

Federal University of Uberlandia
Faculty of Electrical Engineering



**A CONSTRAINT-BASED MODEL TO SUPPORT
ELECTRONIC TV NETWORK DESIGN**

GERSON FLAVIO MENDES DE LIMA

2008

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By

Gerson Flavio Mendes de Lima

Submitted in accordance with the requirements for the degree of
Master of Science



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The Writer confirms that the work submitted is his own and the appropriate credit has been given where reference has been made to the work of others.

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Dados Internacionais de Catalogação na Publicação (CIP)

- L732c Lima, Gerson Flávio Mendes de, 1969-
 A constraint-based model to support electronic TV network design /
 Gerson Flávio Mendes de Lima. - 2008.
- 118 f. : il.
- Orientador: Edgard Afonso Lamounier Jr.
Dissertação (mestrado) – Universidade Federal de Uberlândia
Progra-
ma de Pós-Graduação em Engenharia Elétrica.
- Inclui bibliografia.
1. Televisão - Teses. 2. Engenharia auxiliada por computador - Teses. I.
Lamounier Júnior, Edgard, 1964- II. Universidade Federal de Uberlân-
dia. Programa de Pós-Graduação em Engenharia Elétrica. III. Título.

CDU: 621.397

UNIVERSIDADE FEDERAL DE UBERLÂNDIA
FACULDADE DE ENGENHARIA ELÉTRICA
PÓS GRADUAÇÃO EM ENGENHARIA ELÉTRICA



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ELECTRONIC TV NETWORK DESIGN**

Dissertação apresentada ao Curso de Pós Graduação em Engenharia Elétrica da Universidade Federal de Uberlândia, perante a Banca de examinadores abaixo, como exigência parcial para a obtenção do título de Mestre em Ciências.

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Abstract

Electronic Television Network Design is well established when electronic physics concepts and computer techniques joint through mathematical equations and geometrics concepts, to represent real effects. Even though, the two fields have significant different concepts. This research has as objective to propose one approach constraint-based data model, to support an interactive design interface. In order to provide faster and future improvements of Innovation and evolution network in time and frequency domain (Model).

Considering planning to transport RF modulation, signal types, protocols, and higher frequencies, is always very complex. The intuitive graphics drawings, representing a constraint-based data model (in background), can represent different alternatives for engineer design. Funded, in simplicity and useful screen that represent contextual symbols organized in groups, the techniques presented in this dissertation intend to solve duties imposed for graphics and equations constraints, resulting valued features to CAD/CAE software innovation. The computer technology method based in constraints satisfaction supports faster decision by engineers. A proposed constraint satisfaction data model, brings a differentiated contribution to understand abstract representation of information visualization. The set of Electronic Cable Network symbols are represented as a constraint-based graph connection that highlights the degrees of freedom of the whole designed system. The capability to work with an interaction with these different worlds, simplifies a visual grouping of abstracts and physical characteristics that permit to structure and interpret a visual field in certain way. In Front of Next Generation Networks (NGN) challenges.

In Special thanks
To

My mother; Terezinha
My father (in memoriam):
Prof. Dr. Gerson Mendes de Lima Junior
To my Wife, Janaina
To my son, Joao Henrique

Acknowledgments

One day, a long time ago, I was unhappy facing some challenges of life and not sure to continue with this work. Then, I heard from one “friend” some words to push me forward, he told-me: “Gerson, your evolution is some think that’s not a compromise between you and any other. This is an agreement with you and yourself, just”! No more one can charge for this decision, them you, or your own mind! This friend was not just a colleague, but much more than, he is my supervisor and Mentor, Prof. Edgard Afonso Lamounier Junior. His support and simplest helpfully act front any of my fears, turned the place, were I could find a little bit of my self acknowledge and the motivation to always go ahead and finish this work. I would like to specially thanks to my friend, Ignacio Angel Ocampo, the main Engineer from Argentina’s Country, that gave-me an opportunity to learn all that I know about CABLE TV and introduce this technology and practices in Brazil specially Minas Gerais, working and providing Design and Engineering Services, CAD and Digital Maps, for: CABO TOTAL Company. In the same grade, my Special Thanks to Engineer: David Pedro Junior, to be my Tutor since my under graduation in Electrical Engineer academics practices life, until the present always advice-me using a special respect and stay present in many hard moments of my life and Works. My specially thankful, for all contribution of Federal University of Uberlandia; Prof. Dr. Alexandre Cardoso, and his contagious happiness; to Prof. Adelio Jose de Moraes for high level professional deference, in similarity to Prof. Dr. Jose Carlos de Oliveira followed for nobody less important and a Really Technology “Lover” Prof. Dr. Alcimar. My respects to Prof. Dr. Arquimedes Lopes Silva, first to allowed me to use his work referenced, and always strongly synergy, spontaneous actions to help-me with his simplicity and great experience, adding value to my work. To My Dad (“In Memoriam”) for my younger stimulation to search and learn new acknowledgements in many challenges of life, and always continue to looking for improve skills for innovations until achieving highest priorities. Specially grateful to my Mother and her “infinity energy” always ready to protect and give trust in myself efforts, against the obstacles, and never desist!

The Publication Relation List about this Work:

1. Lima, Gerson F.M. , Lamounier,E., Creating FDO (Feature Data Objects) and Oracle Structure for Enterprise Telecom Solutions (Constraint-based Design) application, *15th Annual Autodesk University –on - Civil Engineering and Geospatial - GS32-1L* The Venetian Resort Hotel Las Vegas, U.S.A. November 27 – 30, 2006 .
2. Lima, Gerson.F.M., Automação de Projetos Eletricos – Software para Desenho e Dimensionamento de Instalações, IV- Encontro Nacional de Instalações Eletricas, Eletricidade Moderna, Aranda Editora, pp. Colectânea dos Trabalhos Apresentados - Vol I, Sala Amarela, Outubro 1995, ISSN 0100-2104, São Paulo – SP.
3. Lima, Gerson F. Mendes, Keiji Yamanaka, Anderson Valadao, “Using Metaheuristics to Improve Quality on Geospatial Data Transformations (Variable Neighborhood Search, and Hybrid Constraint Satisfaction)- CONAREC-may 14-17, 2007 - CALGARY TELUS CONVENTION CENTRE CALGARY, ALBERTA , Canada, Authentication – 20064.

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Chapter 1

Introduction

1.1 Motivation

Effectively, ability to create a better solution for Engineering Design Process, is a key skill that a professional needs to work well, in conjunction with software tools, provided by an easy to adopt conditions to maintain the technical focus and execute the priorities that match the greatest value of the engineering process. However, these tools must improve the work schedule; it should contribute for what it does in designer mind vision. Providing, inspiration and engagement to permit the creation thinking in innovations solutions that really matter, for improving value to design, and not just features for user interface (UI). It is critical to concept a support decision tool by engineers, which simplifies methods that have proof concept value. Expand the CAD/CAE usage over the largest industry of telecommunication, like the Broadband Television Systems to support a real convergence, common called of Multiservice or multimedia, based in Mesh or coupled Networks is a challenge. The purpose of this work is to develop a concept methodology based **on use a constraint-based model**, [51,58], adding a contribution value for **Electronic Networks TV Broadband Design**, establishing, a new model database topology for HFC (Hybrid Fiber-Coaxial), and CATV coupled networks, looking for the highest efficacy of integration, and operation possibility, in real time applications and large solutions [13]. Considering to increase the Software classification to an Engineer System, placing in to highlight the **constrained-based space** for Electronic TV Engineer area.

1.2 Objective and Research Goals

The objective of this dissertation is to investigate computer-based techniques that allow the presentation and manipulation of engineering and geometric

constraints to support electronic network HFC topology, using its interactive parameters, in the frequency/time domain. Besides, it aims to bring to reality the possibility to explore (simulate) different scenarios, emerged in a constrained-based virtual space, that has contemplate physical relevant parameters, but also allow simulation cases during design time (interactivity). To accomplish this goal it is important to satisfy the equations and geometrics constraints emerged from a based model in Signal Modulation frequency or/and time domain. Finally, it is proposed to develop a software application CAD/CAE using constraint based design schematics for buildings backbones. The goals to advice such objectives are:

- To perform an Introduction Outlook of the actual reality of Telecommunications Cable Electronic TV and Broadband latest technology used in World (CTIA 2007/2008) and highly level for visualization, organization to useful approaches grouping objects symbols recognition, and depth perception visualization engineer design.
- To propose a data model released in accordance to classical classifying methods for constraint-based approaches, using the development of incremental graph-based techniques for satisfying a coupled set of electronic engineering and geometric constraints network.
- To demonstrate results based on constraint-based design [51], application for an Electronic mesh CATV network.
- To Analyze these algorithms and implement a prototype-based system in Object Oriented Language (Visual C++) including the use for a Software Engineering design process, documentation to fit this work in formal Computer Science Language, and looking to future evolutions.

1.3 - Electronic TV Network Design

Since 1950, television systems were, launched in United States of America and used to distribute video signal by many fields. Specially in small villages

and farms, using cables, wires, and any type of element that could provide some RF diffusion to promote the view of this valued moving images. The popularity was growing over the time, when the nickname: “CATV” – Cable Television, or Cable TV. Emerged, several companies [3], including state broadcaster, started rebroadcast the UK's (then) three terrestrial TV channels in some cities and larger towns. Early cable television operated in an unregulated gray market, [4] with providers laying cables wherever possible from their signal collection point, often the local electrical store. The system was eventually regulate by the Wireless Telegraphy (Wired Broadcast Relay License) Regulations of 1974 in to an exclusive franchise system, where one company holds a franchise to provider analogue cable television and radio services to a specific area. Franchisers under this system referred to as having "1974 licenses".

Effectively CATV systems, those owned commercially, in general began adding services in the early 1980s as English - language services started to appear on satellite, and with most new houses cabled from construction by the late 1980s [5]. It has become the most common multi-channel television reception system, beating satellite television and long-distance UHF reception of foreign channels in to second and third places.

Beyond premium services, set top boxes are, only provided if the customer's television is unable. To handle VHF signals, as some imported from the UK (which has no VHF television and generally encrypted cable television may). There is no set frequency plan, and the one cable firm may use a mix of European and Irish channel alignments. The physical networks are usually, for analogue standard coaxial cables boosted and tapped at regular intervals, which can lead to serious signal degradation problems, particularly on overhead networks. Digital networks have far more sophisticated trucking systems [6], [7].

Due to the patchwork nature in each the network, each node is usually supplied with the UK terrestrial channels by microwave wireless links (3.5 GHz average) from a central site (usually receiving off-air from Northern Ireland, or Wales in parts of the east coast). They collect the Irish terrestrial channels off-air, and any other channels by satellite; although network

modernization has seen the eventual construction of a backbone network linking main nodes [10].

Overhead cables are common in areas constructed before the foundation of the local cable firm, or where the cable firm did not have a construction agreement with builder companies; Underground cables are more common in developments build post-1985 [9],[11].

Early, cable television has operated in an unregulated gray market, with providers laying cables wherever possible from their signal collection points, often the local electrical store. The system was eventually regulated by the Wireless and (Wired Broadcast Relay License), Network Regulations where one company holds a franchise to provider analogue and recently cable television and radio services to a specific area [12]. Franchisers under this system are referred to as having "1974 licenses".

Cable television hailed as ushering in a new era of programming choice, and broadcast alternatives. Yet, until just recently cable's reality lagged behind the promise of the concept, plagued by complaints of lousy customer service, hard-to justify rate increases, and a failure to live up to technological expectations. In the past [13], few years, with formidable challenges from alternative PAY-TV sources, not to mention technological revolutions imposed from outside, that cable has made a concentrated effort to become organized. The cable companies' physical plant needs to upgrade theirs technology and this are particularly affecting for cable TV. The cost advances such as digital ad insertion technology [17], the growth of interconnected markets, and better billing and traffic control software's and protocols have made cable more appealing to advertisers and investments by the company's owners. As suggested earlier, the NII (National Information Infrastructure - EUA) [1], [2], mentioned in terms of several metaphors. The Only way to follow was a discussion to elaborate on alternative interpretations of the NII concept [20]. The key principle of the NII initiative is the provision of Universal Access. In a global economy that is increasingly information intensive [7], almost everyone agrees that an advanced information infrastructure is the key to economic growth and value creation (Egan, 1994) [8]. U.S. economy is increasingly dependent upon the capture, manipulation,

transmission and consumption of information. The ongoing information revolution expects to influence every facet of American life, be it work or leisure [38].

Companies in all industries are using information technology to re-engineer themselves and to become globally competitive. Businesses are gearing up to be a part of today's global information economy and tomorrow's world knowledge economy. In fact, many of the cable issues in question date back several decades [13]. After the cable companies spent many years and billions of dollars setting up their services, the FCC has begun pushing for the implementation of digital cable-ready TVs that would do away with the industry's traditional use of set-top boxes - a move that could make it harder for the cable companies to continue to innovate [16]. The result is a battle between those who favor protections for the original cable companies and those who believe new competitors should be assisting, in the name of increased competition and better customer service.

According to [24]: "The Internet is different from the other communication technologies that have caused great social upheaval: telegraph and telephone, radio and television. The telephone company offers a variety of telephone-related services to its customers - The essential difference is that the telephone company defines telephone service and the network defines the TV content. In contrast, the NII would be participative in nature - where "every client is a server." It treats its users not as consumers of a product or service, but as contributions, as colleagues.

One interpretation of the NII as a "convergence of technologies and of cultures" depicts it as an "electronic market" and an "electronic town hall" [32]: "The National Information Infrastructure ("NII") - today represented by the universally accessible telephone system, broadcast and cable television, libraries, bookstores, remotely accessible databases, and the Internet, and ultimately supplemented by broadband switched networks with digital connections to homes and public facilities -- can be an electronic market for information, and an electronic town hall."

The endorsement of equal access implies that a broader reach would benefit everyone, but policy-makers need to pay attention to the facts about poverty

and communications in the US today. Poor households are already spending too much on basic communication services, such as long-distance phone calls. Choosing fiber optics as the primary technology for building the superhighway will be very expensive, for both middle and lower classes. The poor may be already taking in more bandwidth than the rich may, but it is in the form of low-grade information via television, rather than the high-grade information available on Internet (Huber, 1994) [14].

The concept of universal access is ill defined for operative at the grass-roots level. For instance, the primary problem is not if there are enough computers to go around, but what they are used for (Hancock et al., 1995) [11].

Second, George Heilmeier president of Bellcore (1996), this trade-off is likely to be complicated by the need for simultaneous competition and cooperation among the many firms that will invest in the NII..." [31]. The future of electronic communication in the spheres of education, business, industry and government will hardly be same as that in the past.

1.4- Hybrid Fiber Coaxial Networks - HFC

The residential Cable TV broadband service, represent one of the major interest areas for actual telecommunications market and will continue grows for the next years. The advents of interactive services, telephony (Voip), Internet, Games on Line, Pay per View, increase and incentive for more broadband capacities and Quality of Services.

The large demand for speed, request for better quality of service in distribution signal, since analogical TV, to interactive digital contents providing services to new subscribers possibility;

And The bi-directional signal can be a two-way (full duplex) communication and multimedia turn the reality of Hybrid concept more efficient to interactive networks and expansible these architectures for Telecommunications services has been adopted to data transmission (High Speed Internet, home shopping, home-backing, video conferencing, home-working, interactive games), VoD (Video on Demand) and Telephony.

The possibilities of integration of Cable TV networks with wireless (personal

communications system) make faster and urgent the investment to improve a better infrastructure to possibility provide a backhaul for the uncountable number of Station Radio Base for Cellular (Erbs) or also called BSC's (Base Service Connections). In Figure1.1, the length limits is a barrier to make services upgrades in TV Networks, so it's necessary to mix newer long distance capabilities to allow the transmission in faster and longest scales, and in the same time have possibility to increase the taxes telecommunication rates without lose quality and have a lowest costs for these upgrade specification.

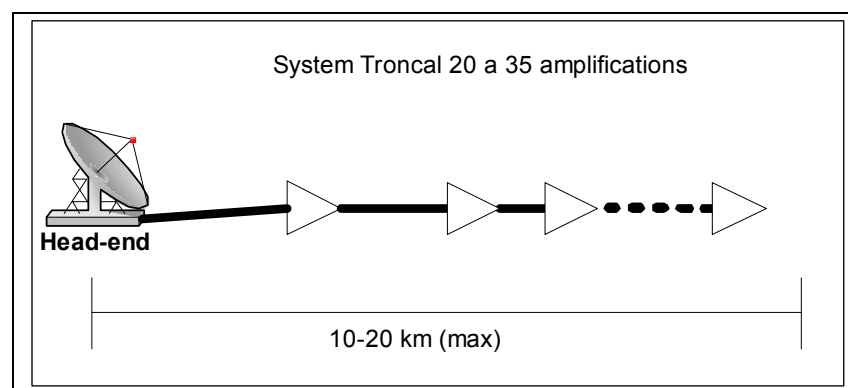


Figure1.1 - Traditional Tree and Branch

The new generation networks (NGN) are converging to an integrated system that represents complete CORE IP services. This system is a mix of Analogical and Digital Optical technologies, becoming a complete infrastructure of telecommunications to provide multimedia services over broadband in a large and interactive amount for the final mile or the customer "subscriber", called in Cable TV like HP or Home Passing. This measured mesh of infrastructure and technologies in common called like NGN or information superhighways. Inside this integrated services, the HFC can be considerate the high potential and easy to adopt access network for access the large width band rates.

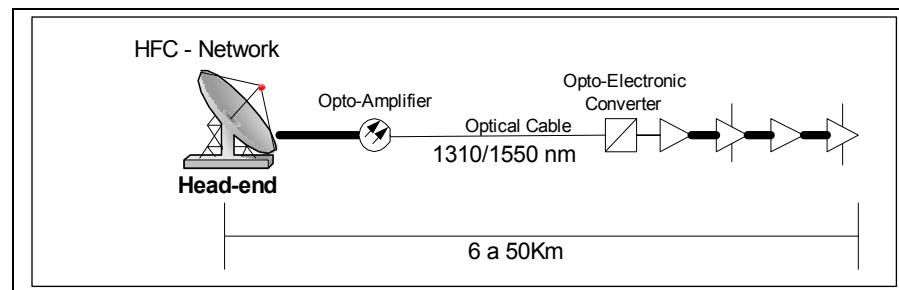


Figure 1.2 - Hybrid Coaxial Fiber Optic Network

As voice over Internet protocol (Voip) and competition from cable operators continues to erode the telephony market, Telecommunication has increasingly forced to build service portfolios outside their traditional sphere of interest. At the same time, core network developments have opened the door to a new world of triple play, offering consumer broadband, telephony, and television services in a single package. We know IPTV is something consumers value and will pay for—in territories in which IPTV services have been deployed, we have seen promising take-up. When you hear stories like that, it is easy to see why IPTV is regard as one of our highest growth segments and why there is not a single tier-1 Telco in the world that does not at least have a strategy for IPTV. [[http://www.iec.org/newsletter/ april07_1/broadband_1.html](http://www.iec.org/newsletter/april07_1/broadband_1.html)- April 2007]

The introduction of asynchronous digital subscriber line 2 (ADSL2), coupled with significant improvements in encoding such as Moving Pictures Experts Group (MPEG-4), advanced video coding (AVC), and virtual channel 1 (VC-1), is making it easier to deliver broadcast-quality content to the home. However, just because you can deliver content via broadband does not mean the consumer will want to watch it. Well-established cable firms already offer triple-play services to their customers, and satellite broadcasters have moved into the broadband and telephony arena. If IPTV is to progress, it must offer the consumer something that differentiates it from its commercial rivals.

In Holland, 90 percent of households that trailed KPN's IPTV service Mine TV have taken out a subscription. At launch, Mine TV offered viewers 48 TV and 60 radio channels—similar to the local cable operator's offering. However, an important part of Mine TV's package was the Film Direct feature, which offered on-demand content from the likes of Warner Bros., International Television

Distribution, and Blockbuster Entertainment. These VoD services have allowed Mine TV to gain a foothold in a cable-dominated market.

Convenience and content availability are the keys to any IPTV and VoD offering. A decade from now we will probably look back in amazement at a time when we rushed home to meet the scheduled start time of a television program. These networks interconnected for optical analogical rings to provide signal transport between hubs, separated for 20 to 50 Km. Hubs for secondary distribution interconnected for these digital optical rings in metropolitan areas using transmission SDH / SONET- interconnected with others public telecommunications infrastructures existents (corporate networks, telephony rings based in SDH, etc). Each one of these hubs cover a determinate region that use the HFC access networks technology, were many nodes cover the average amount of 500HP to 2000HP. The Network web servers, video servers, and data servers, still distributed in different parts to provide capability to the services demand requests for other sections remotes of HFC. This transference of information is base for the transport optical rings. For this integration is essential to use a very good management system to be possible control and supervise this complex network.

Thus, a constraint-based system compilation has been developed to preview the feasibility of these incremental graph algorithms. It must turn possible to help methodology usage, for integrating many different interfaces and protocols in one common and simplified data structure contents, using the key real requirements to provide, for technical people, the information necessary to make a well interconnection between different origin and convergence.

1.5 Electronic Network Design Workflow

Emerging technologies are one reality, and the Network Architecture generally is based on the management forms, also, organizations such as the International Telecommunication Union - Telecommunication Standardization Section (ITU-T), as a Part of their telecommunications management network (TMN) series of recommendations, have defined functional, physical, information and logical layered architectures. This industry has changed

dramatically, enforced by explosive growth of Internet, and progressively the connectivity with mobile technologies and fixed-mobile convergence has led to complex meshed network configurations.

Considering that, most of the Electronic Network Design workflow contemplates symbolic recognition, thematic colors (Lines, Areas, and Network Elements), formulation and many engineering concepts, and for this study proposes, it is considered satisfactions of constraints including management areas. Second Phal and Beitz and Thornton.

The design work can be classified for the following steps Figure 1.3:

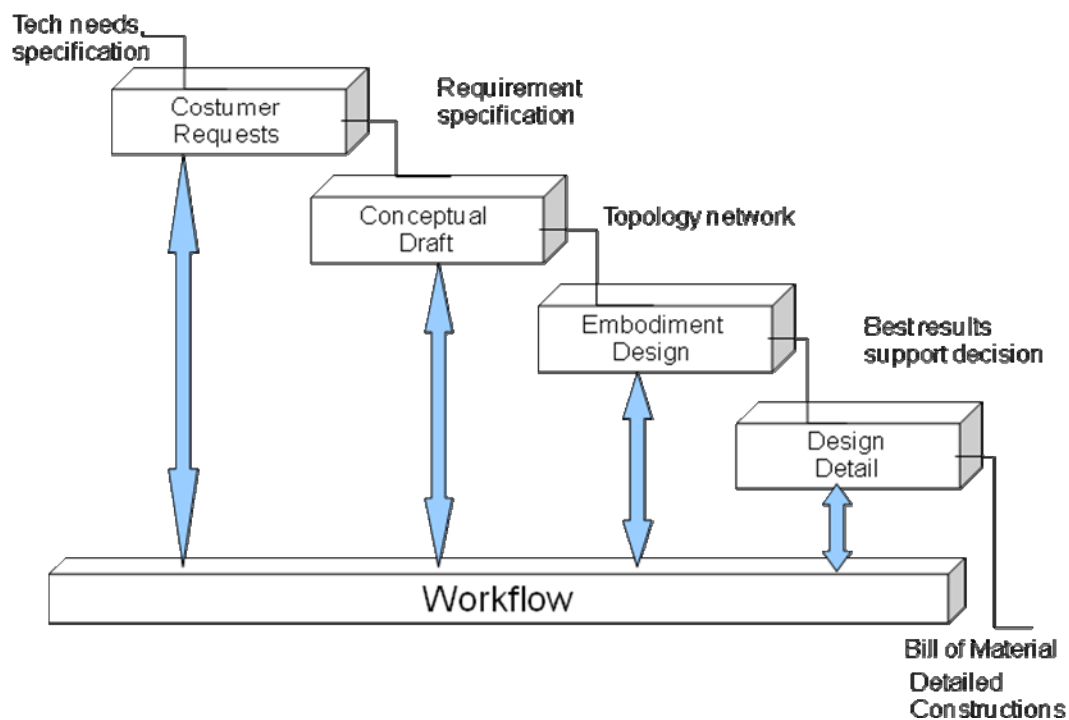


Figure 1.3 - Workflow Steps

1.5.1-Customer Requests (Network Design Requirements)

At this time, it is important to clarify the specification design using for the Service Oriented, in the actual reality conditions to be considered now and in the future, using a planning method based on emerging technologies adoption to increase the actual level used for requirement specifications. In practice is the creation of requirements (i. e. constraints) that describes the general properties and conditions to electronic engineering satisfaction. Bellow in

Figure 1.4, it is presented an overview of actual stage of Electronic Networks architecture, including HFC used for Internet, Telephony and Digital Video.

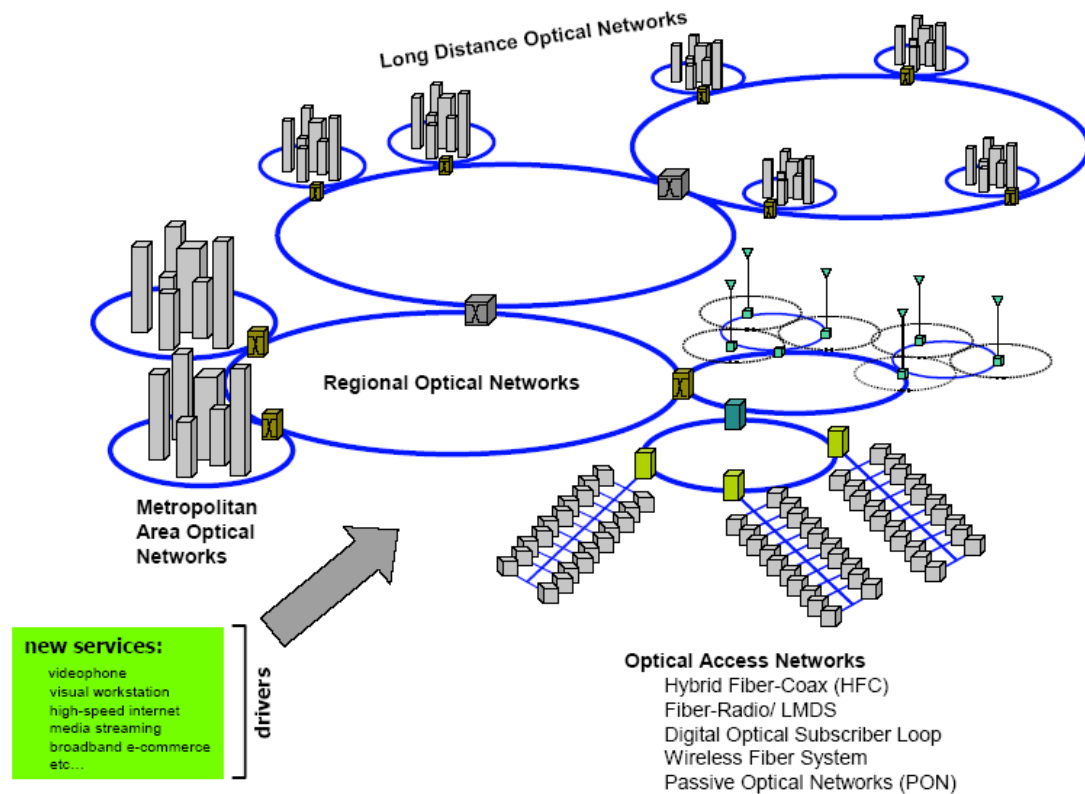


Figure 1.4 – General Outlook Network Architecture

A planning tool is one good way to start the consideration of costs, marketability, performance, assembly, maintenance. Some constraints considerations modeled in Mathematics equations enhance the capability to interaction with these concepts at any Design phase if the design changes the requisites, in order preventing and detecting errors at advanced time line of design workflow.

1.5.2 - Conceptual Draft

This step, is highly affected by anterior process, for bring an inheritance function that determine the complexity and combinations of sub-functions. These separate principles converges in a complete functions structure and

will be connected in further simplifications just possible as a result of the abstract geometry (Draft) , or incomplete geometric information that is subjected to modifications in other time, is common case.

1.5.3 - Embodiment Design

This is a translation from Draft to Design, where the cognition concepts are materialized until a definitive layout, according to technical and economic criteria. According to Pahl and Beitz , the definitive lay-out must be developed to the point where a clear check of function, durability, production, assembly, operation and cost can be carried out.

1.5.4 - Design Detail

The quality for classifying a good design are a list of aesthetic principles to consider when creating or evaluating design is Hierarchy -setting priorities of the most important thing, visually, in main layout most important, most attractive or most convincing part of the message, Emphasis and focus -the visual expression of hierarchy. Use visual emphasis to focus attention through size, position, value, and color. Contrast – big / little, crowded / open, orange / blue is the tool of emphasis, which helps you set that hierarchy, focus attention. Scale the illusion of size of elements relative to one another is important, of course, but the size of things in relation to the format and the size of the format itself are also worth considering. Unity - that which holds the piece together, Color can unify a design, as can a grid, visuals that represent related subjects or a consistent style of imagery. In an age of over-stimulation, unity is often underrated. Design, or draft way to lower cost networks and higher profits. At the detail design, individual geometric elements of the definitive layout are refined with exact dimensions and tolerances and complete geometric shape, to assure that the design can be, constructed, and will work.

1.6 - Electronic Design Constraints

Geometric Constraints and Engineering Constraints specify an Electronic Network Design. The Geometric Constraints relationships are existing relations between two different geometric entities. Engineering Constraints are equations that represent the physics concepts of electronic components (e.g., Amplifier Gain, Cable losses, interferences, noise frequencies filters, etc). Both constraints can be seen as a unique set of equations. [51].

The possibility, for modify some parameters and to propagate it upstream and downstream over an electronic cable network must be consider. These automation is related of algebraic manipulations (Solution of constraint sets) required by the user.

The hybrid constraints concept is the ideal solution as a method to solving the system of equations and geometric constraints. These systems rely on numeric and interactive solve techniques [51]. Graph-based model can decompose the equations into smaller sets in order to achieve a more efficient equation solution work [51].

The concept of constraints hybrid, will allow direct manipulations of under-constrained electronic network parameters. Using the constraint engine algorithms, evolving solution of the constraint set and engineering constraint cycles locally identified and solved. At this part, this research will make, characterization of constraint-based approaches for the Signal modulation and distribution using dynamic Domain considerations.

1.7 Thesis Organization

This work is organized in seven chapters and the introduction, including a brief History of Electronic Cable TV Broadband Networks and their evolution.

Chapter 2 is an Overview about Telecommunications Electronic Network Design technology and the New Generation Network using HFC Concepts; that allow a graph database structure to be implemented using constraint-based graph data model to support the electronic engineer network design.

Chapter 3 is a detailed coupling method used to implement the engineering

and geometrical constraints to support Electronic Network incremental satisfaction of engineering constraints investigates the static time model and approaches for a dynamic states, for time and frequency Domain model.

Chapter 4 is a detailed set of algorithm to, over a graph-based topology, using visual grouping of abstracts and effectively using organized in intuitive visual data. The contents are used to study the modulation basics to support geometric and engineer equations satisfaction exploring the degrees of freedom related of uses, and network topologies data base model in constraints-based concepts. For example HFC – Network

Chapter 5- Is the prototype implementation of software using integration with an API for CAD using Visual C++ and object ARX (AutoCAD Runtime Extension) to create since the symbols standards (draft) Classes, Methods, and members to be able for developed the constraint engine for a complete graph structure database. In the same way use, one graph based in standard symbols, and arcs, considering a graphics usage interface based in high quality level interaction and symbols under rules of Geometrical and engineering constraints models.

Chapter 6-This chapter brings the results of implementation. The User Interface presentation in toolbars commands.

Chapter 7- Presents the conclusion for these work and future possibilities developments.

Chapter 2

Carriers Network Technology & Architecture Outlook

2.1 Introduction

Requests for an information highway running to provide services innovations and improve its utilization over the integration between different telecommunication systems, specially the interconnection of the optical and the RF networks, are the key for evolution and innovation. In Figure 2.1 is presented the schematics of a Telecommunication network, detailing the interconnected layout that compose the complete services oriented provided for the customer, including TV signal in analogical and digital mode and internet services.

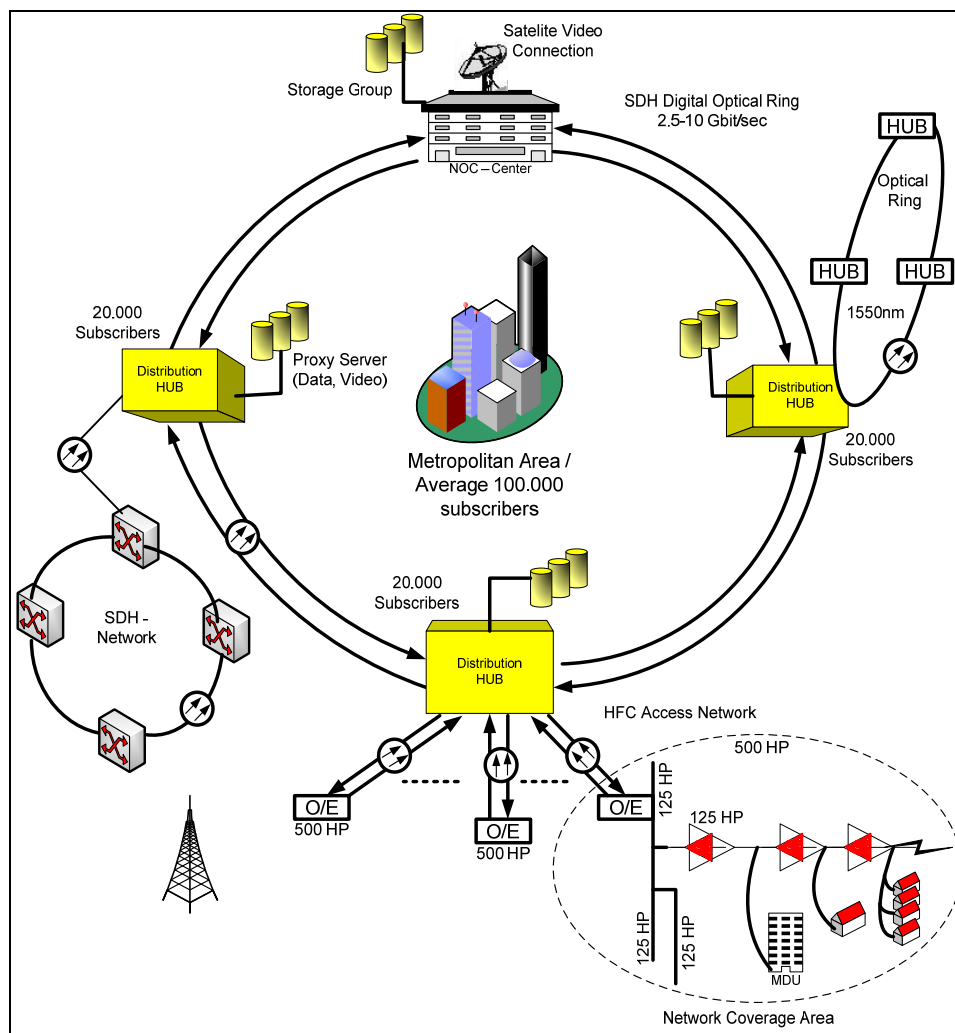


Figure 2.1 - Integrated System - Information Highway

Considering the referred Telecommunications cases, in our application the Graph Structure and the logical method to consider, coupling to be used efficiently cover all concepts inside the rules, in other words, representing the mathematical abstracts the reality of physical laws considering the field.

A well-designed data structure permits many of complexes operations to perform, by algorithm, using as few resources as possible. Therefore, preview in earlier phase the appropriate choice of data structure is indispensable to start a correct dimensioning of: logical, physical and abstracts mathematical parameters that must represent a Virtual Reality in the network.

This insight must be rise for many formal Electronic Multimedia Network design methods and programming languages, such module system, allowing data structures safely reuse in different applications propositions by hiding their verified implementation details behind controlled interfaces.

The object oriented programming languages, uses their purposes in classes applications development, because it is bring accuracy and performance. Depending on networks is becoming either more mature or more disruptive. The fixed mobile convergence (FMC) will integrate mobile phones with PBX, and enable unified communications, including data compression multiplexing providing broadband signal convergence. In this tip, looks at FMC deployment options and equipment are prerequisites of any enterprise network ready for FMC, [61], [62], [63], and [64].

On the large and infinite scientific way, Graph algorithms are a significant field of interest for computer scientists.

In mathematics and computer science, **graph methods** is the mathematical structure used to model pair wise relations between real elements and abstracts relations, like Network Elements or objects from a certain collection. A "graph" in this context refers for a collection 'nodes' and a collection of *edges* that connect pairs of vertices. A graph may be *undirected*, meaning that there is no distinction between the two vertices associated with each edge, or its edges may be *directed* from one vertex to another; (A Coupled concept) [51].

If we are considering pure (mathematics) to study abstract definitions, other variations types of graphs must commonly considered. The graphs studied in computer methods should be differentiate in "graphs of functions" and other kinds of graphs [52], concepts

such as quantity, structure, space, and change, and the academic discipline that studies them. Benjamin Peirce called it "the science that draws necessary conclusions".

Using the graph terminology used in this section, Graphs are generally chosen to represent constraint network because the general domain-independent representation, they allow both qualitative and quantitative operations, and there are a large number of applicable algorithms from the literature.

In Reality; a maturity side technology, IP and Ethernet networking are now well understood and can be intergraded based on use of newer technical changes to the basic infrastructure, has been simplified, since the provider network services. Until the networks deployed with, an emphasis on service delivery performance, optimization and ROI, especially in case of Image frames, interactive video, QoS in higher levels.

Some emphasize the computation of specific results (such as computer graphics), while others relate to properties of computational problems (such as computational complexity theory). Still others focus on the challenges in implementing computations. For example, programming language theory studies approaches to describing computations, while computer programming applies specific programming languages to solve specific computational problems with solutions. A further subfield, human-computer interaction, focuses on the challenges in making programs that really can add value, and not just features, Figure 2.2.

Considering this work, main proposal is provide Advances in Engineering Software and in same level bring the innovation and new technologies for Telecommunication Network Tool and wide concepts expertise. The Broadband Gigabit Ethernet carried primarily on optical fiber (with very short distances possible on copper media). Existing Ethernet LANs with 10 and 100 Mbps cards can feed into a Gigabit Ethernet backbone. An alternative technology that competes with Gigabit Ethernet is ATM. A newer standard, 10 Gigabit Ethernet, is also becoming available (NGN- New Generation Network). The model 10 Gigabit Ethernet (10GBASE-T), being standardized in IEEE 802.3a, is a telecommunication technology that offers data speeds up to 10 billion bits per second. Built on the Ethernet technology used in most of today's local area networks (LANs), 10 Gigabit Ethernet is described as a "disruptive" technology that offers a more efficient and less expensive approach to moving data on backbone connections between networks while also providing a consistent technology end-to-end. Using optical fiber, 10 Gigabit

Ethernet can replace existing networks that use ATM switches and SONET multiplexers on an OC-48 SONET ring with a simpler network of 10 Gigabit Ethernet switches and at the same time improve the data rate from 2.5 Gbps to 10 Gbps. The 10 Gigabit Ethernet is expecting to be use for interconnect local area networks (LANs), wide area networks (WANs), and metropolitan area networks (MANs). The 10 Gigabit Ethernet uses the familiar IEEE 802.3 Ethernet media access control (MAC) protocol and its frame format and size. Like Fast Ethernet and Gigabit Ethernet, 10 Gigabit Ethernet uses full-duplex transmission, which makes possible a considerable distance range.

On multimode fiber, 10 Gigabit Ethernet will support distances up to 300 meters; on single mode fiber, it will support distances up to 40 kilometers. Smaller Gigabit Ethernet networks can feed into a 10 Gigabit Ethernet network .The increased focus on wireless and mobility creates a new era of "always on" communications and ushers in a new level of synchronization, specially in TV technical of PCS. (Signal Digital Process) .Along with wireless and mobility, network security is also creating disruption. The theory of a self-defending network, coupled with enterprises' having less control over their own networks, is creating a scenario where "fewer and fewer people are sitting behind this well-maintained perimeter," [80].

A massive increase in mobile and "anywhere" workers has catapulted the use of VPNs to secure the network, regardless of where end users are entering. This level of network-independent security is going to increase, [81].

Real-time communications, such as unified communications, IMS and fixed mobile convergence, are also introducing interesting challenges, he said. In the near future, IP PBXs and desk phones may go away and be replaced by instant messaging and presence-based software and mobile devices. As these new technologies and considerations continue to evolve, network operations and management issues increase as well.

Networking prose must now focus more closely on service delivery, whether those services are data or real-time. The network itself is turning into an "inter-processor bus" for the enterprise. In turn, organizations will have to reorganize staff that was once base on different technology places, [62].

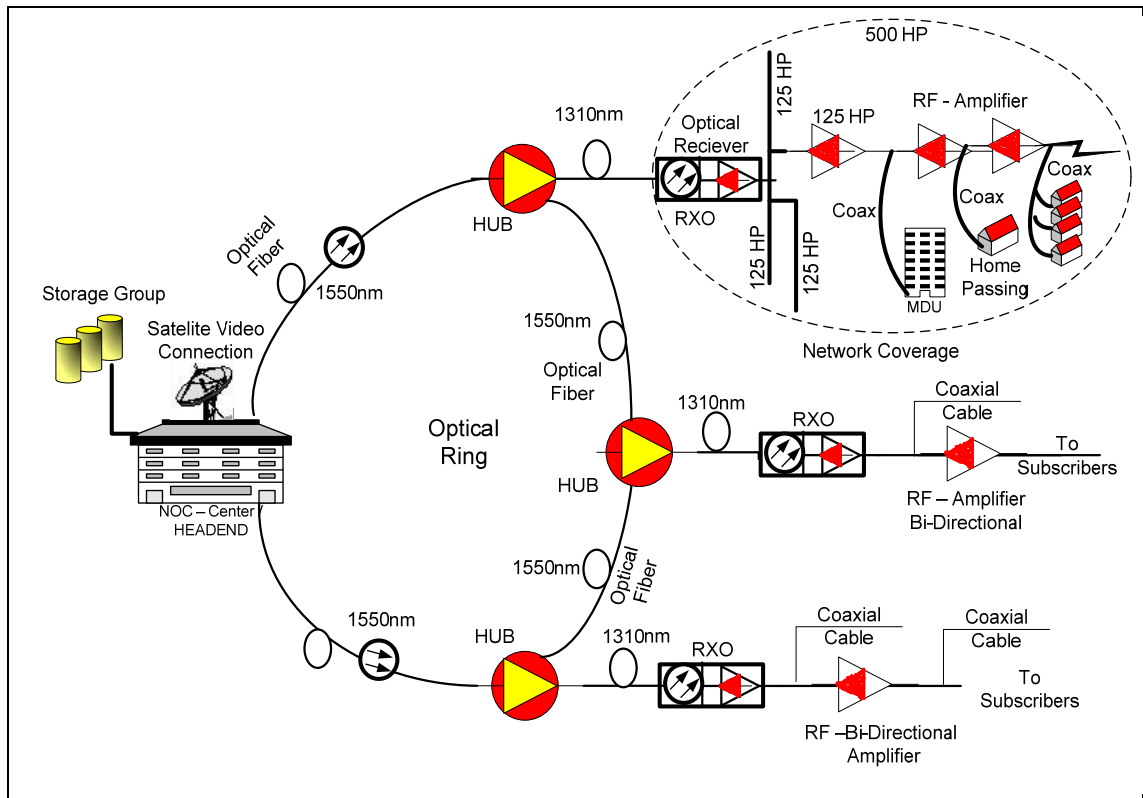


Figure 2.2 – Common optical ring for metropolitan distribution nodes of average 500 HP

For HFC networks and better understanding a symbols, and electronic equipment representation scales, level is defined the following FCC rules and practices for Engineering Design, Figure 2.2:

TV – Broadband - Carrier Signal Level Units

Units of measurement in the cable system

a. dB – expresses ratio of two power levels

1- Gain and loss of signal

2- Not quantity definite dBmv

1- One mV across 75 ohm = 0 dBmv (not zero signal).

2- Signals in dBmv are so many times greater or less than (one) 1, 0 mV.

These parameters are measure in accordance of the modulation level detailed in the frequencies spectrum, Figure 2.3.

Frequencies Spectrum – CATV and MMDS

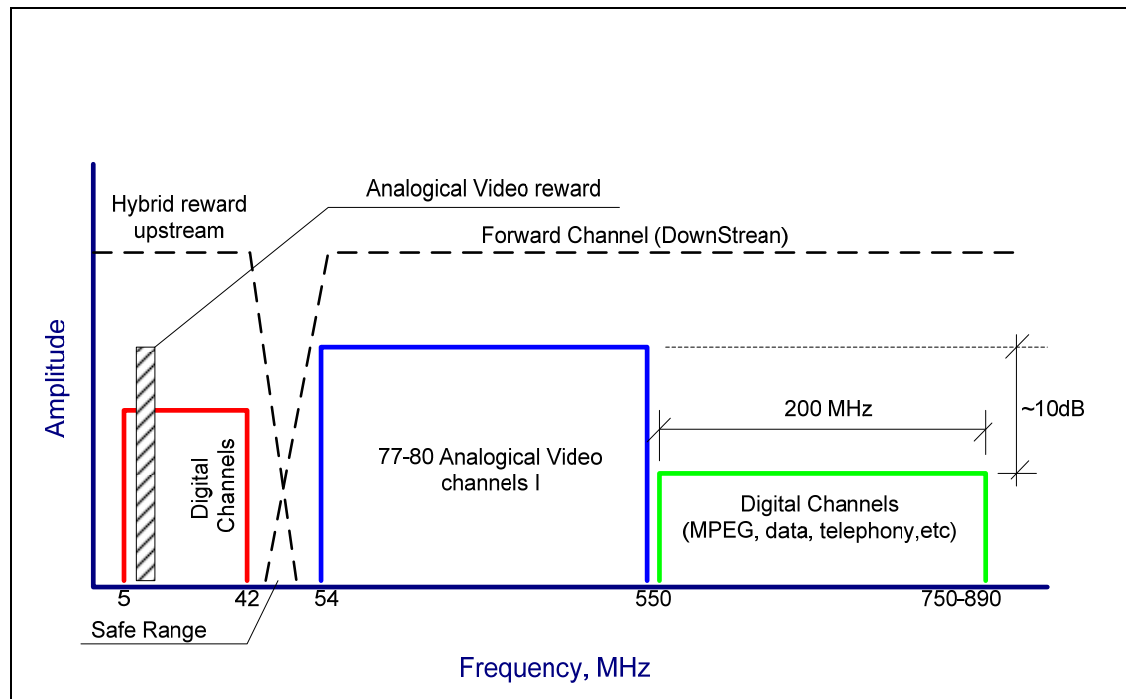


Figure 2.3- Frequency spectrum for Upstream and Downstream link modulation band

a) 5 - 42 MHz – High Frequency Spectrum

Return signal for upstream transmission (Internet cable) and interactive commands.

b) 54 – 300 MHz - Very High Frequency (VHF)

Ch. 2 – 36 (This consideration range is for analogical digital bandwidth usage).

c) 300 MHz - 3 GHz, Ultra High Frequency (UHF)

- 550 systems up to channel 78 – analogical channels
- 750 systems up to channel 116 - analogical channels
- 1.0 GHz up to channel 180 - analogical channels

(This range is for analogical digital channel bandwidth usage, if the consideration is for Digital Channel it is possible to usage of 10 MHz bandwidth for average 8 to 12 channels per hoop).

d) For the designer the main frequencies to concern you with are the two extremes of both the forward and reverse spectrum. Typically, this will be 54 MHz to either 550 or 750 MHz for forward and 5 – 30 MHz on the return. In a 750 MHz system, 750 would generally refer to as the design frequency (Alternatively; Higher frequency 870 MHz to 1.0 GHz).

2.2 – Multiplexing and Multi Access Technology

The HFC networks are inherited for multi-access use. To allow the Physical means of transmission shared between many users and maintain a quality of service (QoS) provided by network system is necessary to use multiplexing and multi-access techniques. The Standard and efficient mode is the Frequency Division Multiplexing (FDM) in combination with a Time Domain Multiple Access (TDMA), this method share spectral parts for many users in different time ranges. It's the main factor to guarantee the QoS for the end customer maintenance, Figure 2.4.

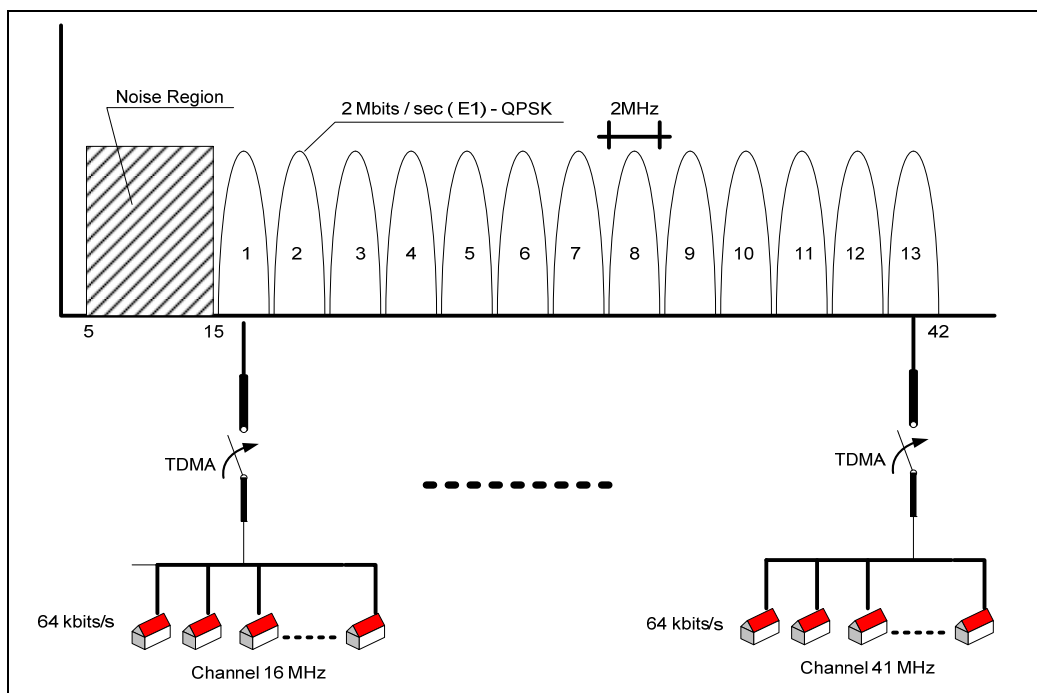


Figure 2.4 Multi-access TDMA-FDM

The **QPSK** – (Quadrature Phase-Shifting Keying) is the most modulation type used to the return channel (reward), motivated for the best relation signal noise. The **QAM** (Quadrature Amplitude Modulation) is the modulation used for direct channel (Forward). This class of modulation is also known as M-QAM, for be commonly used in many degrees of ordinations. Although as higher degree ordinations, more complexity the modulation will have, but also higher spectral efficiency. The **OFDM** (Orthogonal Frequency Division Multiplexing) is the modulation used to chancel the

ingress noise of channel (SBT's 97). This is an orthogonal multiplex method, so with this modulation the sub-channels can be allocate nearest each other, without a possibility of co-channel interferences.

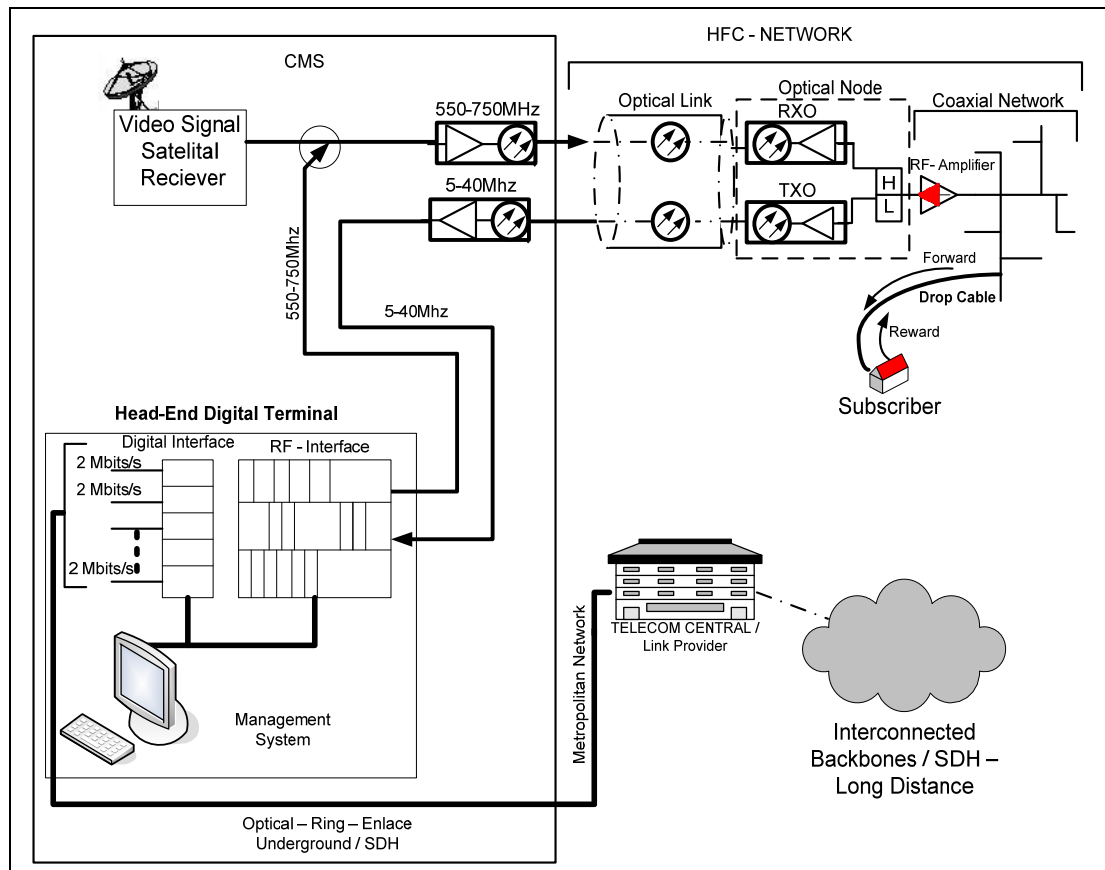


Figure 2.5 - Headend - Digital - CATV and Multimedia Services

After TV channels are received, scrambled, and modulated at the Headend, they are ready to broadcast into the system, and the schema is presented at Figure 2.5. The broadcast signals are transmitted directly into the coaxial system RF, in newer, and large systems, this is typically accomplished using fiber optics. The basic components of the CATV system are commonly represented in design formats as symbols in Figure 2.7, and Figure 2.8, Figure 2.9.

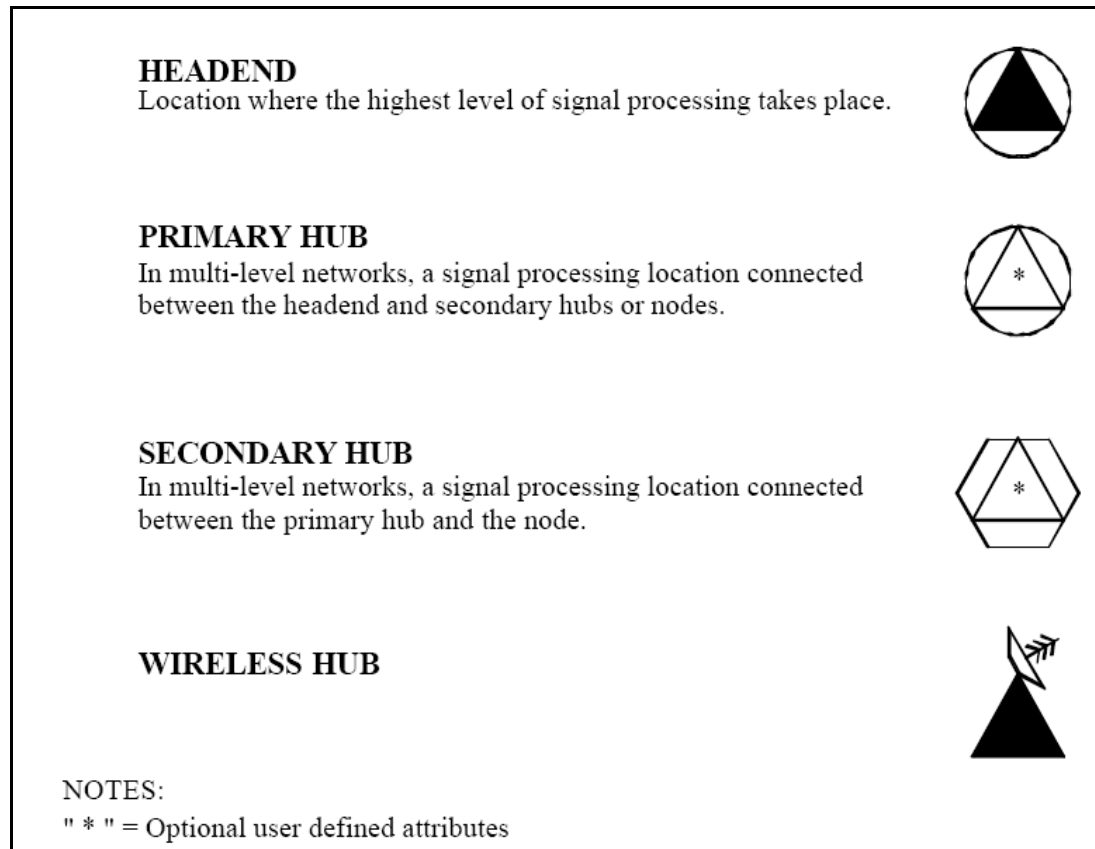


Figure 2.6 – Signal processing locations – [ANSI/SCTE 15, 2001]

The Basic cable components (Coaxial RF) have different Attenuation - signal loss is dependent on length and cable type and the type of isolation and dielectric constants are 0.500 = ½ inch cable (External Diameter), and the Attenuation is greater at higher frequencies. The Aerial Cables fixed over poles (Electrical Company) and Underground – flooding compound to keep water out – same Electrical characteristics as the aerial cable of the same size and type. The common design types are represented in Figure 2.7.

TYPICAL CABLE SYMBOLOGY	
1.000 INCH (25.4MM)	
0.875 INCH (22.2MM)	
0.750 INCH (19.1MM)	
0.625 INCH (15.9MM)	
0.500 INCH (12.7MM)	
0.412 INCH (10.5MM)	

Figure 2.7 Cable Standard Symbols- (Coaxial) [ANSI/SCTE 15, 2001]

To the Network Active Elements as Amplifier types exist many different types but basic concepts are the same, Figure 2.8.

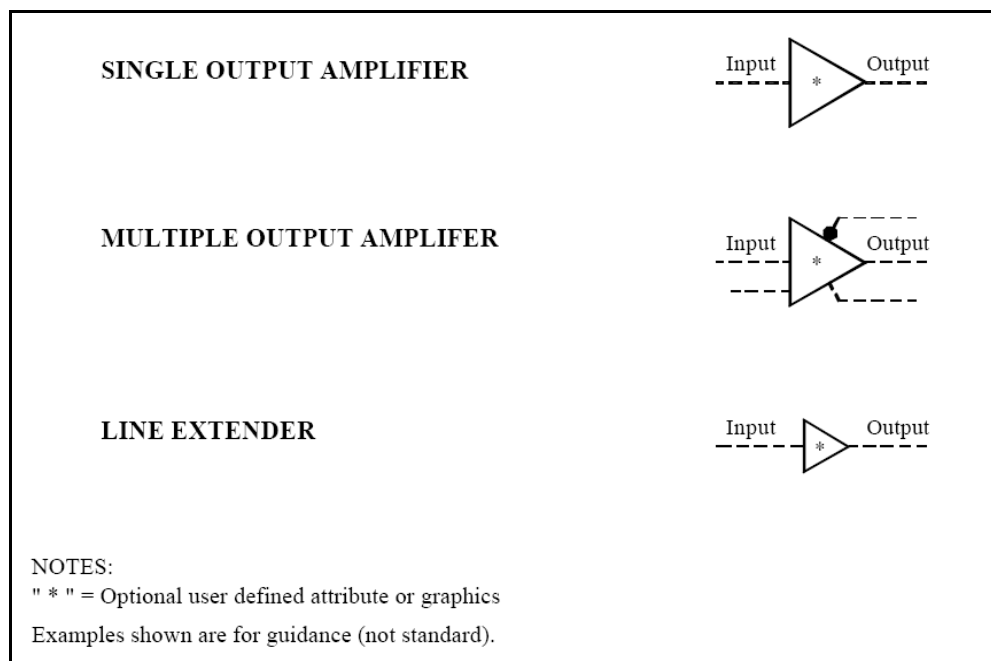


Figure 2.8– Not Standard – RF Amplifiers – [CMS WG6-0001]

Trunk amps with low in/low out for extending reach of system and System amps are used for both express and distribution (multiple outputs). The Line Extenders are simple amplifiers typically one high level output for distribution. Common used inside residential buildings and all amps amplify flat, they amplify equally across all frequencies-equal gain on all frequencies and all amps have optimal levels for input signal. Slope and Tilt Due to

attenuation characteristics (greater loss at higher frequencies), we must run the high channel signals at higher levels than the low channel so that the input levels at the next amplifier will be closer to flat. The EQ's are Two basic types : pre stage equalizers are devices which flatten signal levels on the input of amp, if high channel signal levels have dropped below the low channel levels then an EQ is needed. An EQ loses more signals at the low channel than the high, thereby creating a flat slope (or at least close to it). Mid stage, EQ is the same as pre-stage but they are located in a different part of the amp – in between the gain blocks to give the amplifier the desired output slope. Cable simulators opposite of EQ's, lose more signal on the high channel than the low, for short spaced amplifiers pads are devices, which lose equal amounts across all frequencies, used to knock signal levels down to minimum input level of amp. The Internal couplers are devices for splitting output of amplifier, a plug-in device to create additional lower output legs. The performance noise and distortions increase each time the signal is amplified. Amplifiers do not produce an exact but stronger replica of the input signal in forward and reverse designing a two way system. The Carrier to Noise ratio (C/N) ratio of noise to strength of carrier signal and the Composite Triple Beat (CTB) summation of spurious signals, stack together on each channel to create interference. Composite Second Order (CSO) has similar characteristics as CTB. The Network Passives Equipments are at Figure 2.9.

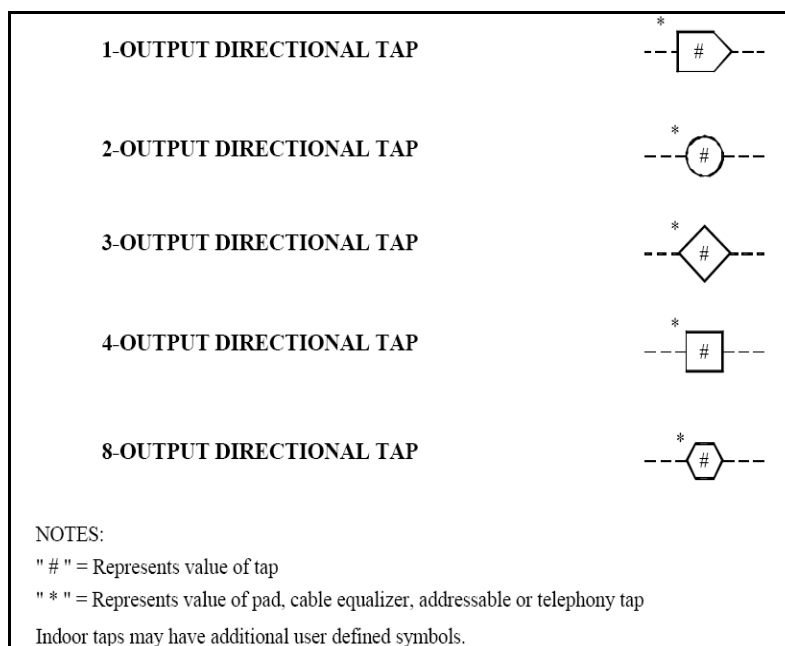


Figure 2.9 – Taps used to connect the External Network and Internal Network (Drop Home, Drop MDU)

Splitters – send the signal into several directions Figure 2.10

- 2 way splitters / 3 way splitters

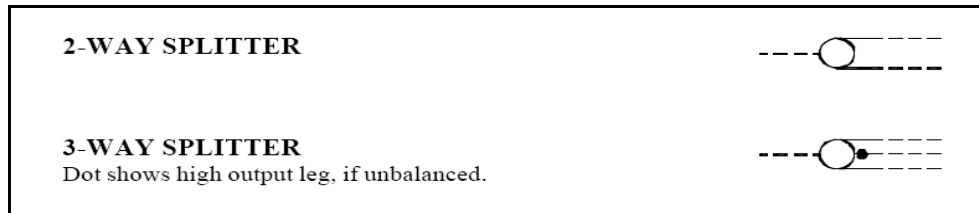


Figure 2.10- Splitters

- drop splitters
- Taps (Figure 2.9)
- Two, four, and eight way taps – how many subs can they feed.
- Tap values
- Tap losses – insertion loss
- Tap output levels – determined by drop referencing, may be different in different areas of the same system depending on drop distances.
- Splices
- In line EQ's – function the same as eq' s in amps except these splice directly into the cable to correct the slope downstream

Other representations in design formats are presented at Figure 2.12, and Figure 2.13.

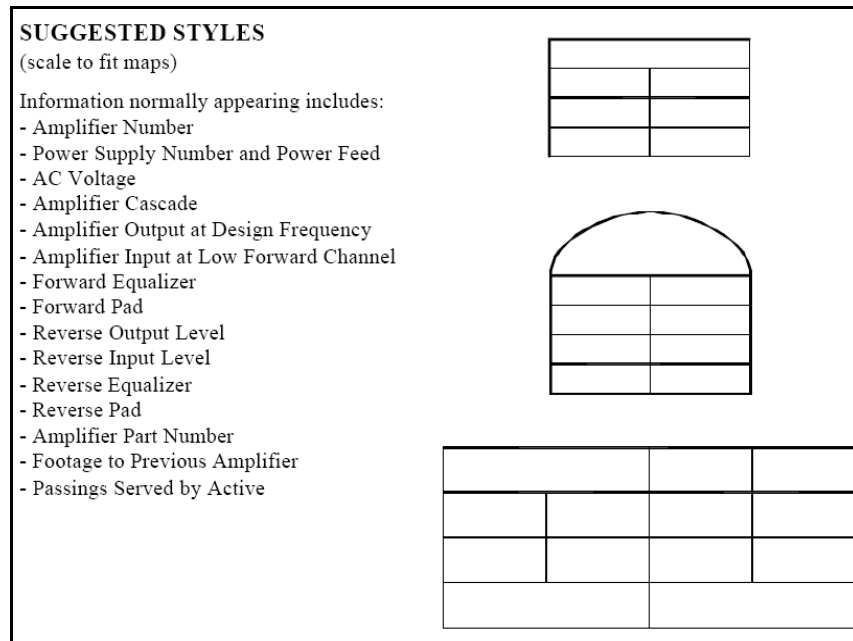


Figure – 2.12 – Data Identification for Design Parameter in Maps

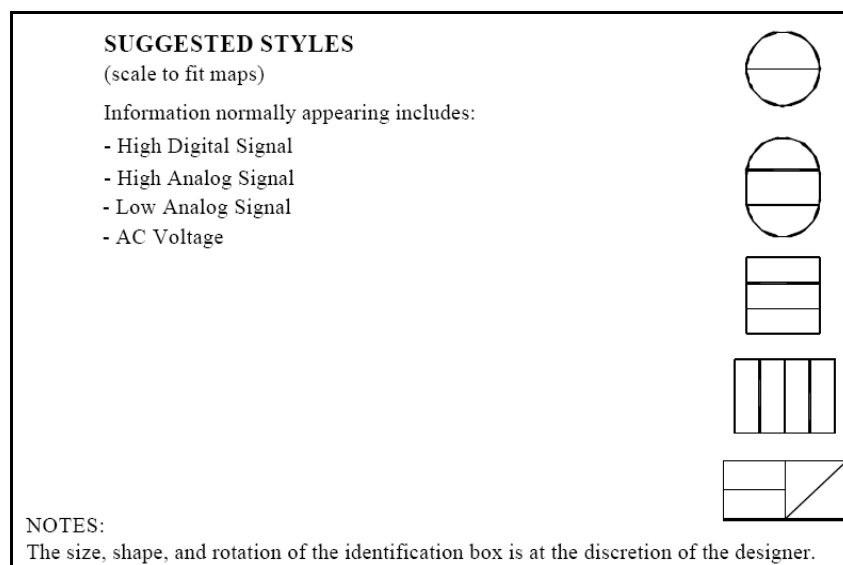


Figure 2.13- Data Identification end of line Parameters

POWER POLE	×
TELEPHONE POLE	○
JOINT USAGE (power and telephone pole)	⊗
CATV POLE	●
CONCRETE POLE	⬡
STEEL POLE	⬢
FIBER REINFORCED POLE	⬤
POWER TRANSFORMER POLE	⊠
JOINT USE WITH POWER TRANSFORMER	⊠
POWER TRANSFORMER PLATFORM	⊠⊠
TRANSMISSION LINE CONTACT	⊙
OTHER SUPPORTING TYPE STRUCTURES Show approximate structure outline or a portion thereof in this manner.	
RISER POLE Use of a number indicates vertical distance from serial connection to ground level.	⊗ R20
(alternate)	⊗®

Figure-2.14 – Poles for Maps Symbols Network Design Representation



Figure 2.15 – Signal Data Representation for internal Electronic Networks

Attenuation [@ 68° F. (20° C.)]

Frequency (MHz)	Maximum (dB/100 ft)	Maximum (dB/100 m)
5	0.58	1.90
55	1.60	5.25
83	1.95	6.40
187	2.85	9.35
211	3.05	10.00
250	3.30	10.82
300	3.55	11.64
350	3.85	12.63
400	4.15	13.61
450	4.40	14.43
500	4.66	15.29
550	4.90	16.08
600	5.10	16.73
750	5.65	18.54
865	6.10	20.01
1000	6.55	21.49

Commscope Catalog – Broadband

Figure 2.16 – Cable Losses per ft and per meter

Mechanical Characteristics

Minimum Breaking Strength	(0.051)	180 lbs.	82kg _f
of Messenger	(0.072)	365 lbs.	166kg _f

Electrical Characteristics

Nominal Impedance	75 ohms
Nominal Velocity of Propagation	85%

Figure 2.17 – Cable attenuation characteristics

The Electronic Design Architectures Models (Concepts and Technology) are basically, what type of amplifiers and how they can be used as:

- Cascade – how many actives in line with each other
- Tree and Branch (not used any more)
- HFC – Hybrid Fiber and Cable Network (nodes)
- NGN- (New Generation Networks)
- MDU – Backbones Designs (Multiple Dwelling Unit)

2.3- Network Design Sequence

The chronological work phases for Electronic Network CATV and other analog areas like Utilities, is start using a mapping program. Using Harnessed the power of AutoCAD with specific, easy to adopt routines to draft base, strand, geography, and as-built.

Base Mapping

- Road Draft and Clean Up.
- Define Lot Lines, or Home Passing (HP) Positioning.
- Define Geography features (Georeferenced Information's) – (Projection System).
- Buildings – MDU (Multiple Dwelling Units) as shown Figure --:

Strand Mapping

- Field Survey to complete information's on the Map.
- Annotation for each number of HP (home passing) per number or address using their Right Symbol.
- Classify the Home Passing (HP) types (Commercial, Residential, Multiple Dwelling Unit) and Economic Level A,B,C or D.
- For MDU – identify the number or Dwelling Units and number of HP's each.
- Use a Special measure equipment to assign the real distance between each pole.

- Classify poles for availability to anchorage Coaxial Cable or Optical Cable, without any interference with electrical distribution network, or other telecommunication cable's provider.
- Mark in the Map, the Head End Position
- Identify the necessary underground future installations and describe it.

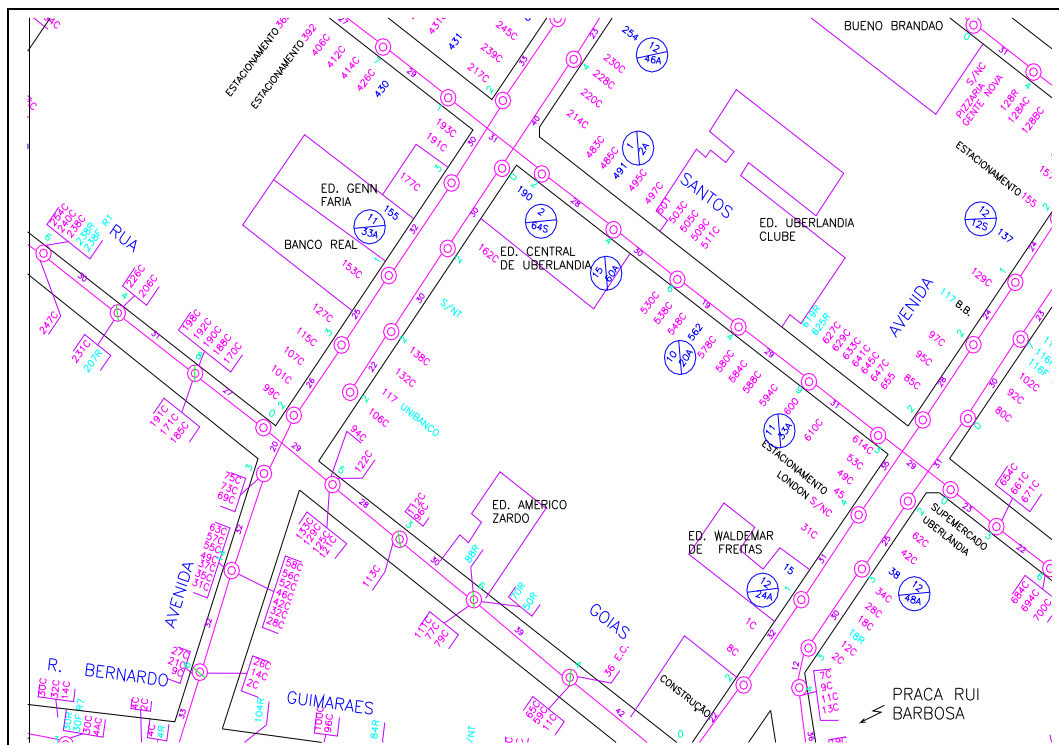


Figure 2.18 - Detailed Strand Map –Site Survey Preliminary Study – Uberlandia - MG/Brazil PROENGTELECOM / IMAGETV - 1998

Preliminary Studies (field survey)

- Realize the House Counting, or the evaluation for better position for nodes to attend the amount of customers in determinate area (Divide the average of 500HP's per node, looking to further divide this node for small number (e.g. average 125 HP's).
- Classify the places with potential customers, Figure
- Disposition special installation for areas with large amount of MDU's
- Define the Best Places to Locate the Optical Nodes (Main RF Transmitter for each node)

- Define Places to positioning emergency power supply equipments (Batteries) to provide easy access for maintenance group in case of energy disruption, lights, etc.
- Define the amount of Express RF amplifiers and the quantity of Line Extenders will be better to provide Video, Internet, Telephony, and other interactive services.

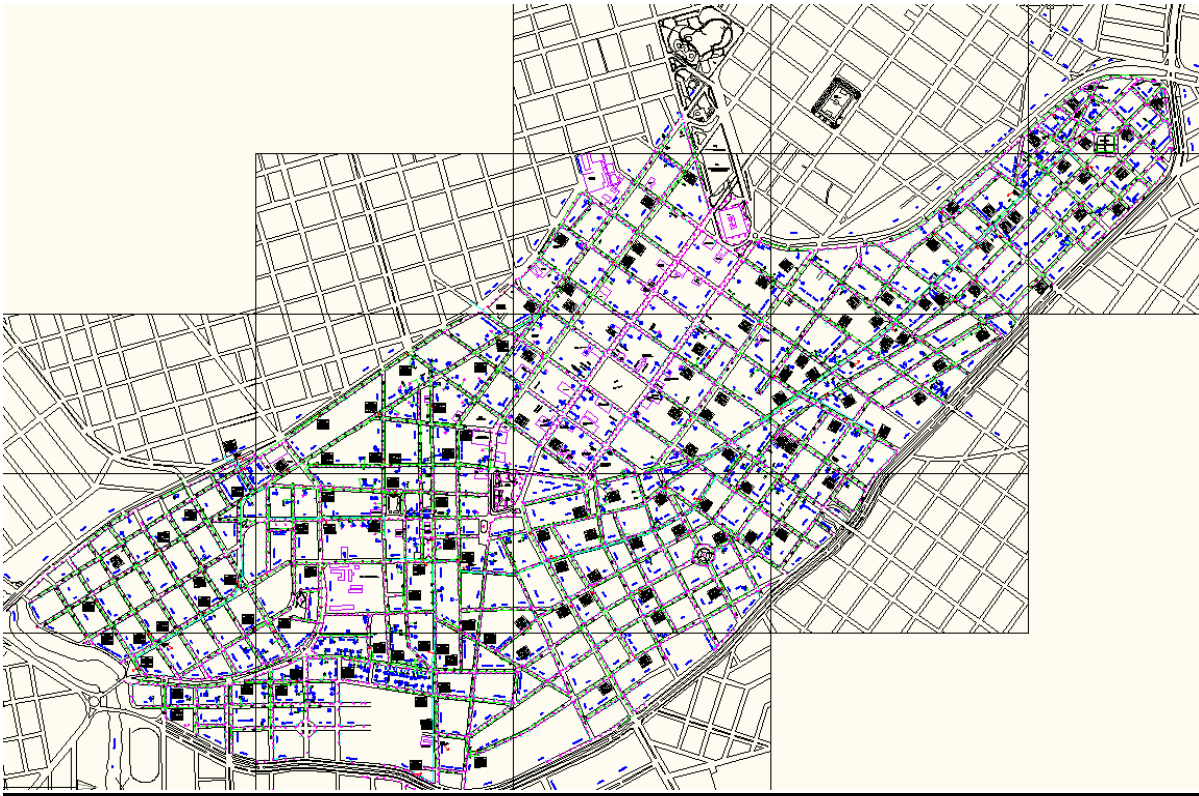
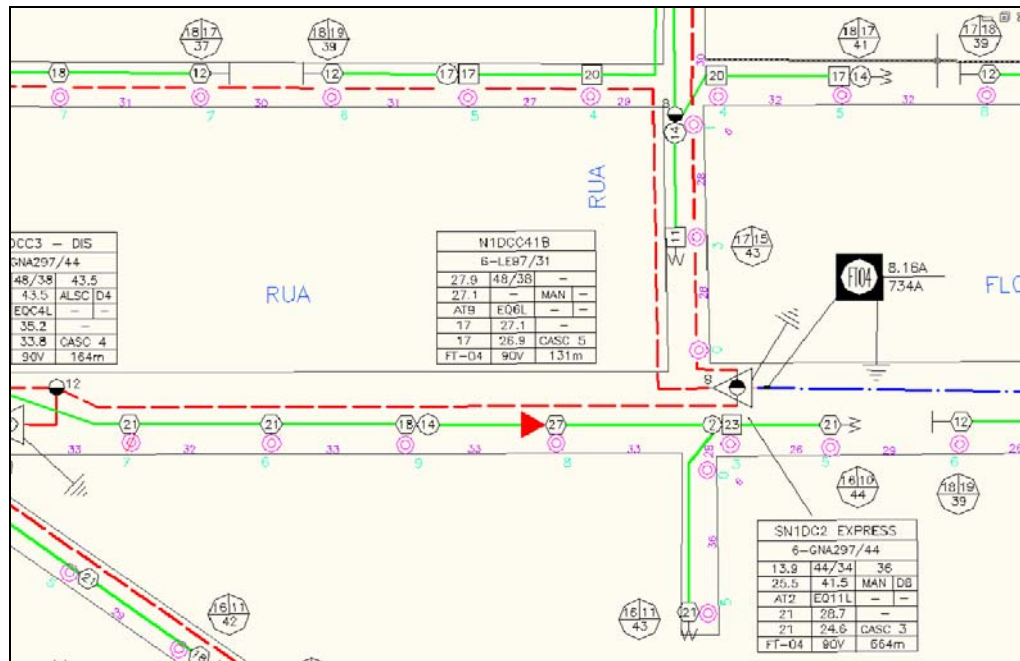


Figure-2.19 - Economical and Technical Area for one or more Nodes Definition-
PROENGTELECOM / IMAGETV - 1998

-Design the Network

- Trace the express coaxial cable routes until the Optical Node.
- Trace the Optical cable Route to Connect from Headend to each optical node (Ring, or Tree)
- Realize the Electronic Parameters Calculation for each Cable Dimensioning, considering the Forward and Return Signal Level, for good network performance and minimum splice work's at as built phase.



