Meeting the Needs of the Headend-of-the-Future Today--The Structured Headend

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Single media CATV networks are rapidly evolving into two-way, multi-media networks. They will be expected to reliably support a much broader range of services and technologies. Digital and analog signals will work in the same network to deliver telephony, data, and video to residential, business, public, educational, and government customers. The timing of the roll-out of each of the services to these markets may vary tremendously, and customer churn will certainly be a part of each market. There may be a smaller number of larger headends that will still need to deliver picture-perfect video. All this on a network that is expected to have unprecedented reliability, and is expected to be there "yesterday".

So there is a lot of confusion, but also some conclusions.

These needs are driving service providers to expect much more from their network infrastructure. They are looking for full connectivity in the fiber and coaxial networks that will be linking digital and ATM switches, as well other digital, RF, and analog elements. To successfully achieve this network performance means planning for advanced services and deploying effective expansion strategies. A cost effective plan that incorporates the needs for flexibility, reliability, and growth, will deliver:

- Service evolution that is fully supported by circuit access and protection, service assurance monitoring, and disaster recovery provisions.
- A reliable network ready for expansion.
- A strategy for upgrading existing systems, regional headend consolidations and completing new-build situations.
- And perhaps most important, modular, growth-oriented headends matching capabilities and incremental investments with customer requirements.

Before significant resources are invested, the plan should consider impact of the following:

- Services timing
- Facility restrictions
- How to get to the "next" services
- Equipment types
- