-07: The IFDX transmission system is required to able to transmit and receive upstream and downstream signals up to 300 metres in a coaxial network without amplifiers.

Appendix I

(This appendix does not form an integral part of this Recommendation.)

This appendix describes an example of allocating frequency bands for upstream and downstream to each of CM groups in the IFDX technology.

The appendix is intended to solve the situation where strong interference is observed. It provides one solution using cross allocation.

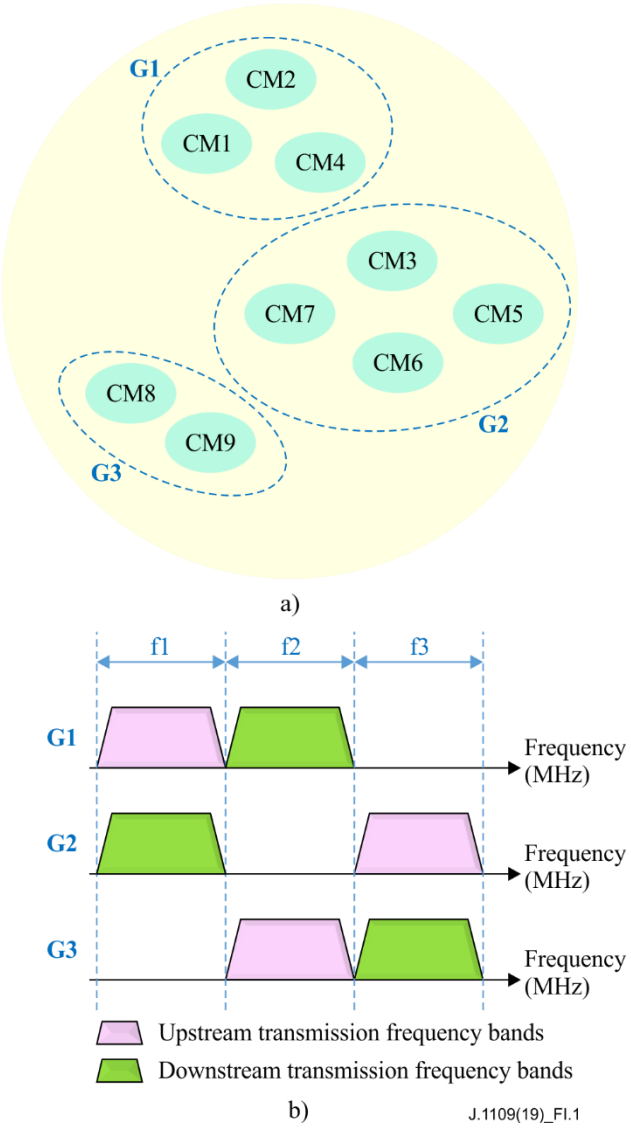

Figure I.1 – Example of cross-allocating upstream and downstream frequency bands

Figure I.1 shows an example of cross-allocating upstream and downstream frequency bands for IFDX technology.

Figure I.1(a) shows the example of grouping of the CMs, there are three RF isolated CM transmission groups (G1, G2 and G3). CMs of each transmission group use the same upstream and downstream frequency band.

Figure I.1(b) shows an example of the allocation of frequency bands to CM transmission groups. Transmission groups use different upstream and downstream frequency bands respectively as shown in Figure I.1(b).

CMs of G1 transmission group use upstream band in a frequency band f1 and CMs of G2 transmission group use downstream band in a frequency band f1.

CMs of G1 transmission group use downstream band in a frequency band f2 and CMs of G3 transmission group use upstream band in a frequency band f2.

CMs of G2 transmission group use upstream band in a frequency band f3 and CMs of G3 transmission group use downstream band in a frequency band f3.

Therefore, IFDX technology can simultaneously transmit the upstream and the downstream signal in the same frequency band.

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