Figure–2.20 - Hybrid Coaxial Fiber Amplifier Adjusts for best performance Network-
PROENGTELECOM / IMAGETV - 1998

- Position the Tables of each active equipment for easy understand of the Signal Level and adjustable possibilities.
- Define the Best passive TAP, to possibility the Last Mile Drops Cable connections, using enough exits to attend the demand of usage. (Considering Insertion Loses – Forward and Backward).
- Equalizers positioning to correct “Tilt” problems in all places of network.
- Consider the other Telecommunication Pops (Points of Presence) location and preview expandability for network interconnections.
- Dimension the amount of the MDU's and preview its demand for the main design.

MDU Backbone Network Design (sub circuits of CATV Network)

- The concept used for a internal building network design is the same as the used for External Network Design, but in minor length scales.

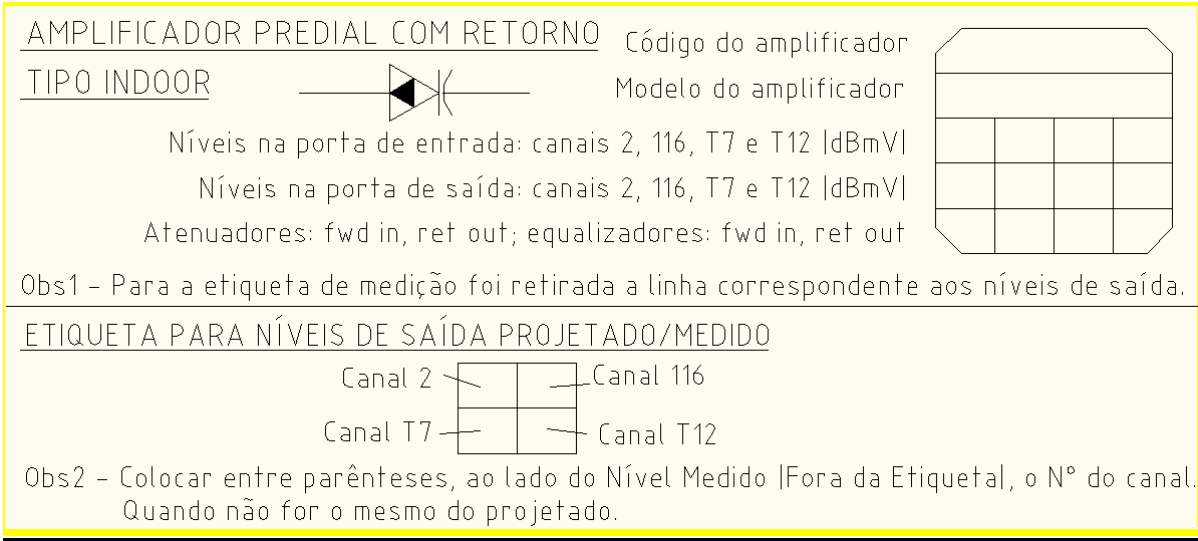


Figure -2.3.5- Legend Specs Detail Standard format - A3 (PROENGTELECOM)

- Is Necessary to consider a detailed field survey to turn possible to identify problems in early phases.
- At figure – is shown the Internal Amplifier (MDU) and it’s adjusts based in the Forward and Reward Level necessary to attend the internal users and the overall network. These parameters are always mentioned in dBmv for low channels and higher channels.
- At the same figure is detailed the level for etiquettes for Analyze the Signal Levels at any connection or interest points.

Network Reference Model and Standards

This section presents the definition and capabilities of layers 1 and 2 converged wire line technologies and relevant standards considered by carriers to deploy next generation service-aware metro and core networks. Figure 1 shows a basic network reference model with its associated standard components. Section 4 will describe the migration path of the network elements contained in this figure. The way these technology components and network elements are designed, impact the type of service to be offered by a carrier; section 3 defines these services and its impact on the evolution of next generation metro and core networks. Figure 1 shows three basic

carrier network segments: metro collector/access ring, metro core/IOF rings, and core IP/SONET network with their associate standard protocols.

2.4-Summary

This chapter has presented the emerging technologies evolution in telecommunication electronic networks. Considering the **NGN networks** and digital **video capabilities**, including **HFC Networks** as a part of a Superhighway interconnected. When dealing with electronic circuits and devices, one typically deals with continuous, but nonlinear, dynamic systems. This makes it a difficult topic, and much scientific research is needed to improve the accuracy and efficiency with which the behavior of these complicated analogue systems can be analyzed and predicted, i.e., simulated. New capabilities have to be developed to master the growing complexity in both analogue and digital design. These levels are also embedding into the CATV equipment symbols used in the AutoCAD based system maps, included with all designs, using the geospatial concepts. Designs done over any required temperature range to ensure full DOC and FCC compliance.

Chapter 3

Electronic Network Technology Based on Constraints

3.1 Introduction

The propose of this dissertation is to make a contribution for a new model database, using interactive capabilities with design information, to represent network electronic elements represented by constraints formulated concepts. The idea is to use this database prototype facility to allow the designer to test a conceptual HFC proposes and transactions, preserving consistency and update trustable [73], including the high frequency spectrum represent physical phenomena's in time domain and / or frequency domain.

The data model, should define integrity constraints based modules agents to leading the geometric and engineer equations satisfaction based and using an interactive algorithm over the proposed design [75].

3.2- Geometric Constraint Representation

The geometric parameters involved in the electronic design in practice are directly dependent of the spatial disposition of each electronic component representation inside the circuit, specially for capacitance and inductance. The Constraint approach is an efficient concept to allow the user to interact with the circuit design model imposing an incremental and verification loop to concept the circuit model and simulation [57], [58]. Graph algorithms are a significant field of interest used to represent and to solve constraints [51]. Typical operations associate graphs methods procedures and non Linear Constraints, specially engineering networks, with their selected output variables. For this research it is used the incremental equation solver that has been improved by many scientific works, referred as **INCES**, and allow to use nonlinear constrains to be processed symbolically as carrier to noise figure, handled according to their constraint states [58]. The related works using **INCES** concepts can consider the constraint dependences as subset of constraints

that is under or over constrained (layers). The special usage of this way is the necessity to implement nonlinear equations and permit its insertion incrementally and at the same capability to simplify engineering constraint cycles into small parts of the equation graph, which is visited due the constraint insertion process.

The Electronic Network data base model must represent engineering constraints as equations within the equation graph. Basic symbols represent geometric entities [51].

Constraints are specified through other objects, so that one object may *depend* upon another. In this situation, the system reacts to a change in one object's parameters by adjusting the constraints of any dependent objects.

The constraints remain satisfied, but the user is free to decide how is the best solution. This provides an easy-to-use interactive interface, with immediate feedback and control. This research turns easy model data preparation for visualization attributes, and integration with the workflow process in Engineer Design, particularly to MDU design.

3.3-Electrical Constraints based Representation (permanent state)

Lopes and Lamounier [57] presented a graph representation for electric circuits as shown in Figure 3.1.

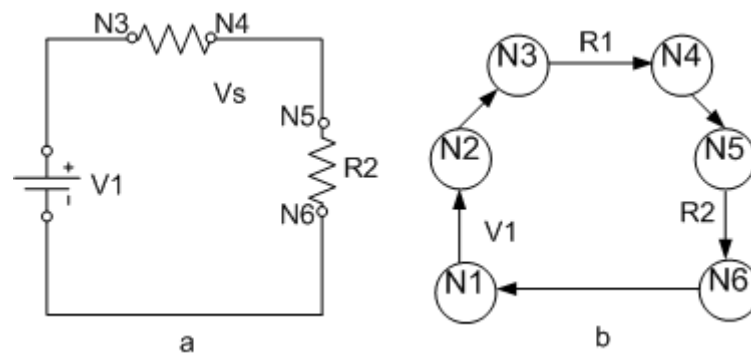


Figure 3.1 – Electrical circuit representation

Using the Kirchhoff's Law (LCK) it was possible to analyze the circuit through:

$$\text{Node – N2: } -I_{R1} + I_{vs} = 0 \quad (3.1)$$

$$\text{Node – N3: } I_{R1} - I_{R2} = 0 \quad (3.2)$$

$$\text{Node – N6: } I_{R2} - I_{vs} = 0 \quad (3.3)$$

Using the matrix of incidence, result: $\mathbf{V} = \mathbf{A}' \times \mathbf{E}$

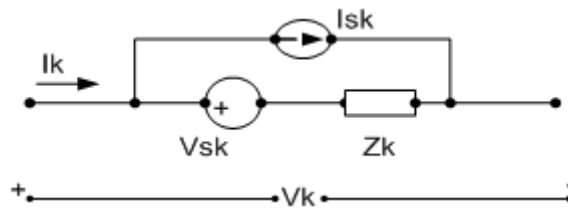


Figure 3.2 – Tension for each node and branch current

Simplifying the above equations, the node Vector (Tension) is present by:

$$\mathbf{E} = (\mathbf{A} \times \mathbf{Y} \times \mathbf{A}')' \times (\mathbf{Y} \times \mathbf{V}_s - \mathbf{I}_s) \quad (3.4)$$

Using this concept, we can determine the Tension for each Node and branch current. Figure 3.2. The challenge duties for this research, is establish a similar constraint model equivalence concept for an electronic elements, specially capacitance, inductance, amplification, splice, and equalizer, under the Time and Frequency Domain. The methodology to implement digital services over an existent HFC network is a fundament to all electric circuit that receive energy of a external power supply to its operation, and presents non linear characteristics exhibiting saturation because the physical limitation of the external power supply. In the cable systems the main non linear distortion are the Composite Second Order (CSO) and the Composite Triple Beat (CTB) [61].

3.4-Electronic Constraint Representation

High fidelity modeling of radio frequency (RF) passives and active analog circuits are critical for top-down constraint driven. The compact modeling of passive RLC

networks has been an intensive research area in the past decade, due to the increasing signal integrity effects and interconnects dominant delays in designs [13]. In electronics, a signal is an electric current or electromagnetic field used to convey data from one place to another. The simplest form of signal is a direct current (DC) that is switched on and off. This is the principle by which the early telegraph worked. More complex signals consist of an alternating-current (AC) or electromagnetic carrier that contains one or more data streams. Data is superimposed on a carrier current or wave by means of a process called modulation. Signal modulation can be done in either of two main ways: analog and digital. In recent years, digital modulation has been getting more common, while analog modulation methods have been used less and less. There are still plenty of analog signals around, however, and they will probably never become totally extinct. Except for DC signals such as telegraph and baseband, all signal carriers have a definable frequency or frequencies. Signals also have a property called wavelength, which is inversely proportional to the frequency. In some information technology a context, a signal is simply "that which is sent or received," thus including both the carrier and the data together. In telephony and TV a signal is special data that is used to set up or control communication.

3.5-Quality Signal Parameters to Constraints Data Model

In communications, the carrier-to-noise ratio, often written CNR (Carrier to Noise Ratio) or C/N (Carrier to Noise), is a measure of the received carrier strength relative to the strength of the received noise. High C/N ratios provide better quality of reception, and generally higher communications accuracy and reliability, than low C/N ratios.

$$C/N = 10 \log_{10} (P_c/P_n) \quad (3.1)$$

Where:

P_c : Incoming carrier strength in microwatts.

P_n : Noise level in microwatts.

In analog and digital communications, signal-to-noise ratio, often written S/N or SNR, is a measure of signal strength relative to background noise. The ratio is usually measured in decibels (dB).

If the incoming signal strength in microvolts is V_s , and the noise level, also in microvolts is V_n , then the signal-to-noise ratio, S/N, in decibels is given by the formula:

$$S/N = 20 \log_{10}(V_s/V_n) \quad (3.2)$$

If $V_s = V_n$, then $S/N = 0$. In this situation, the signal borders are unreadable, because the noise level severely competes with it. In digital communications, this will probably cause a reduction in data speed because of frequent errors that require the source (transmitting) computer or terminal to resend some packets of data. Traditionally, this has been done by using the narrowest possible receiving-system bandwidth consistent with the data speed desired [61]. However, there are other methods. In some cases, spread spectrum techniques can improve system performance. The S/N ratio can be increased by providing the source with a higher level of signal output power, if necessary. In some high-level systems such as radio telescopes, internal noise is minimized by lowering the temperature of the receiving circuit to near absolute zero (-273 degrees Celsius or -459 degrees Fahrenheit). In wireless systems, it is always important to optimize the performance of the transmitting and receiving antennas.

By definition, CNR is the difference, in decibels, between the amplitude of an RF signal and the amplitude of noise present in the transmission path of the RF signal. The RF signal may be unmodulated (also called continuous wave, or CW) or modulated. The noise may be one or a combination of several types: thermal noise; shot noise and relative intensity noise (RIN) in optical fiber links; and, in cable systems carrying a mix of analog TV channels and digitally modulated carriers, non-thermal noise such as composite and intermodulation noise. This work focuses on thermal noise generated by passive and active devices through which the RF signal is transmitted. The amplitude of thermal noise-also known as additive white Gaussian noise, or AWGN-is usually specified over a certain bandwidth, called noise power bandwidth. [61],[79],Appendix A.

3.6- Related Constraints with this Research

It is usual to see that a number of common interfaces are implemented in the same area in high- speed designs. Each interface has its own specification on the relative timing requirements for signals within that interface (like differential pairs). It is desirable, to have the I/O cells belonging, to the same interface, physically close to each other (or even in a preferred order), which reduces the delay and SI variations, between signals of the same interface. In particular, differential signal pairs are usually required to escape and to be routed together on the package.

This imposes not only a closeness constraint but also bump assignment feasibility constraints (e.g., bumps escaped on the same layers). It is decisive, for the attainable quality models, for verification of the network circuit behavior. The device models are use to represent some function in the nodes or arcs. The requirements for a good model in a circuit simulation environment are quite stringent. The models must be accurate, because they limit the attainable simulation accuracy. Additional model, restrictions may be posed by simulation algorithms, such as the Newton Raphson [57], [58], algorithm and the time integration scheme: good models are at least continuous as a function monotonic in the device behavior. Usually, the continuity of the first partial derivate is also required, causing (Graphic Simplification) smoothness.

For performance targets, Federal Communications Commission regulations require that the analog NTSC TV channel CNR in U.S. cable systems be no less than 43 dB at the subscriber terminal. Good engineering practice suggests that the worst-case CNR should be better than the FCC minimum-most modern cable networks are designed to provide end-of-line CNR in the mid to upper 40s. The assumed channel transmission characteristics in the DOCSIS *Radio Frequency Interface Specification* include the following minimum CNRs for digitally modulated carriers, regardless of modulation format:

Downstream: 35 dB / Upstream: 25 dB

3.7-Summary

The most advanced physical models now use a significant number of empirical fit-parameters, and some times unphysical values are assigned to the physical parameters, because they have to account for effects that were not properly

incorporated in the model. This may also reduce the independence of the parameters, and cause the increased model and modeling.

A list of net constraints and a list of complete path constraints are fed to the sub-graph generator during operation. A refined sub-graph is output, to the net constraint generator:

- a) Transforming the differential equation in a circuit based in one algebraic equation (Carrier to Noise Figure) presented in Chapter 4, Figure 4.3 and Figure 4.4.
- b) Satisfy the equation for one single algebraic incognita.
- c) Use of the inverse transformation to simplify, the transmittion Line representation, in only one single incognita algebraic equation.

Chapter 4

Constraint Modeling for Signal Modulation and Electronic Components

4.1- Introduction

The (Orthogonal Frequency Division Multiplexing) is one modulation technique used to minimize the noise channel ingress. It uses dynamic bit allocation per channel. Basically, the spectral allocation is subdivided in sub-channel groups in identical bands, each one using its own sub carrier. In contrast to the modulation frequency division (Frequency Division Multiplexing-FDM), the technique OFDM number of bits per channel depends on the noise level in operation carrier. It means that in the signal region signal of more possibility for noise and attenuation, the bits number per channel can be low. In some cases, the channel can be completely mapped.

In case of the high noise level or interference tones in fixed frequencies (e.g. AM Radio, FM, TV channel, etc), this region should not contain any information. In case of one of sub-channel of the return carrier allocation, it is affected by this noise or for some interference tone, only this channel will be affected, and go out of the air. (E.g. only one subscriber considering the communication rate of 64 Kbit/s). In other modulation methods, this kind of noise will cause the full 10Mbps/sec, affecting many subscribers at the same time. In other view, the spread frequency techniques are used in addition to the OFDM technique. For these purposes, the CMS devices stay constantly monitoring the return channel, and changing the frequency position, for the case of noise level stay in over value of the QoS limits established. These capacities have good application for case of many users with small connectivity taxes rates or equal in lower case equal to 64Kbps/s. How we are using the orthogonal multiplexing methodology, the sub channels are allocated very near each others, without the interference risk of co-channel. These characteristics turn the OFDM technique very efficient to spectral occupation contexts. At the same comparison the

TDMA / QPSK possibility uses a number of 72 to 90 voice circuits or channels per 64 Kbit/s (DSOs) of bandwidth inside the 6MHz spectral [102], as shown in Figure 4.1. The OFDM at least provide the double capacity, and could have 240 DS-0s inside 6 MHz [104].

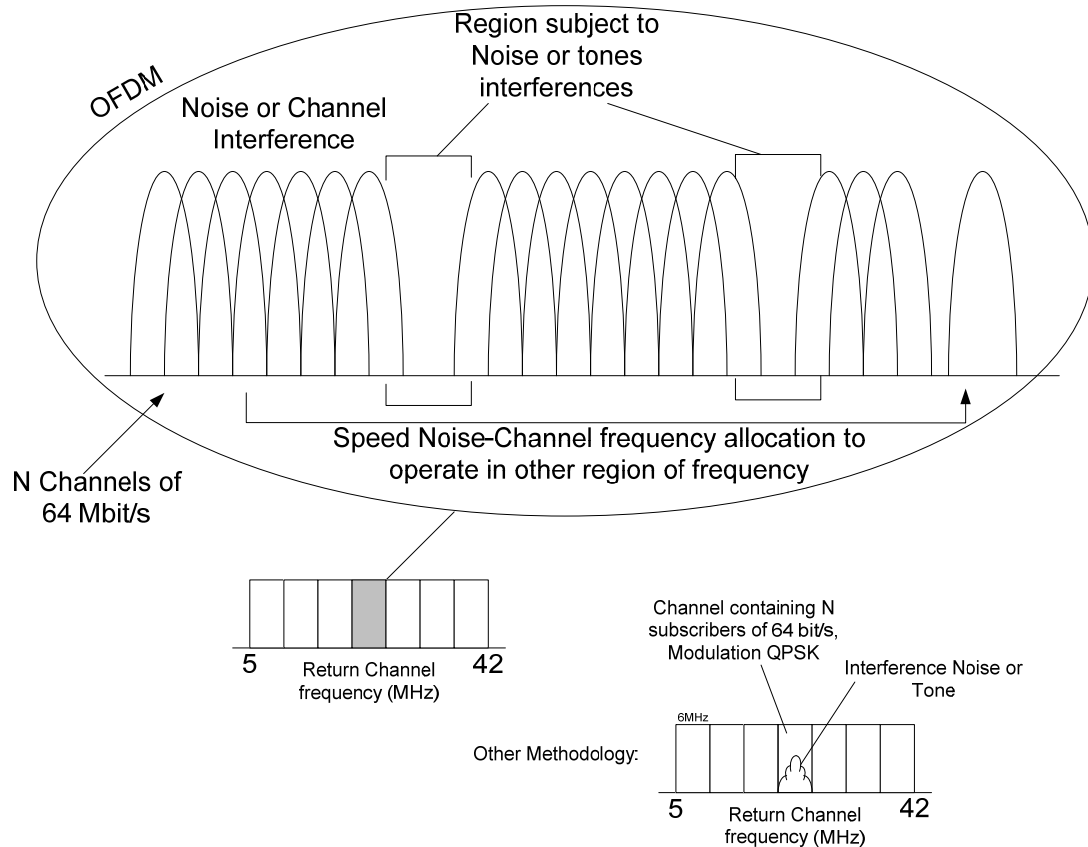


Figure 4.1. - Modulation Representation – Noise Relation (crlima10, pg 25 SBT 97)

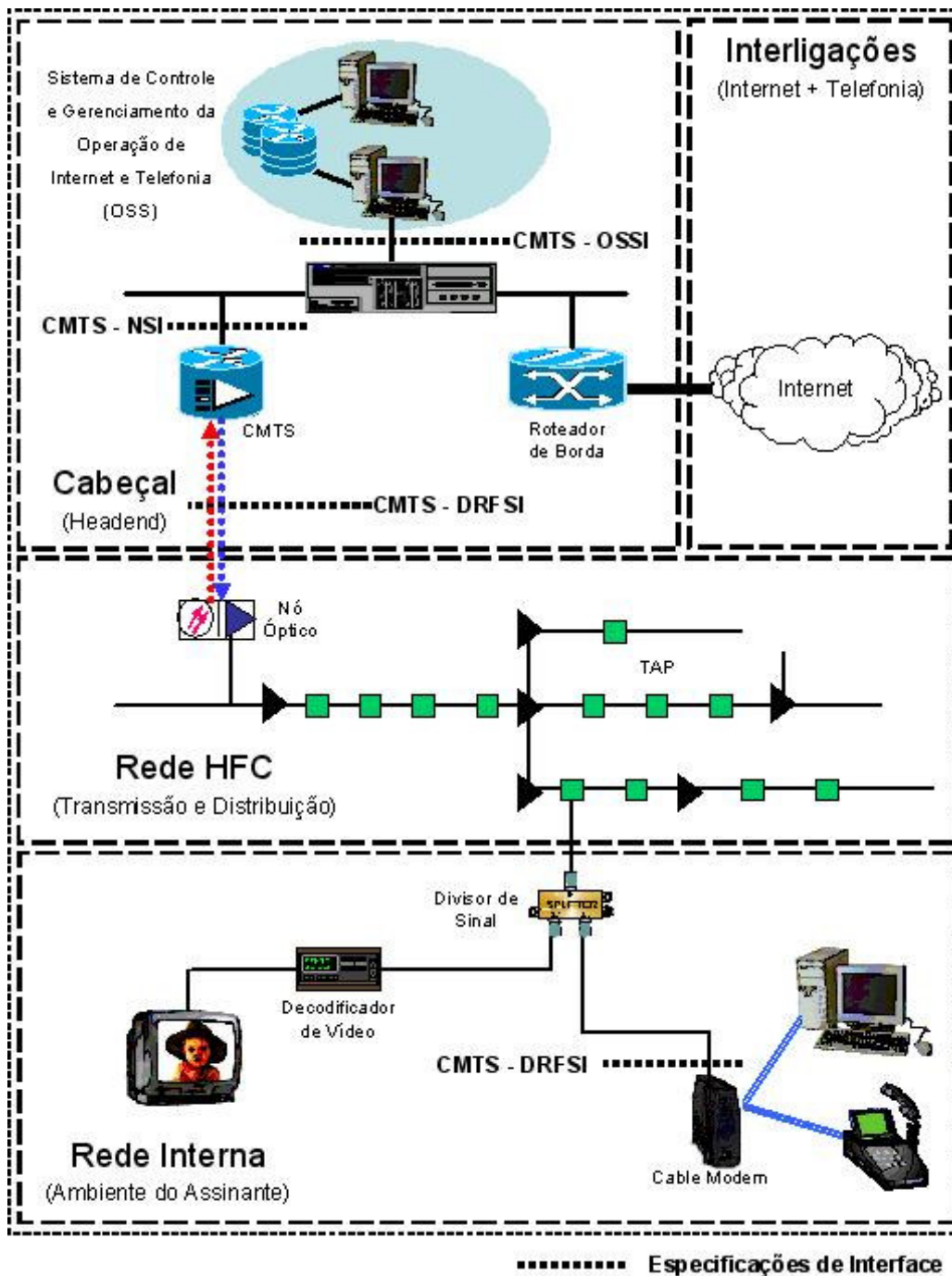


Fig: 4.2 –Basic Architecture of HFC Network data transmission¹

In the Figure 4.2, the Cable Modem is the equipment that realizes the interface of the subscription data network, (e.g. Ethernet), over coaxial cable network. The communication between the CMTS (Cable Modem Terminal System) and the CM's

¹

MORAIS, V. M. (2006). Metodologia para Implantação de Serviços Digitais em uma Rede HFC Existente. Dissertação de Mestrado, Departamento de Engenharia Elétrica, Universidade Federal do Paraná, Curitiba, PR, 163 p.

are possible to establish the communication and interconnect the data network with the Headend and other internal networks from subscribers, compounding a large coverage network based in HFC. The interconnection of that large LAN can be joined with other CMTS using one high speed commutation device, like a Switch. The Switch is able to interconnect many CMTS (*Cable Modem Termination System*), and other servers to provide large bandwidth gateways, for applications in IP telephony and other providers like Internet. [77].

For the OSS (*Operation Support System*), it is possible to use for controlling the service plan for the subscriber and manage network parameters to control the Quality procedures requisites for the applications. The Standard DOCSIS establish a data control model for reference OSI (*Open Systems Interconnection*), [78].

