The INCA™ Technology

Improving Robustness and Bandwidth Utilization of CATV Upstream Channel in DOCSIS-Compliant Systems

Introduction

INCA™ (INcreased CApacity, INgress CAncellation) is Libit's novel DOCSIS-compliant physical layer technology for improved communications over the CATV upstream channel. The INCA technology significantly enhances performance by enabling highly robust operation and high data rates in the upstream link from the user's home to the head-end.

Upstream Noise and Capacity Constraints

Cable operators are encountering severe impairments in the return path of HFC (hybrid fiber-coaxial) cable networks that seriously limit the ability of operators to provide reliable data transmission to a large number of users.

The frequency band used for upstream communications (5-42 MHz) is subject to severe ingress noise, impulse noise, common path distortion noise, and burst noise; these impairments are caused by HF signals, electrical appliances, electricity lines, harmonic distortions in the cable, and other sources. The noise level at the head-end receiver is proportional to the number of connected homes, whether or not they have cable modems installed. The initial low penetration of cable modems among cable TV subscribers has lead cable operators to group a large number of homes together, and connect them to a single head-end receiver. This practice intensifies hostile conditions in the upstream channel.

In addition to suffering from severe noise impairments, the upstream channel is characterized by limited bandwidth. The cable plant is asymmetrical: the upstream channel has less than 40 MHz bandwidth, while the downstream channel has up to 800 MHz bandwidth. With the increased penetration of symmetrical services requiring high two-way capacity – such as IP telephony and video conferencing – cable operators are running into serious capacity constraints in the upstream path. Splitting groups of homes into smaller clusters sharing a single head-end receiver leads to a reduction in the level of noise, and increases the capacity available to each subscriber. However, as such a process is very costly, cable operators are interested in implementing this approach as efficiently as possible.

The INCA Solution

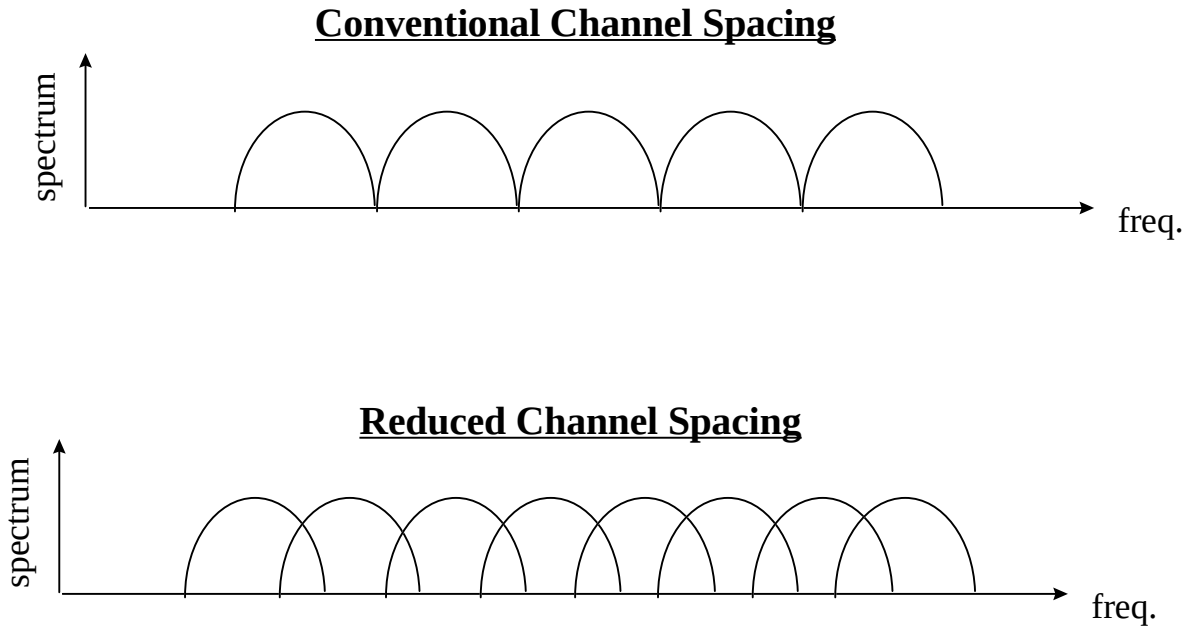
The INCA technology addresses both the short and long-term needs of cable operators. INCA enables increased upstream capacity and enhanced reliability of data transmission in the hostile upstream channel.

Bandwidth Efficiency

The INCA technology enables a significant increase in bandwidth efficiency by allowing a reduction in channel spacing between adjacent signals without degradation in performance. INCA algorithms are capable of canceling strong inter-channel interference resulting from reduced channel spacing. By reducing channel spacing and using an INCA-enabled receiver, the number of channels can be increased by as much as 50%, depending on channel conditions. Operators can then offer services requiring high data rates in the upstream channel, such as IP telephony, leading to increased revenues.

Figure 1 depicts the spectrum of the upstream frequency band with conventional channel spacing, and with reduced channel spacing that can be tolerated by a head-end receiver implementing INCA's cancellation techniques.

Figure 1: INCA – Increased Capacity



Robust Operations

INCA algorithms are designed to operate in channels with extremely strong narrowband ingress and impulse noise conditions, the most prominent impairments in the upstream channel. The INCA-enabled receiver is capable of tolerating ingress and impulse noise conditions that are 10-100 times worse than those handled by the algorithms of existing receivers. The INCA receiver can operate reliably in channels with tens of thousands of impulses per second, and in channels in which the ingress noise is stronger than the signal. Improved robustness enables operators to accelerate deployment and reduce cable plant clean-up costs.

Cost-Effective Deployment

The INCA technology comprises a set of proprietary algorithms that are implemented at the head-end receiver side only, with no modifications required to cable modems at the subscriber side. As a result, cable operators can deploy INCA without affecting the installed base of subscriber-side equipment. Implementing INCA only has a marginal effect on the cost of silicon at the head-end side, constituting only a small fraction of operators' overall investment in the cable plant and cable modems. This a major advantage of INCA over other proposed technologies for the upstream channel which require major modifications at the subscriber side. Moreover, as INCA does not require any changes to cable modems, operators will continue to benefit from the continuous improvement, integration and cost-reduction of DOCSIS-compliant cable modems.

Depending on the state of the cable plant and the number of subscribers, operators can choose between optimizing their networks for improved robustness or increased capacity. As cable plants are upgraded and noise impairments are reduced, operators can place greater emphasis on increasing upstream bandwidth. This capability allows operators to adapt upstream communications to changing conditions over the various life-cycle phases of network deployment and expansion.

Field-Tested Technology

The INCA technology has been verified on signals recorded in the field on both HFC (hybrid fiber-coaxial) and all-coaxial plants – over both aerial and underground wiring – in the US, Europe and Japan. Tests were also conducted in the challenging frequency band of 5-15 MHz. Verification tools included simulation and a hardware prototype. INCA has been tested on a simulated CATV communication system comprising an INCA receiver and DOCSIS-compliant transmitters. The receiver was tested in tough channel scenarios including AWGN, ingress noise, impulse and burst noise, reflections and group delay, and AM hum. Both simulation results and tests on real signals indicate that INCA provides better performance than other proposed technologies for the upstream channel in terms of spectral efficiency and highly robust operations.

Next-Generation DOCSIS

The INCA technology can be further utilized to improve robustness and bandwidth utilization of systems based on the emerging DOCSIS 1.2 standard that will include high-order constellations such as 32-QAM and 64-QAM, trellis-coded modulation, and additional state-of-the-art communication tools.

Summary

INCA is a powerful technology that enables improved performance of DOCSIS 1.0 and 1.1 CATV systems, without requiring costly changes to cable modems at the subscriber side. By increasing upstream capacity and enhancing robustness, INCA enables cable operators to cost-effectively introduce two-way services and significantly expand revenues.

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