4.2– Engineering Constraints Geometric and Equations for Signal Radiation over HFC Networks

The following equations must be considered for a complete calculation to the forward and reward signal to provide the broadband TV and the internet running well on the typical design.

The quantum efficiency for all wave lengths is expressed as the equation [78-80].

$$\rho = \left(\frac{\eta \cdot q \lambda}{h \cdot c} \right) \quad (4.1)$$

Where:

n: quantum efficiency of fotodetector (decimal)

q: charge of electron ($1,60219 \times 10^{-19}$ Coulombs)

λ : laser wave length (m)

h: Planck's constant ($6,63 \times 10^{-34}$ Joule's)

c: wave speed propagation in vacuum (3.108 m/s)

If the quantum efficiency n is constant for all wave lengths, the equation (4.1) can satisfy the growing responsively and proportionality to λ .

In real devices, the quantum efficiency is dependent on the wave irradiation.

In the silicon, it's in an order of 80% to 90% considering the λ between 850nm a 900nm, or in other words a responsivity of average 0,5 A/W, and it's good for the first window transmission optical fiber. To the Germanium (Ge), the max value occurs in a wavelength of 1300 nm. This value is good for the second window transmission.

For other compositions like InGaAs, the best efficiencies are in 1400nm e 1600nm, appropriate values to the third window transmission with low signal loss [80]. For InGaAs or Ge presents high efficiencies in quantum region of 1300nm and 1550nm, and the HFC network present in practice typical values of 85% [78],[79].

The determination of the signal level of Radio Frequency and their electric field intensity, irradiated for each of its points.

To establish a frequency plan, where the carrier width for each channel is 6MHz, a lot of distortion components have a same nominal frequency. The beating number will depend on the channel plane adopted, and or the number of the phases.

Usually, a Cable TV system is demonstrated by an intermediation methodology determined by the number of beating of second and third order, for each nominal frequency, respectively:

Second Order: $2.f1$ or $2.f2$ e $f1 \pm f2$ (2.2)

Third Order: $3.f1$; $f1 \pm f2 \pm f3$; $2.f1 \pm f2$ or $f1 \pm 2.f2$ (2.3)

Where: $f1$, $f2$ e $f3$ are carrier nominal frequency

The nominal carrier frequency are arbitrary and not necessary continue.

In Figure 4.4 the graphic number of beats of second order for bandwidth of

330MHz – 40 channels

450MHz – 60 channels,

550MHz – 77 channels e 750MHz 110 channels [61], [62].

The frequency plan presented in Figure 4.3 is for analogical standard video and use a bandwidth of 6MHz for each Television channel. The beating of second order will occur over each Television Channel for many times, and through the results are obtained by combination between two different carriers and result in harmonics that coincide with determinate carrier of the channel plan, dislocated $\pm 0,75\text{MHz}$ e a $\pm 1,25\text{MHz}$. In analogous mode is presented in Figure 4.4.

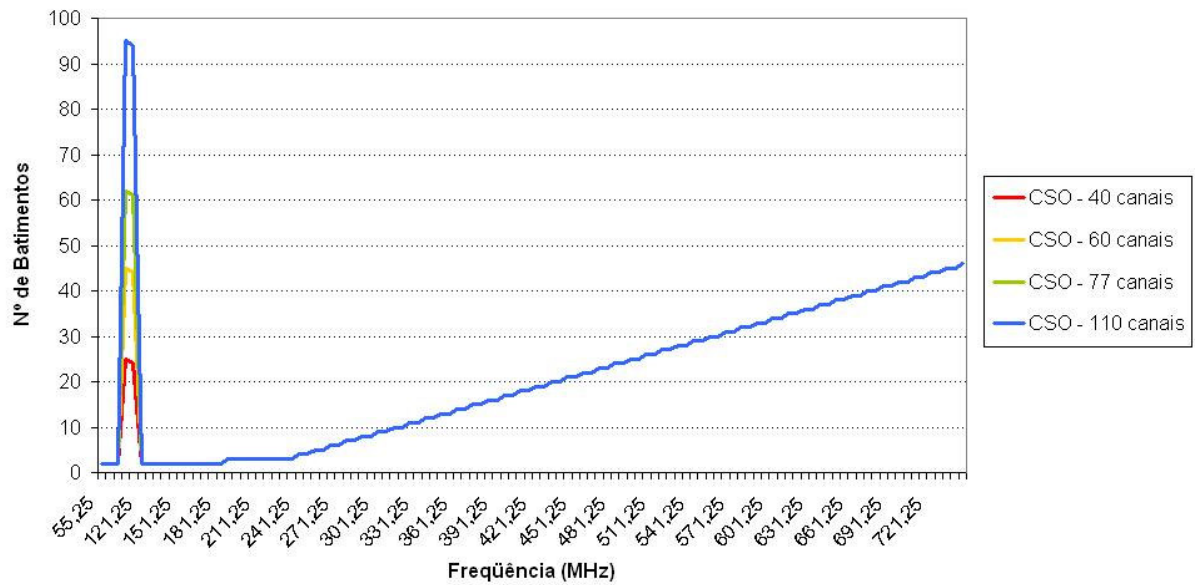


Figure 4.3 - Distorções de 2ª Ordem Composta [61]

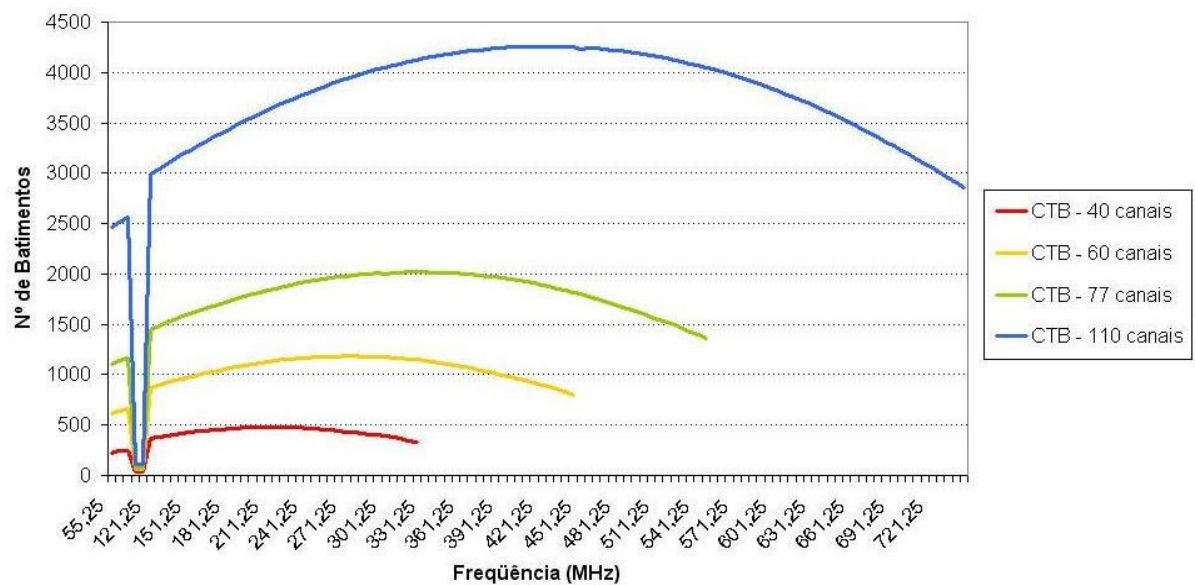


Figure 4.4 - Batimentos Composto de 3ª Ordem [61]

The Fundamentals of RF and Microwave Noise Figure Measurement [62] defines noise figure as the "...degradation in signal-to-noise ratio as the signal passes through the [device under test]." The most commonly accepted definition originated in the 1940s², which stated that the noise figure (F) of a network is the ratio of the

² Friis, H.T., Noise Figures of Radio Receivers, Proceedings of the IRE, July 1944, pages 419-422

signal-to-noise power ratio at the input to the signal-to-noise power ratio at the output: $F = (S_i/N_i)/(S_o/N_o)$.

In the previous example, the amplifier output CNR is 8 dB worse than the input CNR, so the amplifier noise figure is 8 dB. The noise figure of an amplifier is independent of input and output levels. Amplifier manufacturers try to reduce the noise figure by optimizing impedance levels and circuit design, and choosing low-noise transistors or hybrids. Typical cable TV amplifier noise figures are in the 7 to 10 dB range. Calculating downstream CNR in a cable network is generally done by first calculating the CNR of each type of standalone amplifier used in the network, and then calculating the CNR of the longest cascade of amplifiers in the network. The cascaded amplifier CNR is then combined with the headend and fiber link CNR using power addition. This exercise yields the overall CNR from headend to the network end-of-line.

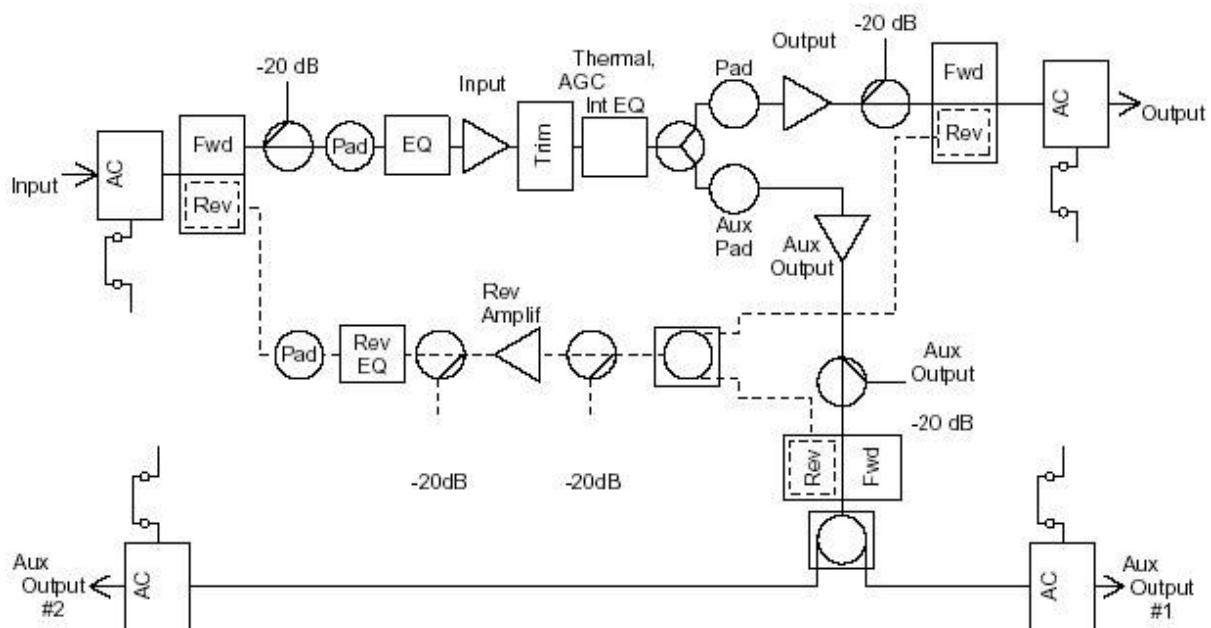


Figure: 4.5. –Amplifier Schema System Indoor – Scientific Atlanta

Graph Representation for TV Electronic Amplifier Configuration:

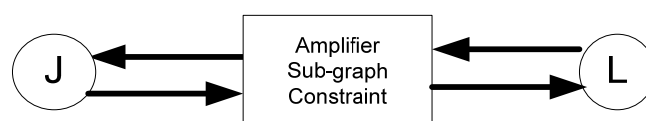


Figure – 4.6 - Equation Constraint Graph Representation for Amplifier

In Figure 4.6, node J and node L represent respective Input and Output amplifier nodes of Figure 4.5, where, inside it have a complete operation simplification of the electronic device equivalent circuit in the frequency domain considering in only one simplification equations C1,C2, that's is the optimization result of full sub-graph constraint satisfactions.

$$C1: \quad CN = -NT + (O - G) - (NF + L) \quad (4.2)$$

Where:

CN : Carrier to Noise considering only one amplifier in Node (dB) (MDU)

NT : Power Thermal Noise (-59, 16 @ $BW = 4\text{MHz}$) (dbmv)

O : Amplifier Output RF Signal Level (dbmv)

G : Amplifier Gain (dB)

NF : Amplifier Noise Graphic Figure (non linear graph) (dB)

L : Insertion Loses of Equalization Amplifier (dB)

$$C2: \quad EQ = \frac{\Delta_{op} - \Delta_{med_{in}}}{\left(1 - \sqrt{\frac{f_{m_{chL}}}{f_{op_{system}}}}\right)} \quad (4.3)$$

Where:

EQ = Equalization Factor (TILT correction)

Δ_{op} : Input differential operational Gain (dB)

$\Delta_{med_{in}}$: Differential Input Gain (dB)

$f_{m_{chL}}$: Frequency of forward lower channel (MHz)

$f_{op_{system}}$: Operational frequency of the system (MHz)

$$C3: \quad NP = NT - 10 \times \log(BW) \quad (4.4)$$

Where:

NP : Noise Power per Hertz – Carrier Forward

NT : Power Thermal Noise (dbmv)

BW : Bandwidth rate Thermal Noise measure (Hz)

$$C4: \quad NP_{ret} = NP - 10 \times \log(BW_{ret}) \quad (4.5)$$

Where:

NP_{ret} : Noise Power per Hertz – Carrier Reward

NP : Noise Power per Hertz – Carrier Forward

NT : Power Thermal Noise (dBmV)

BW : Bandwidth rate Thermal Noise measure (Hz)

$$C5: \quad CNR_{ret} = -NP_{ret} + (I_{ret} - P_{diplex} - P_{combiner}) - NF_{ret} \quad (4.6)$$

Where:

NP_{ret} : Noise Power per Hertz – Carrier Reward

NP : Noise Power per Hertz – Carrier Forward

I_{ret} : RF Input Power Level Reward sense (dBmV)

P_{diplex} : Reward Power Level Diplexer Filter (dB)

$P_{combiner}$: Return Amplifier Combiner Power Level insertion loses (dB)

NF_{ret} : Return Amplifier Noise Figure

$$C6: \quad CSO = CSO_0 - (AO - OR) + LC + 0,33 \cdot TC \quad (4.7)$$

Where:

CSO_0 : CSO Sum of identical second order Beat Ratios (dB).

OA : Signal Output operational level on amplifier (dBmV).

OR : Signal Output referential level on amplifier (dBmV).

LC : modificação do número de carregamento de canais no amplificador (dB).

TC : Differential Amplifier Gain (tilt) (dB)

$$C7: \quad CTB = CTB_0 - 2 \cdot (AO - OR) + LC + 0,8 \cdot TC \quad (4.8)$$

Where:

CTB_0 : CTB Carrier Triple Beat referential manufacturer level (dB).

OA: Operational Amplifier Level Output (dBmV).

OR: Operational Reference level on Amplifier (dBmV).

LC: Number of loading channel in the Amplifier (dB).

TC: Differential Gain modification (tilt) (dB)

The adoption of the new Inside Home Wiring Rules It will also enhance the availability to the industry and the public of cable system and multichannel video programming systems information In Figure 4.7.

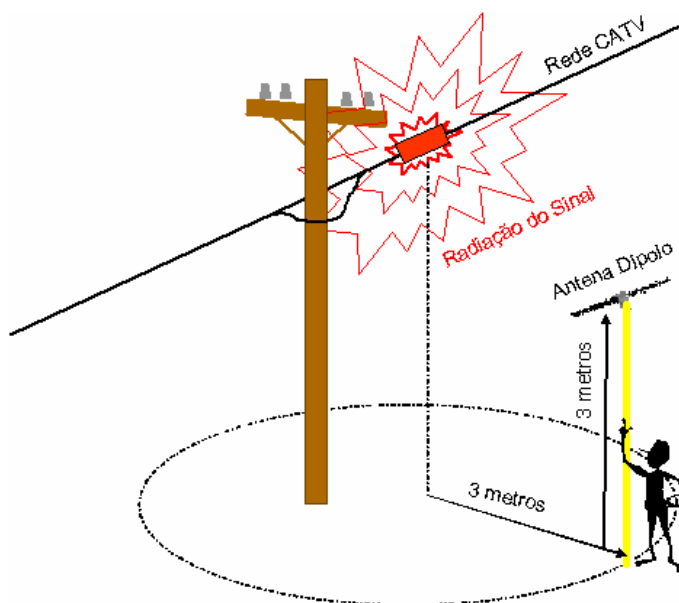


Figure 4.7 – Signal Radiation (leakage) measure method [61]

The Cumulative Leakage Index (CLI) is presented, second the FCC (Federal Communications Commission), regulamentation 76.611,

Where:

L : The Length network susceptible to signal radiation (Km);

E_i : Electrical Field in 3m length ($\mu\text{V/m}$);

R_i : distance of inclination of the power irradiation signal for one point at 3000 meters of the Center system or Cable TV Network (m);

n_i : number of radiations of level higher than $50\mu\text{V/m}$;

For each amplifier the C1, C2, C3, C4, C5, C6, C7, equation Graph is visited and

further increased. Due the incremental nature of the implementation engine, is proportionally to number of equations gain efficiency for a larger number of equations.

4.3– The Constraint data model for Network RF Amplifier

Figure 4.8 are shows constraint-base to represent the indoor Amplifier and one Splitter. In the MDU Schema on the left is presented the physical representation for the connection between one amplifier (in door) connected to a splitter by coaxial cables. On right, the Geometric Graph presents the existent relation of geometric constraints by each one, the amplifier A1 and for the splitter S1. Finally, the Equation Graph on the right is illustrated by the equation 4.2 particular equation graph to the amplifier A1.

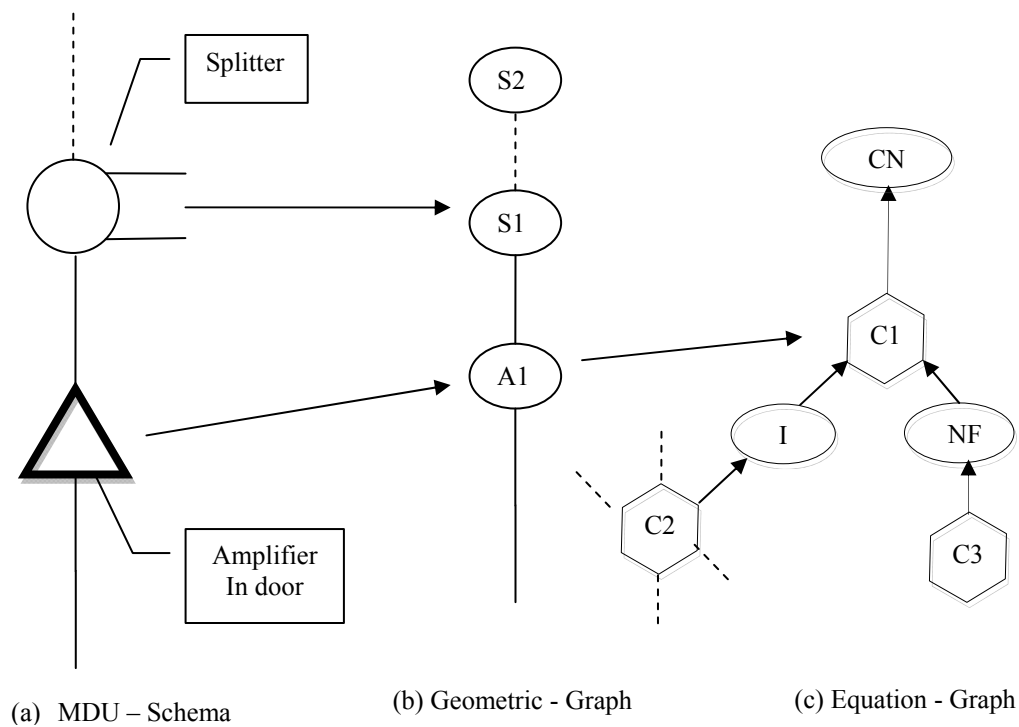
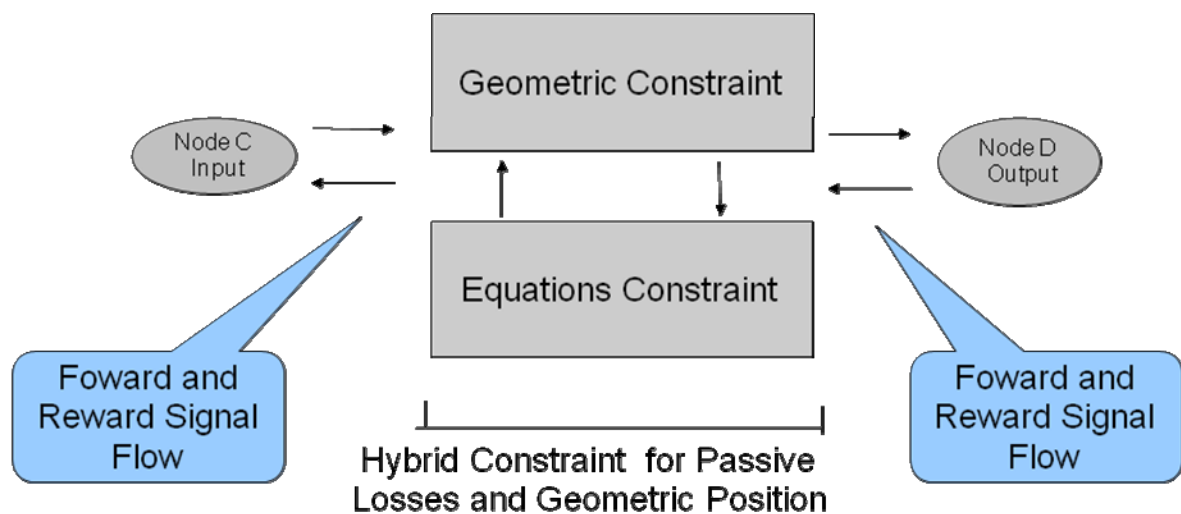


Figure 4.8 – Graph representation of an Amplifier and Splitter

4.4– The Constraint data model for Passive HFC Network components

For the general HFC network applications, it is common to use the following passive components: Splitter, Equalizer, RF Cable, Cable Simulator. Figure 4.9 present a general data model for the passive components logical information, and for each different component the equations and particular characteristics are used. But, the data model and relationship graph will be very similar, specially in the algorithm functionality.



Representation for : RF cable, Cable Simutator, Directinal TAP

Figure 4.9 – Constraint data model for HFC Passive Components

4.5 – Constraint Satisfaction

The engineers, at the design work, realize a definition for the steps to the project conception. The floor numbers of the MDU schema and the position of the indoor amplifier are necessary to control the forward and reward signal level on the network elements in a sequential process to perform constraints satisfaction.

The geometric and equation constraints satisfaction, occur at the same process for all components as an Indoor Amplifier, Splitter, Equalizer, coaxial cable and others. Although, the equations are different for each component, the equations satisfaction will be realized after the geometric constraints are satisfied. The Figure 4.8b and Figure 4.8c represent the Geometric and the equations set for one in door Amplifier at the design time. When is defined the amplifier position A1, its equation set C1 is placed.

4.6 – Summary

This chapter has presented the considerations for implementation of a Hybrid Constraint Solver System to manipulate and to compose a complete graph data base to represent the MDU electronic design. At the next chapter is detailed the implementation of the constraints as engineering equations and geometric constraints to complement the connectivity of nodes and compound separated electronic HFC network elements at the memory in the design process.

Chapter 5

Implementation Details

5.1- Introduction

This chapter presents some implementation details of the system proposed and discussed in previous chapters, focusing on the internal MDU (Multiple Dawdling Unit) design, and use the same concept data model. The demonstration of the algorithms proposed is described using a constraint implementation and a constraint manager engine data model for satisfying the engineering equations.

5.2-Constraint Engine Modules Architecture

An Amplifier geometric position A1, (Figure 5.1a), place a set of equations C1, C2 and C3, (Figure 5.1b). The equations C2, C3, provide results to C1. The equation C2 corresponds of the equation graph representing a cable that brings the signal until the Amplifier A1, and it's result in the value of the variable I. The variable NF is a result value obtained in the graphic Figure Noise, which depends of the Amplifier manufacturer in Figure 4.3 and Figure 4.4. The equation constraint C3 is a hard constraint, [106,107]. The design work to insert the Amplifier symbol communicates with the geometric graph and equation graph between the AutoCAD API.

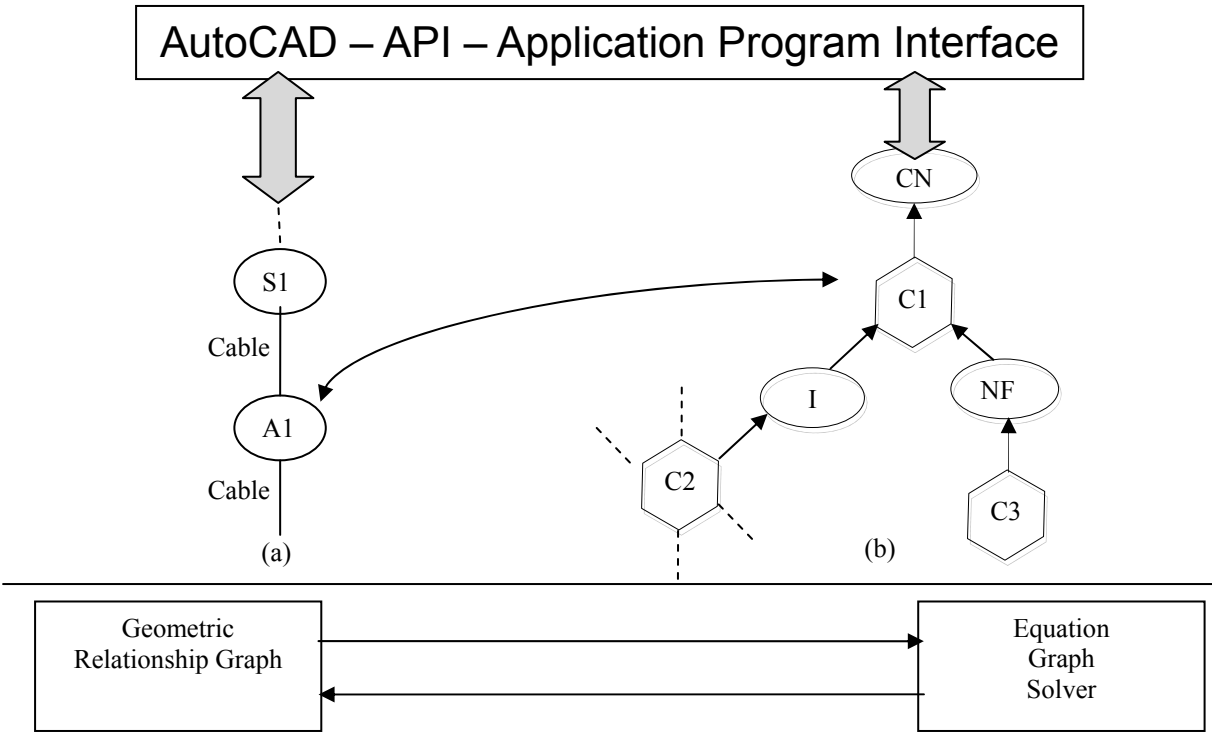


Figure 5.1 -Hybrid Constraint Engine

5.3 – The Representation of Constraint Equations and Variables

All constraints equations and variables nodes are implemented as classes (object-oriented programming).

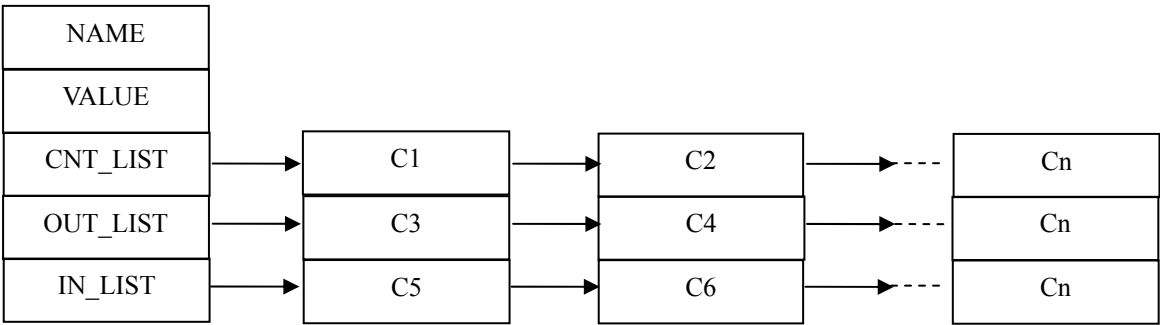


Figure 5.2 – Variable Node Data Representation

Figure 5.2 represents the definition of the main data members of the variable node. The NAME is a String of the variable name, the VALUE is the numeric value of the variable, and the others are pointers.

5.4 – Building the Geometric Graph Process

Nodes representing the geometric entities and a set or arcs for geometric constraints compose the Geometric Relationship Graph. The direction of the arcs defines the geometric direction and the propagation changes are propagated in the design.

The Implemented Graph configures a relationship between two geometric entities, and these entities are referred to as reference and target geometric entities, according to graph pointers. This information is stored as the fields RefGO and TarGO, denominated as Constraint Edge, in data structure Figure 5.3.



Figure 5.3 - Geometric Constraint Edge

In this case, is the data structure used to define the main data member of a node in the relationship graph. The GEOMETRY field maintains a pointer to the geometric entity created by the Constraint Manager.

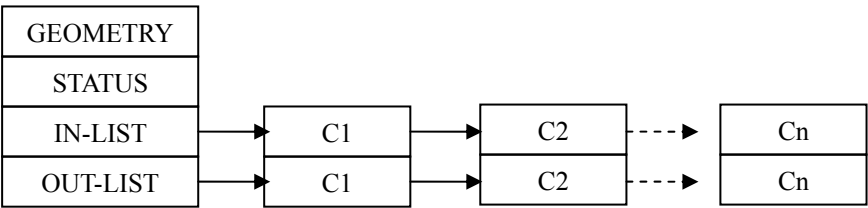


Figure 5.4 – Node Relationship Graph – Data Structure Representation

- GEOMETRY – Maintain a pointer to the geometric entity (AutoCAD Handle).
- STATUS – Indicate the (Inheritance) “logical position”.
- IN-LIST and OUT-LIST – Indicate the connection of geometric entities representing the design model inside the graph.

5.5 – The Graphical User Interface (GUI)

The GUI is based on AutoCAD MAP – SDK – Software Developer Toolkit. [Customization Guide Autodesk]. The capabilities of AutoCAD MAP interfaces interaction provide a power tool to follow the computer graphics standards and open source concepts to implement and easy to adopt tool and open source data base model, for many different acknowledgments areas of science research. The AutoCAD®-based interface is a good tool for extend design information to users in a huge and traditional CAD community.

Objectives for Interact with AutoCAD – GUI environment and Constraint Manager Interface:

- Deliver a product that requires CAD software functionality but is not targeted at traditional CAD users.
- Build products that can read and create DWG™ files that are fully compatible with AutoCAD DWG files.
- Create host programs that run an application in a child window or through a web page.
- Deliver products with scaled feature sets at scaled price points and provide an AutoCAD-based platform that cannot be customized or extended by end users
- Replace an aging CAD software system and take advantage of new AutoCAD software technologies.

Features benefits to use products built with AutoCAD® OEM software are, the development platform can read DWG™ and DXF™ file formats for every version of AutoCAD software through AutoCAD® and can write DWG files for AutoCAD® software R14 or its later versions. DXF files can be written back to the AutoCAD® software Release 12 version. A Capability to create host programs that run AutoCAD OEM design software in a child window, Microsoft® Windows® .NET Form, or through a web page. This development platform, provide a full control of the level of AutoCAD® functionality exposed to users end also provides encryption and binding security mechanisms that prevent copying or reverse engineering of code software programs.

5.6 – Database Fundamentals – Symbol tables, Transactions (AutoCAD –API)

AutoCAD Drawing Database (DWG) is represented in Figure 5.6, and allow the **User Interaction GUI a Simple User Input and Entity Selection** the capabilities below:

- In-Memory representation of the Dwg File
- Objects are stored hierarchically in the database - Db Structure
- All objects have identities – Objectid, like *Primary Key* in a relational database
- Objects are always accessed in a transaction
- The transaction defines the boundary of database operations
- Objects have to be opened first in a transaction before they can be used
- Objects can refer to other objects – such as a line having a reference to a layer

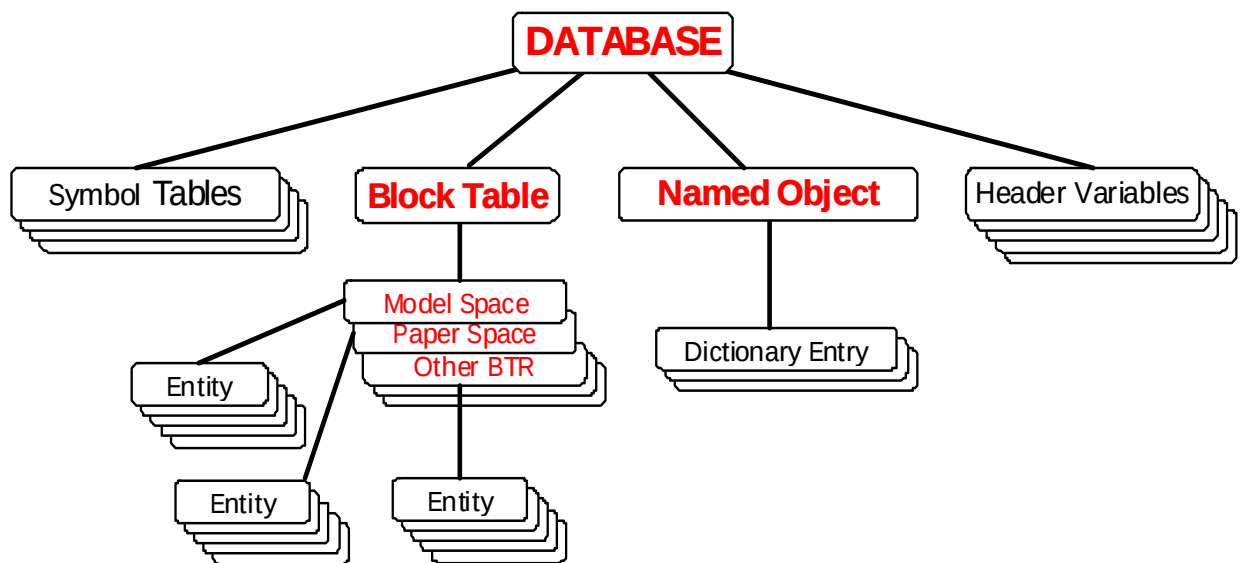


Figure 5.6 - Database Structure [Customization Guide Autodesk-2008].

- Database Components – GUI
 - o Symbol Tables
 - Examples Layer Table, Line type Table, Text style Table etc.
 - Containers to store Symbol Table *Records*
 - Example LayerTableRecord, LinetypeTableRecord etc

- All Symbol Tables have common methods of a container such as
 - Add – to add a record
 - Item – to lookup an entry with a search string
 - Has – To know if an entry exists
 - Is enumerable
 - Each symbol table can hold only records of a specific type
 - For example, a LayerTable can hold only LayerTableRecords
- Use SnoopDb to see where the Layers reside

User Interface Design

- AutoCAD Defined
 - Menus – Application level menu, Context menu
 - Dialogs
 - AutoCAD's Enhanced Secondary Windows (Palettes)
 - Color, Linetype, Lineweight, OpenFile dialogs
 - Tabbed Dialog Extensions (to Options Dialog)
 - Status Bar
 - Tray
 - Drag-Drop
 - And more. Explore Autodesk.AutoCAD.Windows namespace
- Windows Defined
 - Windows Forms (Winform)
 - Host of other controls defined in CLR
- Add Context Menu
 - Application
 - Level – Application.AddDefaultContextMenuExtension
 - Object Level – Application. AddObjectContextMenuExtension
- Showing Modal and ModelessDialogs
 - Application.ShowModalDialog
 - Application.ShowModelessDialog

- Persists size and position automatically

Handling Events

- Event
 - message sent by an object to notify something has happened
 - message is received in a function call by one or more listeners
 - event sender only requires function pointer to dispatch a message
 - any interested party can implement the function and receive the event
 - function must have a specific signature that the sender requires
 - Use .NET delegates to 'wire' sender and receiver
- Delegates
 - Like a class (can be instantiated) but with a signature
 - Holds references to functions having same signature
 - Like 'Type-Safe' function pointer
 - Can encapsulate any method that matches the specific signature.

5.7 –Software Work Process and Interactions GUI – Constraint Manager

A process representation necessary to establish between a Constraint Manager Creation topology and the graph representation (logic memory), including Geometric and Engineering Constraints to carried process by the user and the information flow are as follows:

- The user selects to create a symbol representation- Design Symbol.
- The AutoCAD interface creates a Node for the symbol insertion and node creation.
- The event handle request to the constraint manager to node point inclusion.
- The constraint manager starts to construct a Relationship Graph (RG) node and sub graph to represent the node.
- The constraint Manager passes the coordinates of the line segment to AutoCAD symbolic display.
- The GUI display the node position and the repetitive symbol inserted.

The connection between nodes process are:

- The user select to create a connection cable or wire to perform a link between one start node and next node (if it exists or not) represented by a segment line.
- The AutoCAD creates a Node or use a preexistent node to define the line segment nodes (arc representation) of the RG.
- The Constraint Manager creates a line segment in memory and the AutoCAD represent a line segment.
- The Constraint Manager constructs a RG node and an Equation sub graph to represent the node.
- The Constraint Manager sends the coordinates of the line segment to AutoCAD for display.
- The AutoCAD display the line segment.

Some variables of the equation Graph are automatically created during the geometric entities creation, and other need to have an user interaction. The user selects s to create or interact from a Variable menu option. The AutoCAD event handler sends a request to the Constraint Manager to create an additional variable (e.g. frequency value). The Constraint Manager creates a node in the Equation Graph to represent the variable.

- The user selects to create an engineering constraint from the Engineering Constraint properties of equipment devices characteristics or cable type signal level attenuation modified by the user in the properties engineers menu.
- The AutoCAD send to Constraint Manager the graph node constraint in the Graph Equation.
- The POSITION and OUTPUT fields for the constraint equation node are updated [51], [58].
- After updating the constraint dependency, the descendant nodes are locally satisfied trough constraint topology propagation. The geometric representation is presented by AutoCAD interface updated screen.

5.8 –Summary

The satisfaction of coupled engineering and geometric constraints through the Equation Based Approach and geometric constructive approach integrations is made by the integration of both procedures, and result in a graph topology database.

This chapter has described the implementation process of the constraint database model proposed in this thesis.

The implementation is composed for the main components: The GUI – Graphical User Interface and the constraint manager. The GUI is based on AutoCAD – API (Application Program Interface) and Object Oriented Classes methods. The Constraint Manager use Graph-based methods to maintain the geometric information used for AutoCAD API – to update the design geometry. The chapter present the process detailed work to maintain the interaction of these components, and , the Equation Graph using the dynamic updating as the implementation

Next chapter, presents the results and discusses advantages and limitations of the prototype implementation and usage.

Chapter 6

Results and Discussions

6.1 – introduction

The chapter goal is to demonstrate the practical implementation of the Constraint Data Model to use for Electronic TV Network Building design discussed in previous chapters. Finally, the limitation and future improvements are discussed in this chapter.

6.2 –Main Features of Implementation

Constraint-based Implementation to support an Electronic TV Backbone Internal Design, Figure 6.1 – Consideration for an MMDS – MDU – Application – Case Study, In Figure 6.2 - Similar Case Study for a Wired Network distribution using common HFC Metropolitan Connection (Last Mile) - Implementations

As the design process, the following results are obtained:

- The constraint based model allows designing electronic TV projects using the best performance signal efficiency.
- The interactive environment increase the engineer concepts application in the geometric design – supported by the incremental nature of the algorithm.
- The work automation gives an approach in time to design.
- Reduce design costs through the built of material

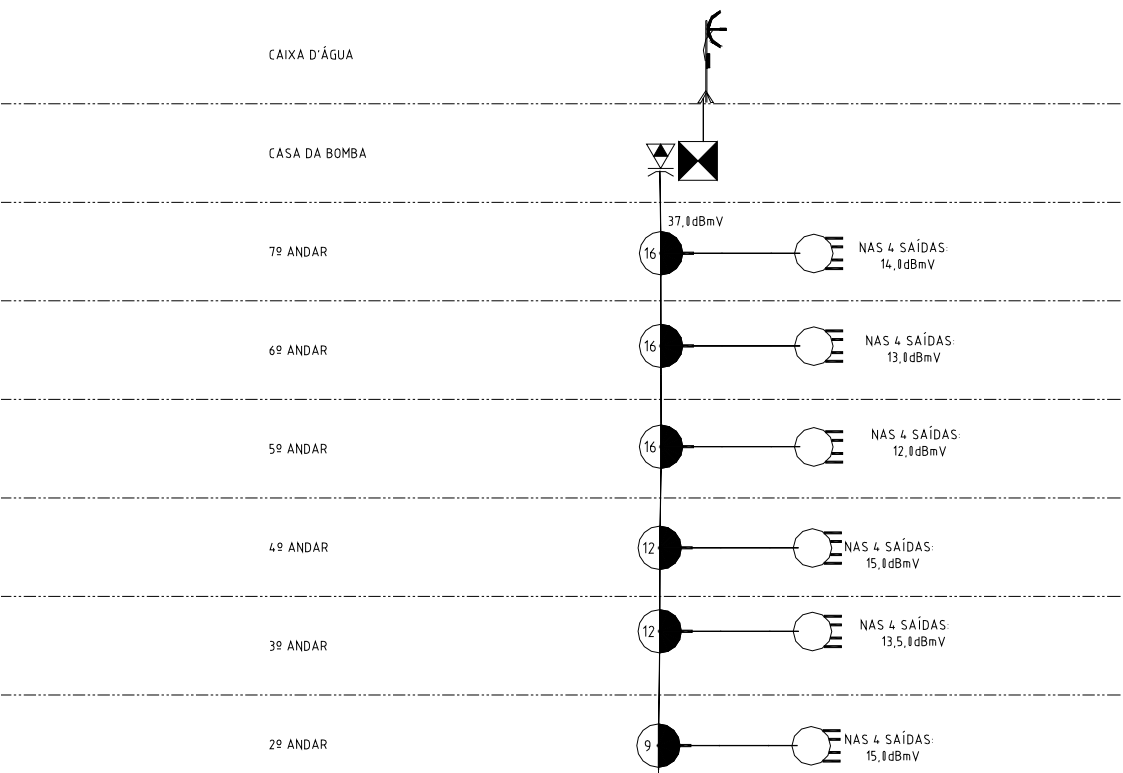


Figure 6.1: Case Study Design Model – MMDS –Backbone MDU TV – Network Design

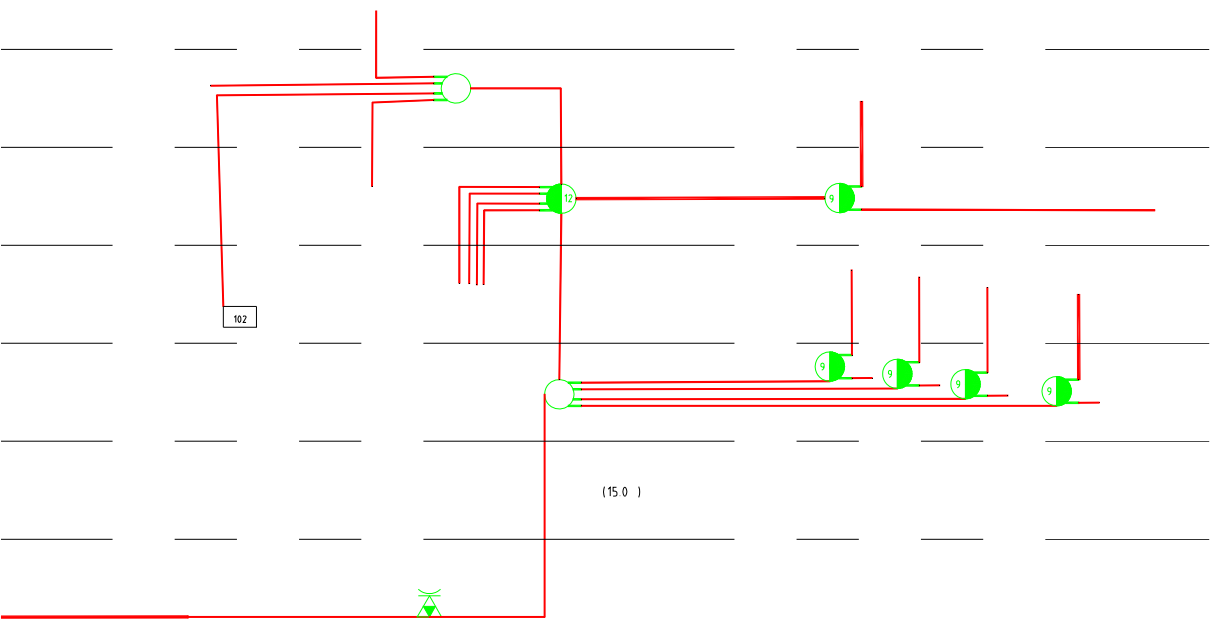


Figure 6.2- Case Study – Design Model – Wired Cable Backbone Internal Design – MDU

The MDU (Multiple Dwelling Unit) Internal network design for this thesis is in practice case of this propose, the same: for cable wired connection as the Case Study at Figure 6.2 and for the MMDS (Microwave Multichannel Distribution System) at Figure 6.1.

The only differences for our case study analysis are the standard frequency for the Forward Signal a Reward Signal, but all engineer constraints equation model are the same. The principal consideration is for Standard Wired Connection is common used frequencies for Forward Signal Between (750 MHz and 1 GHz), and for MMDS the Forward frequency is normally at 550MHZ in Higher Forward frequency. Therefore, for the equations satisfaction the only significant difference will be the signal level loses in the Cables used in the internal distribution network cables and devices like Splitters, Equalizers and In-Door Active Amplifier specification. For consideration in software algorithms are the same steps and graph topology data model.

6.3 – The incremental Process for Electronic TV Network Design

This section proposes are show the Case Study and its incremental constraint equations solving design cycle. The first step, is to have the insertion channel level as a result of the reception level of Down Converter (Case of MMDS – Figure 6.1), and the insertion signal level that is placed by last mile network HFC cable, direct in the external TAP (preview parameter defined in the external design network, Figure 6.2. The average level to consider in this Case Study is (Figure 6.3):

Amplifier Input:

Forward Signal Level for Higher Channel: 22 dBmv

Forward Signal Level for Lower Channel: 18 dBmv

Reward Signal Level for Higher Channel: 18 dBmv

Reward Signal Level for Lower Channel: 17 dBmv

These above levels are measured in the nominal frequency of 750 MHz (Particular Reference for Case Study, *(SLM – Signal Level Meter) common Measure Device results*.

Adopting one Scientific Atlanta in Door Amplifier device for the Output level will be:

Amplifier Output:

Forward Signal Level for Higher Channel: 47 dBmv
Forward Signal Level for Lower Channel: 37 dBmv
Reward Signal Level for Higher Channel: 24 dBmv
Reward Signal Level for Lower Channel: 24 dBmv
Device Adjustments: Equalizer Forward value= 2 dB, Attenuator level PadFw=4 dB

Análise de Amplificadores

ENTRADA

FwH(dbmv): 22

FwL(dbmv): 18

RwH(dbmv): 18

RwL(dbmv): 17

SAIDA

FwH(dbmv): 47

FwL(dbmv): 37

RwH(dbmv): 24

RwL(dbmv): 24

Equalização

EQFw(db): 2

PadFw(db): 4

EQRw(db):

PADRw(db):

Selecionar Cabo <

Calcular

Inserir <

OK

Cancel

Figure-6.3 – Amplifier Calculation – User Interface Results

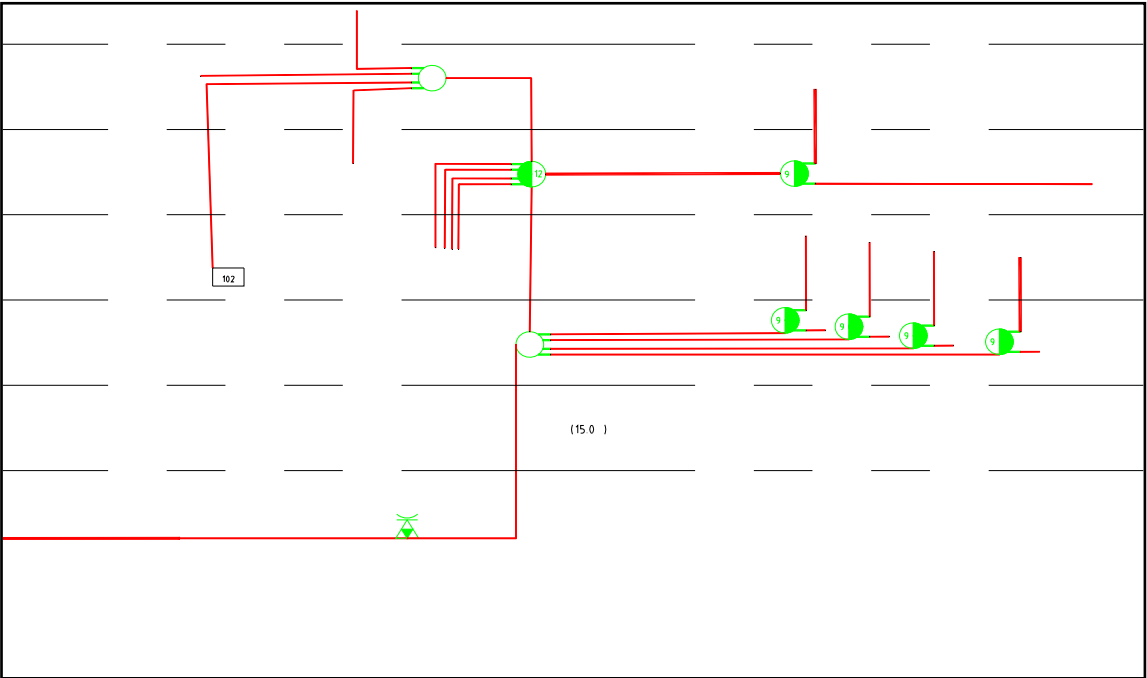


Figure 6.4 – MDU – Backbone Electronic Design

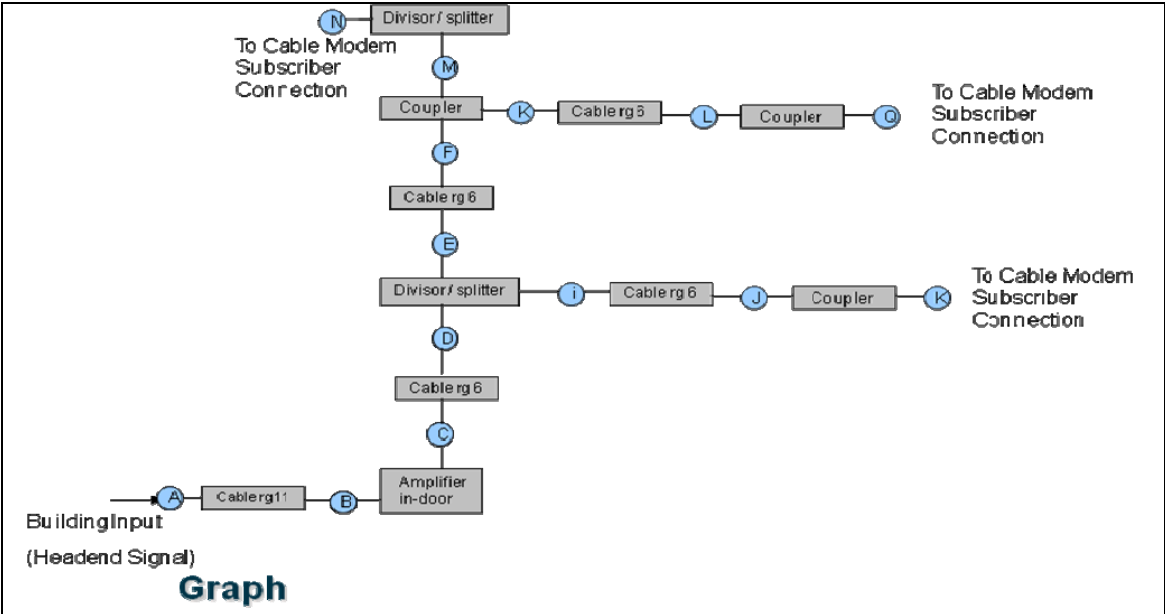


Figure 6.5 – MDU – Graph Representation of Electronic Backbone Design

Design Geometric Interaction and Graph Construction

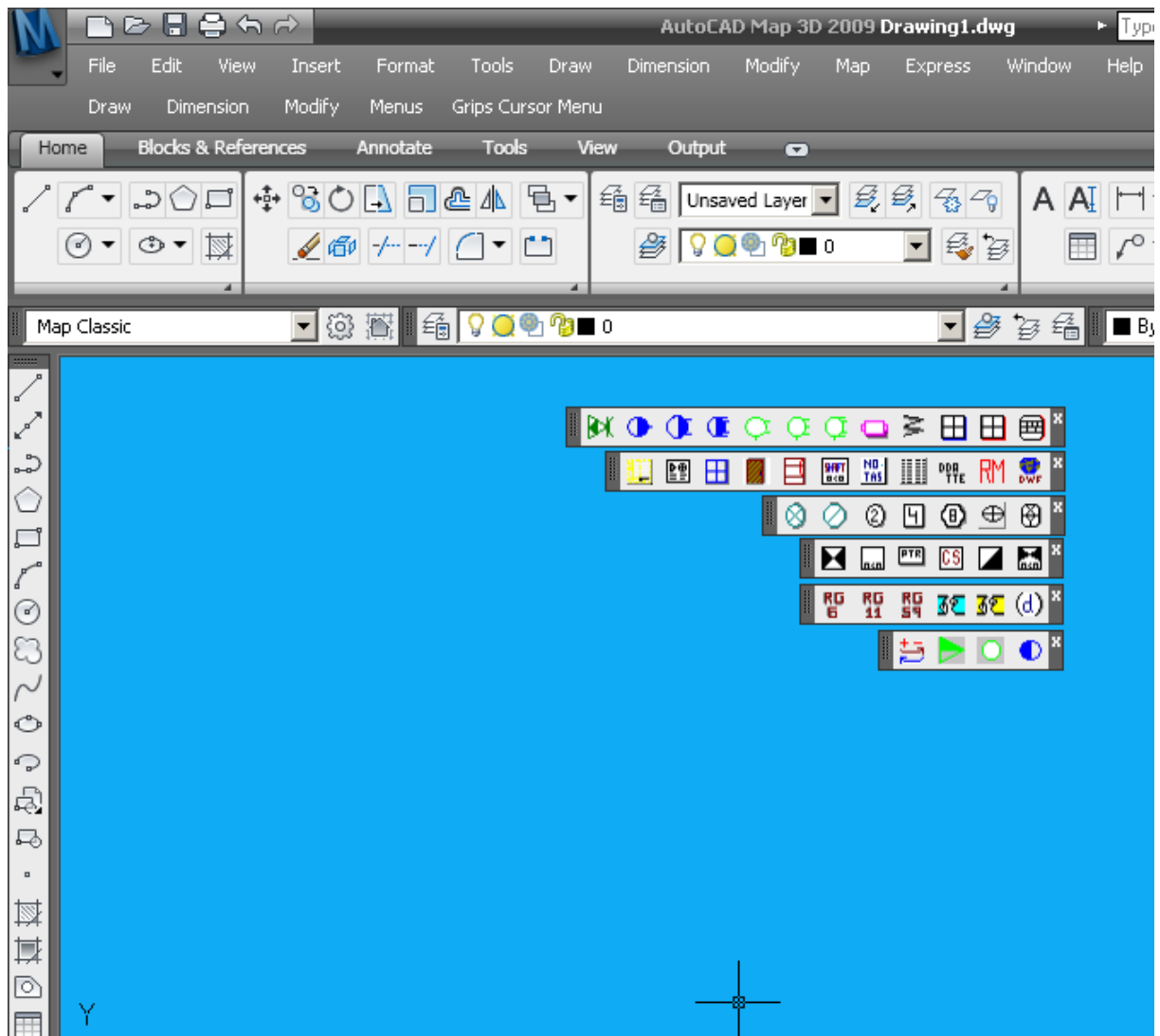


Figure 6.6 – AutoCAD and Constraint-based Implementation for Electronic TV Backbone Internal Design – Multiple Dwelling Unit

Figure 6.6 represent the interface of all commands and AutoCAD, developed to possibility for the user to work with the necessary procedures considering all components necessary for concept a good design of the Cable TV internal Backbone Building or common called MDU design. At this commands were placed the technical symbols representation to cover the most used components in cable TV in accordance of the standards requirements and physics representations.

One of the advantages of this implementations is to propose the complete tool to design the internal backbone, different of other applications that propose for large

TAP 2: Insert a 2 exits TAP.

TAP 4: Insert a 4 exits TAB.

TAP 8: Insert a 8 exits TAB.

Label: Insert a signal level label.

Label 2: Insert a signal label for amplifier.



Figure 6.11 – Design Boxes Symbols menu bar

From left to Right we have:

Internal Box: Insert an internal box preexistent.

Internal Box: Insert an internal box to build.

PTR: Insert a Cable connection symbol representation.

CS: Insert a Cable Simulator symbol representation.

Internal Telephony Box Wall: Insert an internal box symbol for telephony.

Internal Telephony Box shaft: Insert an internal box symbol for telephony.



Figure 6.12 – Design Cables Symbols menu bar

From left to Right we have:

RG6: Command to draw the RG 6 cable model.

RG11: Command to draw the RG11 cable model.

RG59: Command to draw the RG59 cable model.

Tub_tel1: Indicate the preexistent telephone ducts to use in the backbone design.

Tub_tel2: Indicate the new duct to be used in the backbone design.

(d): Indicate the Distance of CATV cable for illustration proposes.



Figure 6.13 – Signal Calculation Menu bar

Cable Calculation: Start the signal calculation engine for cable analysis.

Amplifier Calculation: Start the signal calculation engine for video indoor Amplifiers.

Splitter: Start the signal calculation engine for splitters.

Equalizer: Start the signal calculation engine for equalizers.

6.4 – Design Process for Electronic TV Network – Case Study

The sequence steps of the work to perform a design is described, in the following figures, as a logical method to design an internal network of a MDU. At figure 6.14, the first introduction message is shown:

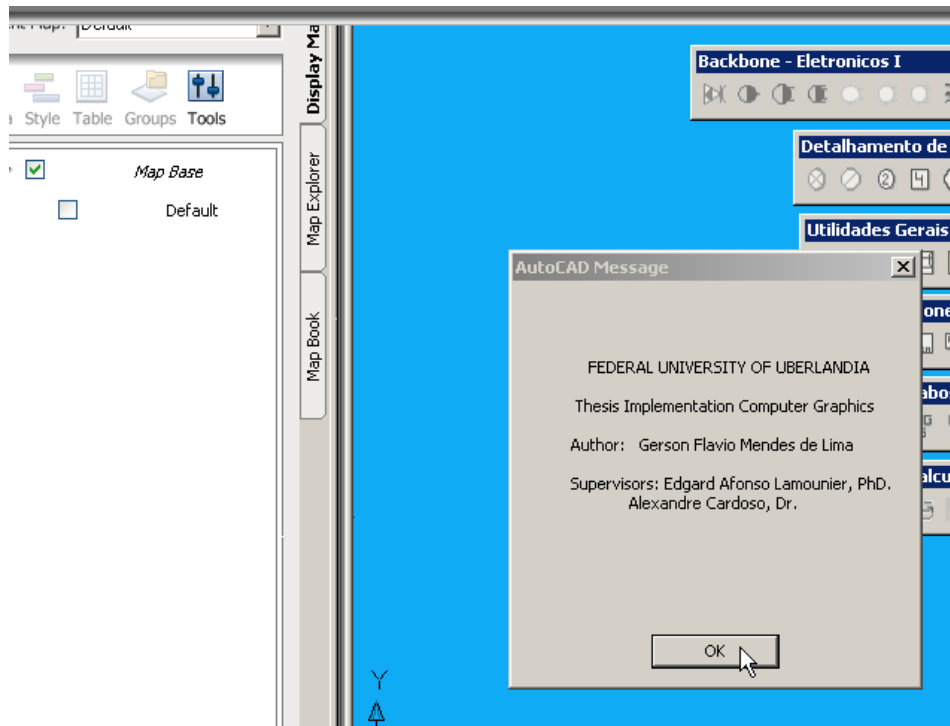


Figure 6.14 – Introduction Message

After the introduction message, the implementation program request to adjust for the frequency to work, Figure 6.15:

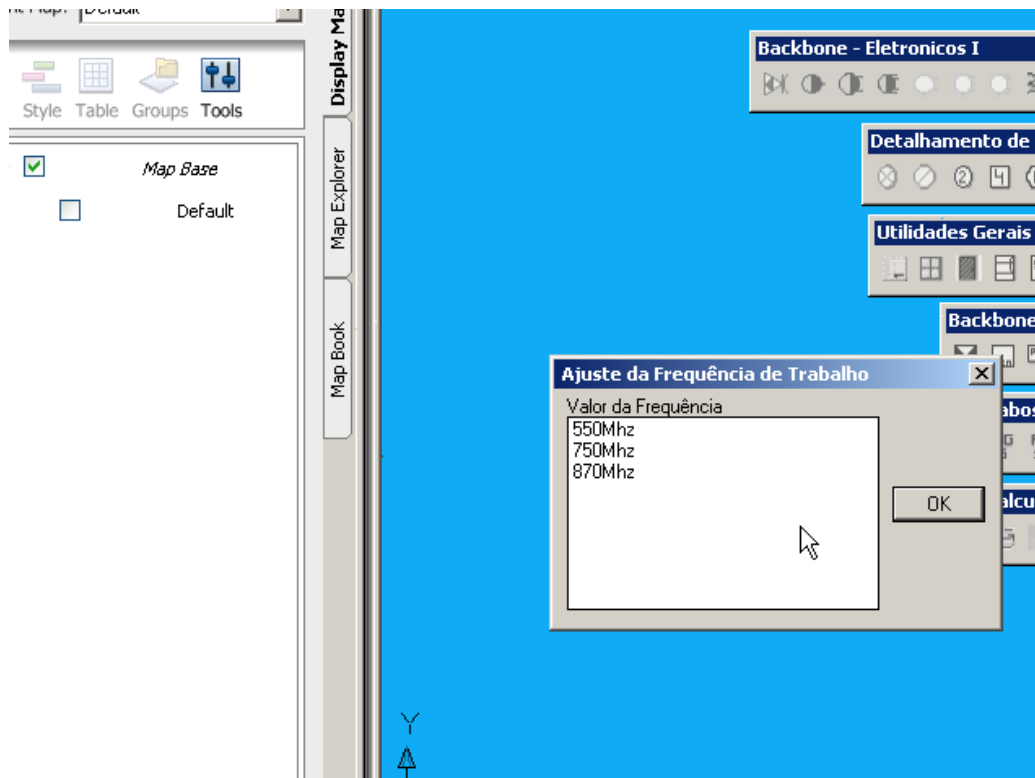


Figure 6.15 – Frequency Information adjust

Following, are requested the number of floors of the building, as presented in Figure 6.16:

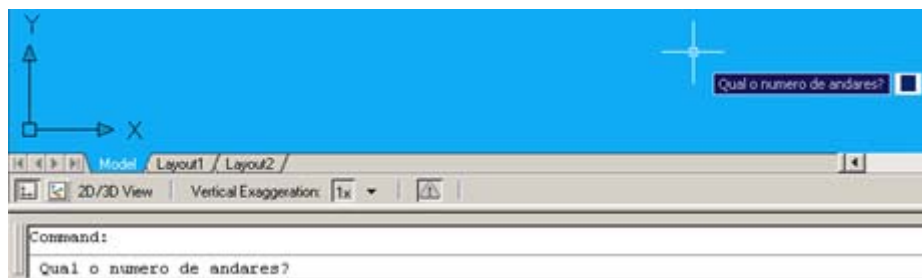


Figure 6.16 – Request for the number of Floors (andares)

Since is defined the number of floors, the user must set the identification description of each one, until all building pavements are identified, Figure 6.17

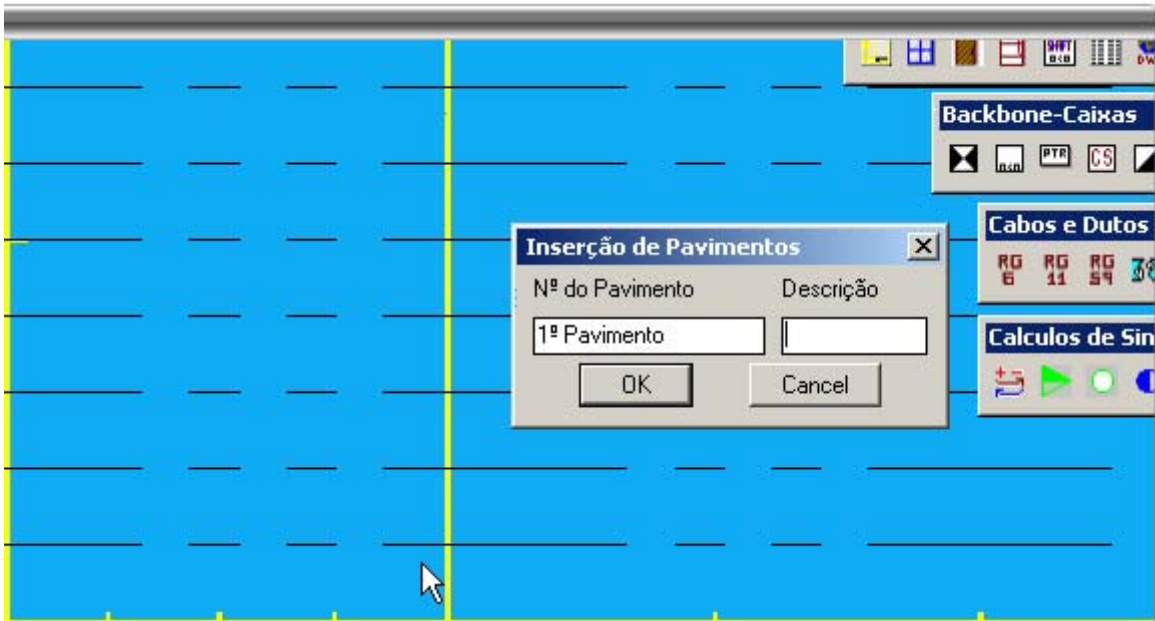


Figure 6.17 – Floors identification and description

To certificate the complete identification of the MDU, is requested the attributes information of the building address location, optical node source signal, design date, drop identification, relevant observations, and revision date, as presented at Figure 6.18

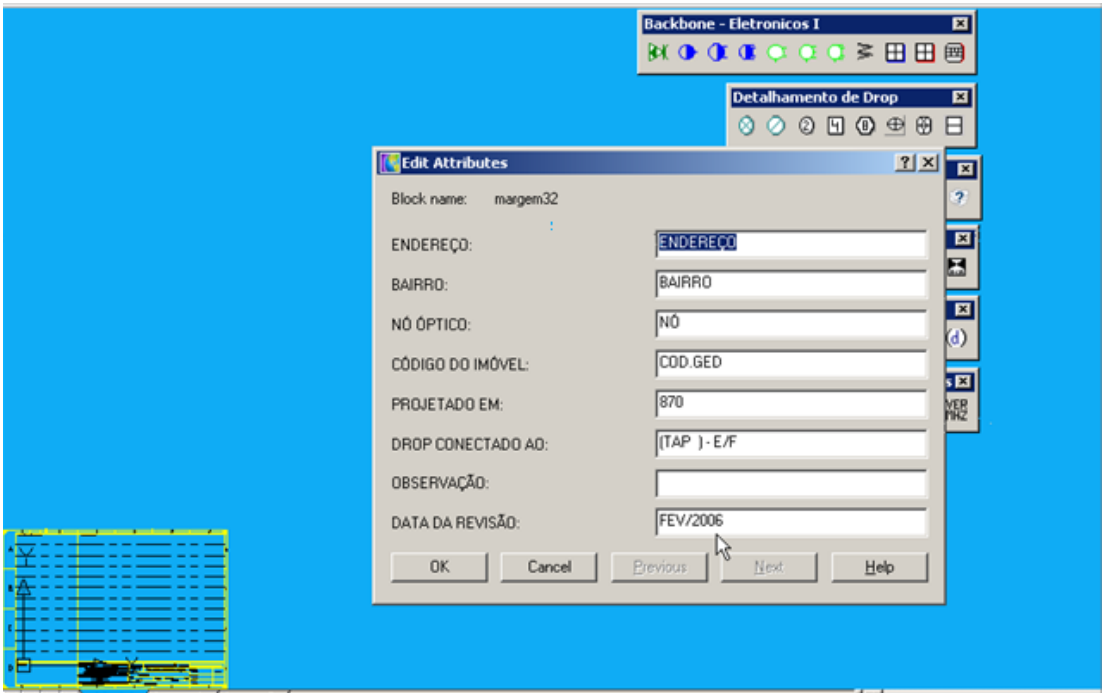


Figure 6.18 – MDU address identification attributes

At Figure 6.19, is detailed the next design step, instead the coaxial Cable RG11 is the first connection type before the Indoor placement, as shown:

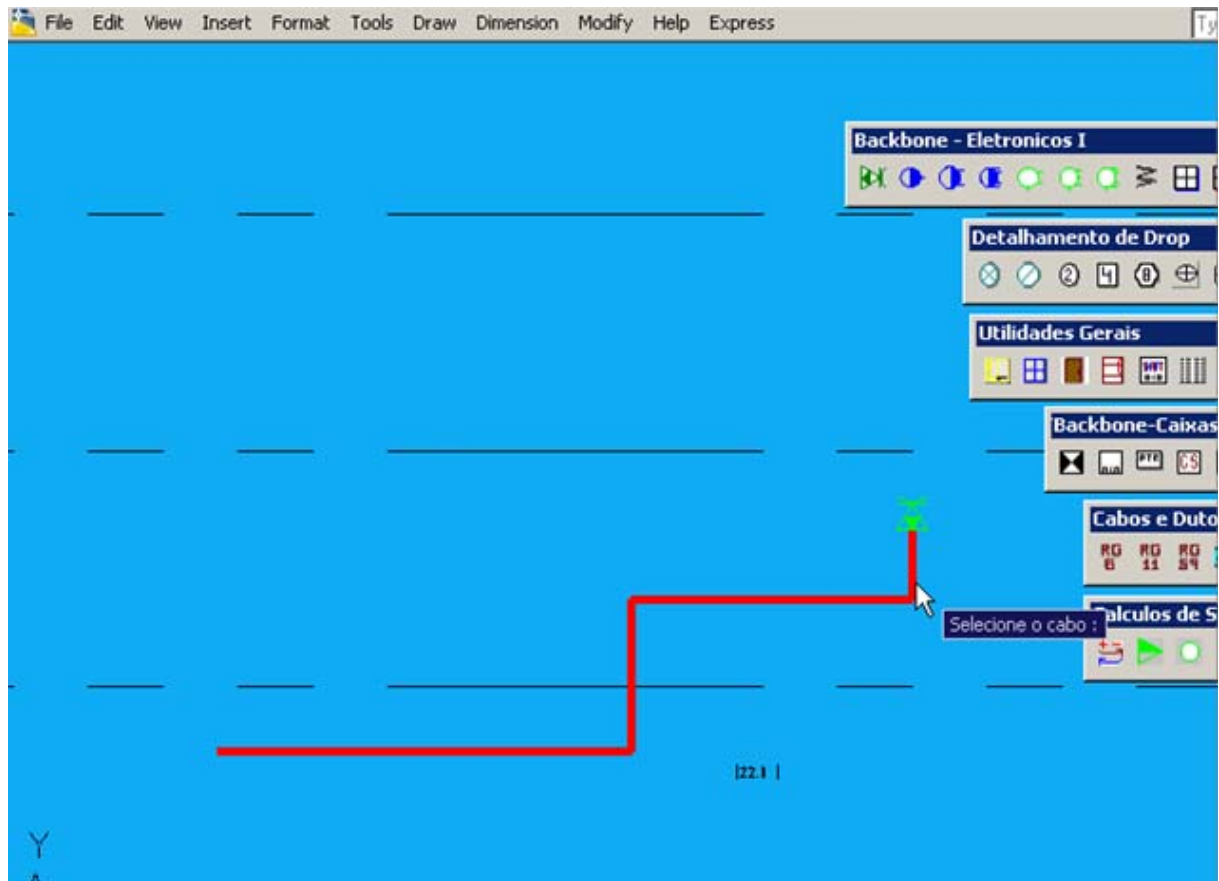


Figure 6.19 – Cable RG11, and the indoor placement

Is important to highlight, in this implementation, the design is presented in schematics view, without scale, and the cable length are inserted as a text to provide an easy to read draft for the user. In the Figure 6.20, the results of equations presenting the signal levels are inserted automatically in specific labels.

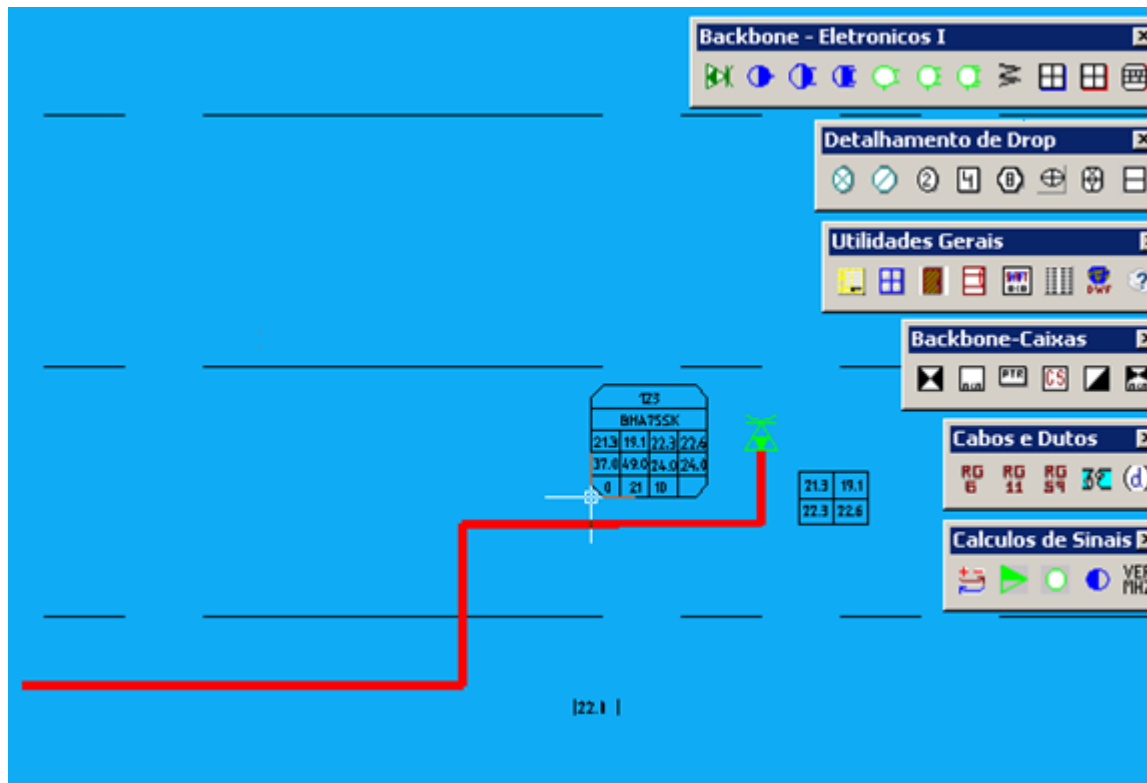


Figure 6.20 – Amplifier levels and adjustments and Cable Fwd and Rwd Levels inserted as labels

In Figure 6.21, the continuation of the design process is presented until the first Splitter, and connected by a cable RG6 with 15 meters length.

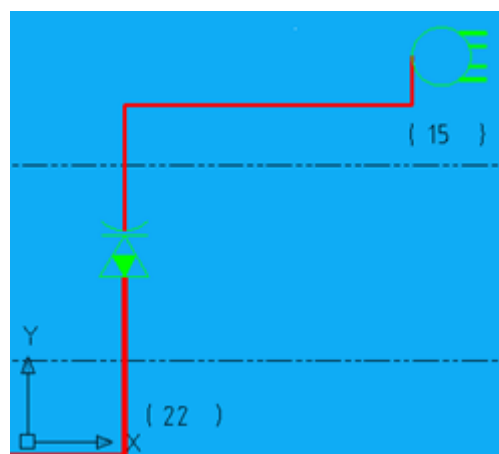


Figure 6.21 – Connection between Indoor and a 4 Way Slitter

The first branch of the 4 way Splitter is connected to an 2 Way Equalizer representing a internal loses of 9 dBmV, presented in Figure 6.22:

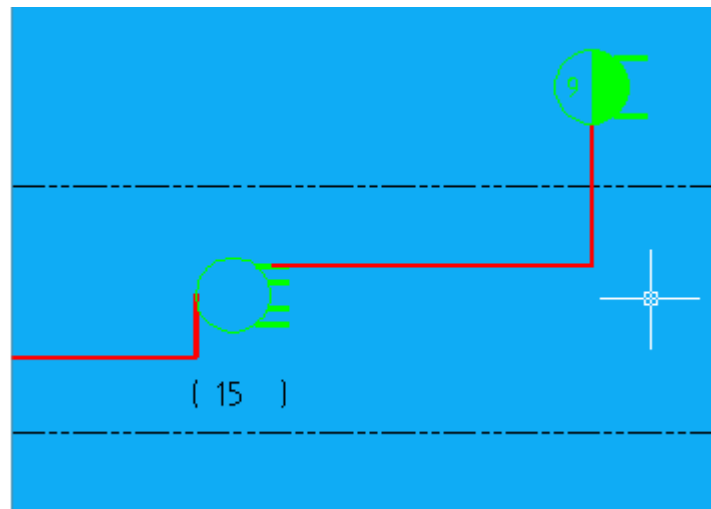


Figure 6.22-Connection between a 4Way Splitter and an Equalizer 9 dBmV

In Figure 6.23 is presented a label representing in its first row the respective signals FwH (Forward High) and FwL (Forward Low), representing the highest frequency and the lowest frequency used to modulate a video channels. The second row represent the RwH (Reward High) and (Reward Low) corresponding to a reward frequencies channels.

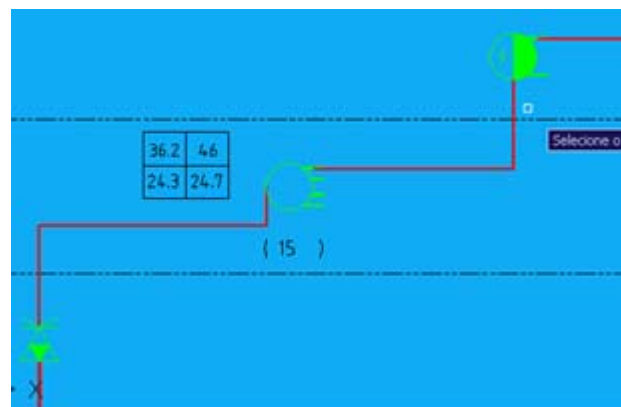


Figure 6.23 – Label of signal levels FwH / FwL and RwH / RwL.

The same information is presented in Figure 6.24, where are presented the labels of Splitter and the following sub sequential Equalizer.

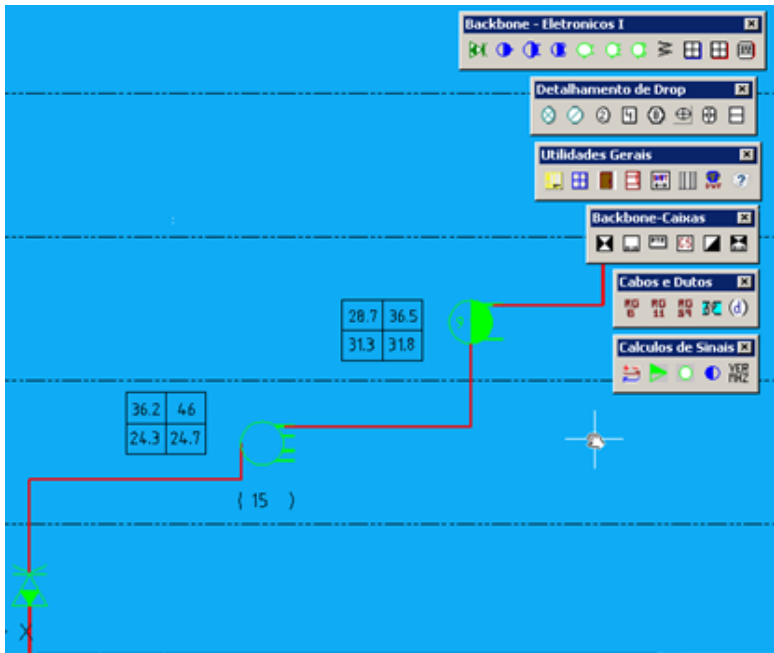


Figure 6.24 – Splitter and Equalizer level labels

The signal propagation over the network will automatically generate a insertion of labels representing the resultant signal levels of the proposed network architecture in Figure 6.25.

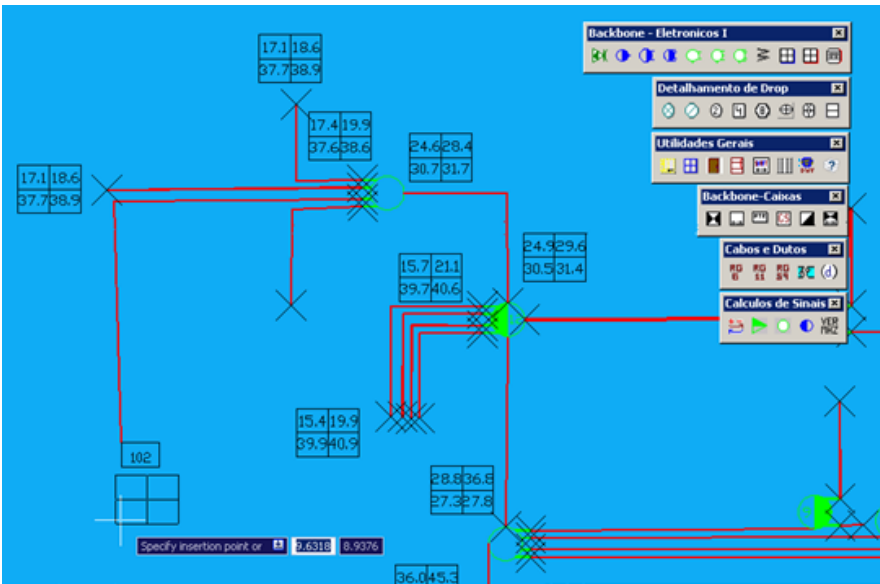
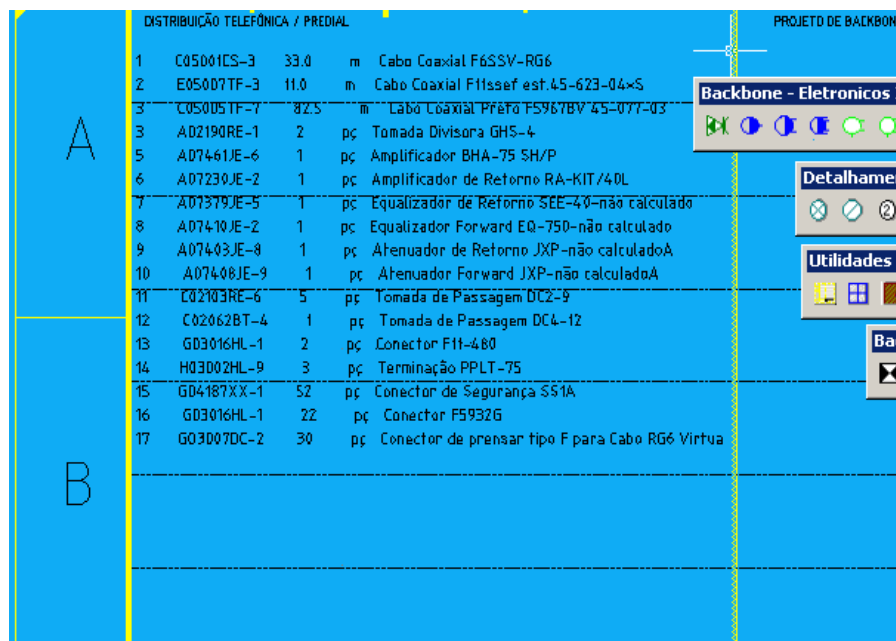


Figure 6.25 – Network Labels indicating the signal levels

Finally, are generated the complete Bill of Material of the proposed network, automatically are calculated the different cable types length, in meters , and the

respective codes of material management necessary to control the exactly costs of the proposed network. The text is inserted in the upper left corner of the A3 paper format, as in Figure 6.26.



DISTRIBUIÇÃO TELEFÔNICA / PREDIAL				PROJETO DE BACKBONE	
1	C05001CS-3	33.0	m	Cabo Coaxial F6SSV-RG6	
2	E05007TF-3	11.0	m	Cabo Coaxial F11sref est.45-623-04xS	
3	C050051F-7	82.5	m	Cabo Coaxial P11sref F5967BV 45-077-03	
3	AD2190RE-1	2	pc	Tomada Divisora GHS-4	
5	AD7461JE-6	1	pc	Amplificador BHA-75 SH/P	
6	AD7230JE-2	1	pc	Amplificador de Retorno RA-KIT/40L	
7	AD7379JE-5	1	pc	Equalizador de Retorno SEE-40-não calculado	
8	AD7410JE-2	1	pc	Equalizador Forward EQ-750-não calculado	
9	AD7403JE-8	1	pc	Atenuador de Retorno JXP-não calculadoA	
10	AD7408JE-9	1	pc	Atenuador Forward JXP-não calculadoA	
11	C02103RE-6	5	pc	Tomada de Passagem DC2-9	
12	C02062BT-4	1	pc	Tomada de Passagem DC4-12	
13	G03016HL-1	2	pc	Conector F11-480	
14	H03002HL-9	3	pc	Terminação PPLT-75	
15	G04187XX-1	52	pc	Conector de Segurança SS1A	
16	G03016HL-1	22	pc	Conector F5932G	
17	G03007DC-2	30	pc	Conector de prensar tipo F para Cabo RG6 Virtua	

Figure 6.26 – Bill of Material

6.3 – Summary

The final design is complete and brings to use the capability to evaluate the signal level with accuracy to result in quality of services for the subscriber, and provide capability to control costs over a good documentation of each MDU design through the inventory fidelity. The main results are:

- Intuitive application easy-to-adopt by the engineers and technicians.
- The resultant Design is a fidelity model for future or existent network and can be used for documentation proposes and patrimonial management.
- The bill of material bring a capability to preview and cost control.
- The implementation provides accuracy in designs of the last mile network, turning it more efficient.

- In the next chapter are presented the conclusions and suggestions for future works.

Chapter 7

Conclusions and Future work

7.1 – Introduction

This dissertation uses the concept of the interactive constraint-based to support the electronic video network design based in mathematic and engineering model for time frequency domain and non-linear considerations. This new approach use the SCTE and DOCSIS standards documentation established for Cable Design proposes [64]. The system has been evaluated using well-known design internal building backbone for MDU (Multiple Dwelling Unit).

This Chapter also draws conclusions and discussions for long-term research.

7.2 – Conclusions

The initial objective of this work is to evaluate constraint-based techniques supporting the coupling of engineering and geometric constraints. An innovation of this implementation brings to reality non-linear methods and simplifications to model a generic telecommunication network like a Transmit Line.

The implementation is a concept proof of an experimental constraint-based data model for electronic building backbone design. It's include:

An Equation Graph is used to represent the design sequence for the satisfaction of engineering constraints and maintain the best model consistency solution, and equations satisfaction. (Considering standard design proposes for Backbone Design), specifically in MDU, HFC design.

The use of INCES algorithm incrementally in local propagation techniques, still shows its feasibility to rapid constraint satisfaction. This method allows the interactive design in backbone network constraints equations and the efficiently propagation is not

affected for the locally update interaction process, eliminating high cost processing. Constraints are also used to represent the degree of freedom of geometric entities. The Relationship Graph is used to represent geometric entities and geometric constraints. An experimentation network constraint-based data model has been built on the proposed techniques. The presented case study has shown that providing efficient techniques to support incremental satisfaction of design constraints, contributes to better performance during engineering design.

A main result of this work shows that the constraint-based model bring to the electronic TV network design an efficient process to represent the physics real case that allow the engineer to design over an intuitive interaction with the schematics representation using an efficient engineer equation solver. In addition, actually only a few numbers of applications in this area have similar proposes of the present research, but no one is based in constraints.

This fact open new perspectives to implement other applications using constraint-based model to many areas of knowledge as in Telecommunications, as in Electrical, or Electronic field.

The INCES is embedded inside this implementation, but it is not possible the interaction between the user and this method, it will be objective for future works

The Related Works are produced by Lode Data Corporation that uses software modules: Design Assistant, and Drafting Assistant, and Visium Group that produces a set of solution softwares focused in Business solutions. In future work is sujested to make a complete comparison of the related software.

7.3 – Future Works

The following is suggested as future work:

- Expand the present implementation for a complete external metropolitan network using the same model.
- Use a similar model for integrated circuit design, (VLSI) Very-large-scale integration.

-
- Backbones for buildings receiving the signal in Down Converter Amplifiers using MMDS – Microwave Multichannel Distributions System (similar model) .
 - Propose to implement a symbol standardization using this work as a model to government regulamentation entities.
 - The flexibility to interact with INCES.
 - Make a comparation of related works.

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A.1- Transmission Lines (TL)

This research explore Transmission Line to add a substantial contribution for the constraint-based model works, such an artificial NRI medium was first realized experimentally at microwave frequencies [72] using a volumetric structure with thin wire strips and split-ring resonators. A planar NRI medium was later realized by periodically loading a conventional transmission line (TL) with lumped-element series capacitors and shunt inductors [68], [70].

Considering the following equation:

$$\frac{\partial v_y}{\partial z} = -i_z Z, \quad \frac{\partial v_y}{\partial x} = -i_x Z, \quad \frac{\partial i_z}{\partial z} + \frac{\partial i_x}{\partial x} = -v_y Y, \quad (1)$$

Where, Z and Y are the per-unit-length series impedance and parallel admittance, respectively. Comparing this standard equation (1) with Maxwell's equations in a homogeneous isotropic medium and mapping the field components of the transverse magnetic (TM_y) solution to the voltages and currents in the structure, we can obtain the following equivalent material parameters for the distributed TL structure:

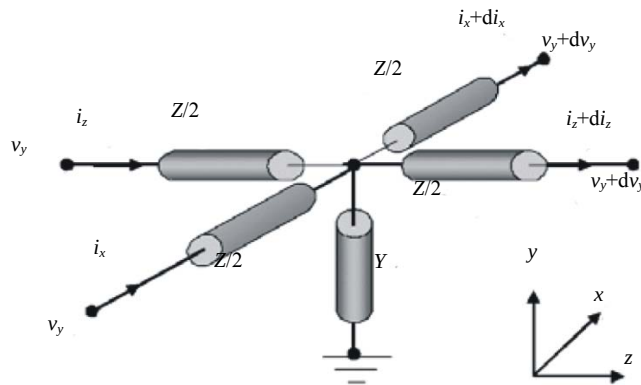


Figure 3.8.2 Unit cell for a two-dimensional distributed LC network (Eleftheriades *et al.*, 2002)

μ and ε are the equivalent permeability and permittivity of the structured material (i.e., the distributed TL structure), implies a medium of low-pass topology with:

$$\begin{cases} j\omega L = Z = j\omega\mu \Rightarrow L = \mu(H/m), \\ j\omega C = Y = j\omega\varepsilon \Rightarrow C = \varepsilon(F/m), \end{cases} \quad (2)$$

Where, L and C are the per-unit-length capacitance and inductance of the distributed TL structure, respectively, both of which are positive real quantities. However, in such an approach the equivalent material parameters are highly dispersive as one has $\mu = -1/(\omega^2 C')$ and $\varepsilon = -1/(\omega^2 L')$, by using negative-impedance-converted LC network as follows:

$$\begin{cases} j\omega\mu = Z = -j\omega L'' \Rightarrow \mu = -L''(H/m), \\ j\omega\varepsilon = Y = -j\omega C'' \Rightarrow \varepsilon = -C''(F/m). \end{cases} \quad (3)$$

Eq.(4) shows that the permeability and permittivity of the equivalent material are negative and do not vary with frequency. The corresponding propagation constant is proportional to the frequency:

$$\beta = -\sqrt{-ZY} = -\omega \sqrt{L''C''}. \quad (4)$$

the relationship between the network characteristic impedance (Z_0) and the equivalent wave impedance (η) is preserved as:

$$Z_0 = \sqrt{L''/C''} = \eta = \sqrt{\mu/\varepsilon}. \quad (5)$$

For simplicity we take the 1D unit cell as an example, and based in (Collin, 1992; Pozar, 1998), we obtain the following dispersion relation:

$$\cos(\beta p) = 1 + ZY / 2, \quad (6)$$

The LC unit cells in PR (Positive Reference) TL and NIC TL networks are shown in Fig.2a and Fig.2b, respectively.

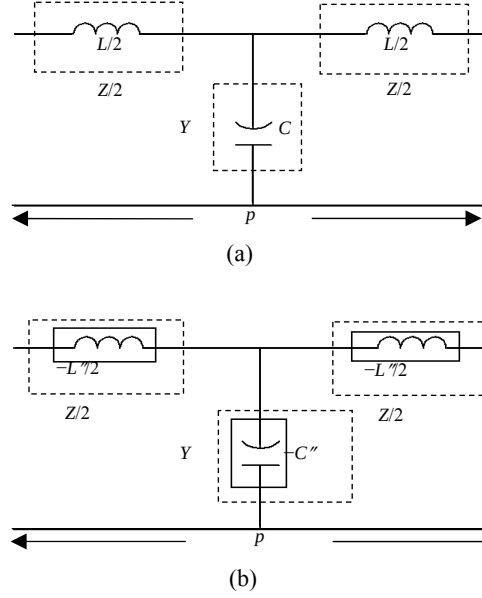


Figure.3.8.3 Unit cells in one-dimensional network of (a) positive refractive index transmission line and (b) negative impedance converter transmission line

Where p is the period, and the series impedance (Z) and shunt admittance (Y) of the unit cell are given by:

$$\begin{cases} Z = j\omega L, & Y = j\omega C, & \text{for PRI TL,} \\ Z = -j\omega L'', & Y = -j\omega C'', & \text{for NIC TL.} \end{cases} \quad (7)$$

If the electrical length of the unit cell is small or considering the **ideal** coaxial cable to TL, we can apply **Taylor approximation** $\cos(\beta p) \approx 1 - (\beta p)^2 / 2$ to Eq.(7) and obtain

$$\beta = s\sqrt{-ZY}, \quad (8)$$

Where :

$$s = \begin{cases} +1, & \text{for PRI TL,} \\ -1, & \text{for NIC TL.} \end{cases}$$

Considering the ideal operational amplifier with differential input and differential output and its equivalent circuit (**Carter and Brown, 2001**), where:

$$V_{\text{out}} = V_d \cdot \text{Gain} = (V_+ - V_-) \cdot \text{Gain} \quad (9)$$

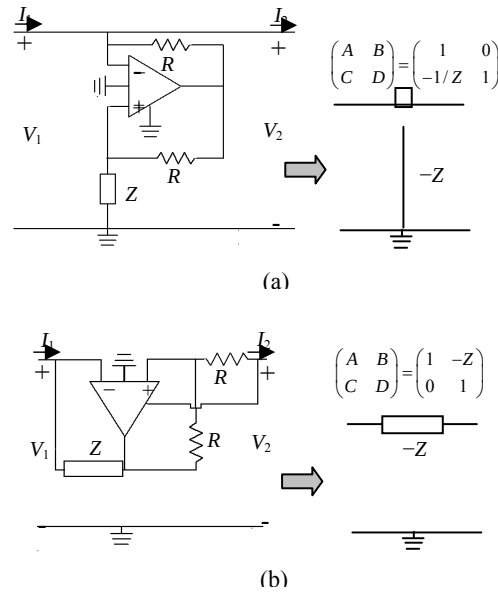


Figure 8.2.3 Negative impedance converters of series impedance (a) and

For this ideal model, we can apply the Matrix of equivalent impedances as:

$$\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} V_2 \\ I_2 \end{pmatrix}. \quad (10)$$

If we replace the impedance Z with a capacitor (C), an inductance (L) or a resistance (R), we can obtain the corresponding negative capacitor, negative inductance or

negative resistance. By periodically connecting the negative series inductance and negative parallel capacitor, we can realize the active NIC LC transmission line as shown in Fig.8.2.4.

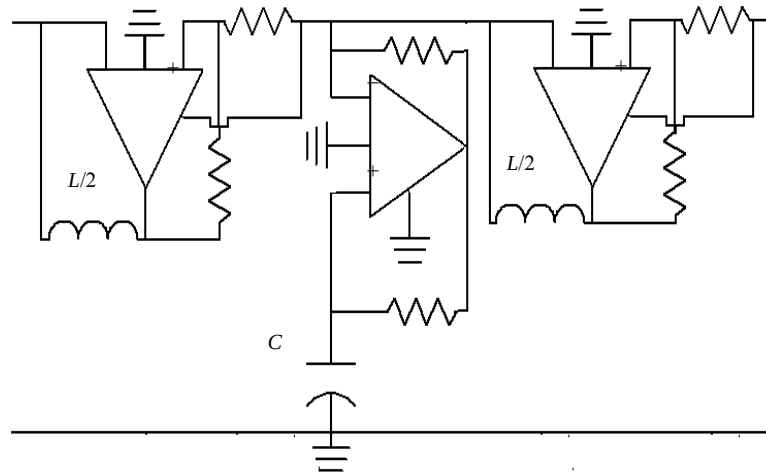


Figure 8.2.4 Unit cell of our negative impedance converter LC transmission line

The non-dispersive and thus can lead to many interesting new applications such as designing some novel broadband devices and architectures.

The latter condition usually excludes a direct interface between a circuit simulator and a device simulator, since the finite-element approach for a single device in a device simulator typically leads to thousands of nonlinear equations that have to be solved, thereby making it impractical to simulate circuits having more than a few transistors.

A2 -Timing Constraints

It is observed that substrate routes in a package vary significantly. For example, for a typical chip size, the sub-state route length can span from 1mm up to 21mm. One of the impacts of such variation is on timing measured from cells to package pins. Through 3D EM simulation [9], we _and that ignoring package substrate or cable route length variation per se can impact the timing by more than 70ps for2.5V SSTL 2 [10] I/O cells. In another words, different substrate route lengths result in significantly different delays. If power supply variation and package stack up variation were taken into account, more significant delay variation would exhibit, making timing closure extremely difficult to attain. Therefore, for I/O cells that have critical timing relations like differential pairs, we have to consider this delay variation when we place them. A common practice is to place deferential pairs close to each other so that the corresponding package routes will have similar route length.

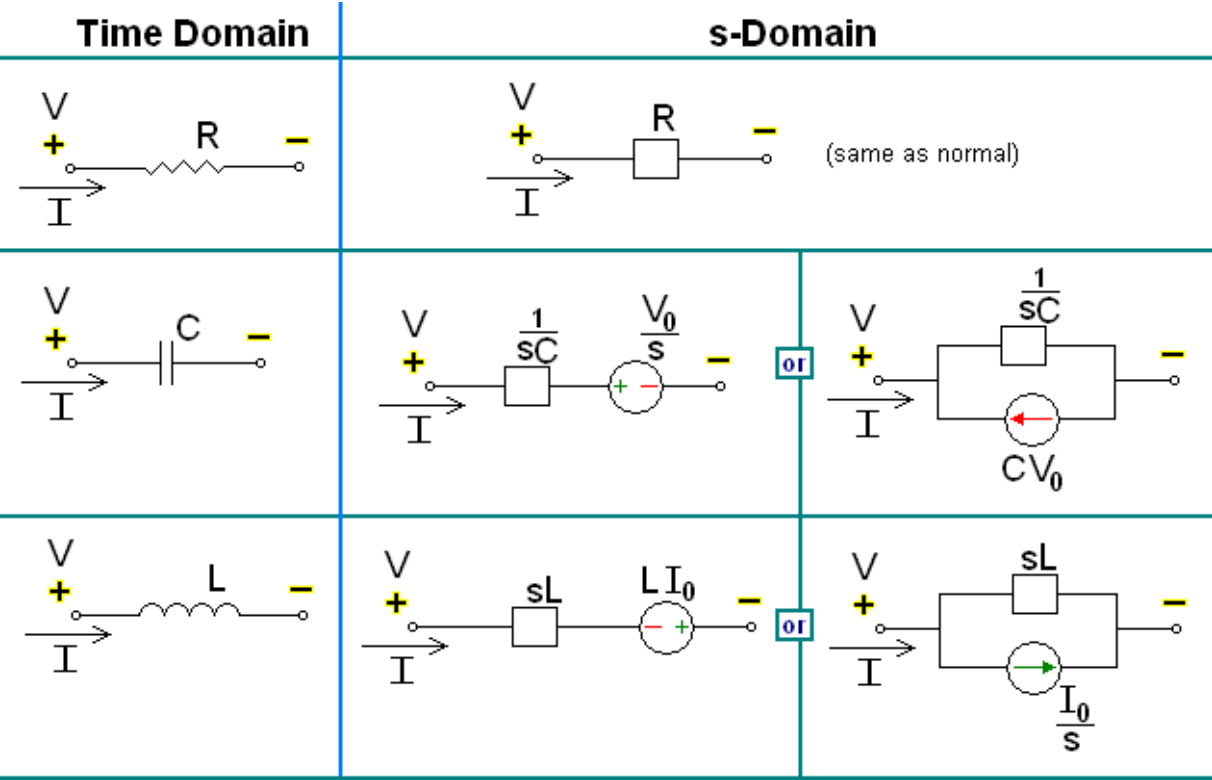


Figure 3.8.5- Electronic Based Symbols Constraints

A3- Laplace Transformation Model

The Laplacian method is the traditional standard used by mathematics concepts in physical modeling. It can be applied for a large range of excitations signal fonts and return, in once a natural response and forced response:

$$\mathcal{L}[f(t)] = F(s) = \int_0^{\infty} f(t) e^{-st} dt$$

The function $F(s)$ is a Laplacian Transformation $f(t)$ and one function for frequency domain generalized $\underline{s} = \sigma + j\omega$. We are interested in the analyses the condition for $t > 0$; and for $t < 0$ where the initial conditions are:

Compared with the Fourier, is possible to result in:

$$\mathcal{L}[e^{-\sigma t} f(t) \mu(t)] = \mathcal{L}[f(t)]$$

So, the Laplacian Transformation is one function for time domain $f(t)$ inside of an complex $F(s)$.

Considering the physical systems, the operator S , is obtained in similar quantity of the following characteristic equation of the systems above detailed. Using Laplacian equations the differential and integral calculus can be substituted by the Inside Signal in time function and be transformed in function of S . To obtain the Laplacian Transformations $f(t)$, is also necessary to define a real and univocal variables using the $t \geq 0$, and should satisfy:

$$\int_0^{\infty} f(t) e^{-\sigma t} dt < \infty, \text{ For some real value of } \sigma.$$

In this case we can consider $f(t) \in \mathcal{L}$ transformable. That functions are described for the linear controls, that mostly cases satisfy this conditions.

$$F(s) = \mathcal{L}[f(t)] = \int_0^{\infty} f(t) e^{-st} dt$$

For example, considering the quadratic (degree pulse) pulse bellow:

a) For this entrance $f(t) = e^{-at} \mu(t)$. Calculating $F(s)$:

$$F(s) = \int_0^{\infty} f(t) e^{-st} dt = \int_0^{\infty} e^{-at} e^{-st} dt = \int_0^{\infty} e^{-(s+a)t} dt$$

$$F(s) = \frac{-1}{s+a} e^{-(s+a)t} \Big|_0^{\infty} = \frac{1}{s+a}$$

$$\text{b) } \mathcal{L}[\mu(t)] = \int_0^{\infty} e^{-st} dt = \frac{1}{s}$$

The transformation for the **degree function** is: $\frac{1}{s}$ (forward Signal)

A4-Inverse Laplacian Transformation

$$f(t) = \frac{1}{2\pi j} \int_{c-j\infty}^{c+j\infty} F(s) e^{st} ds, \quad t > 0$$

or

$$f(t) = \mathcal{L}^{-1}[F(s)], \quad (\text{Reward Signal})$$

A5-Transformation of Derivates Function

$$\mathcal{L}\left[\frac{df}{dt}\right] = L[f'(t)] = \int_0^{\infty} f'(t) e^{-st} dt$$

Integrating each part:

$$\mathcal{L}[f'(t)] = f(t)e^{-st} \Big|_0^{\infty} + s \int_0^{\infty} f(t) e^{-st} dt = sF(s) - f(0)$$

For example:

$$\mathcal{L}\left[L \frac{di}{dt}\right] = [sI(s) - i(0)]L$$

A6-Transference Function (Network Function)

Considering $V(s)$ e $I(s)$ as fasorial Voltage and Current, associated with one

net of two terminations:

$$\boxed{Z(s) = \frac{V(s)}{I(s)}} \quad \begin{array}{l} I(s) \text{ is an excitation Function.} \\ V(s) \text{ is a response function.} \end{array}$$

$Z(s)$ is an input impedance; the net function is:

$$H(s) = Z(s) = \frac{V(s)}{I(s)}, \text{ or better: } H(s) = \frac{V \text{ output } (s)}{V \text{ input } (s)}$$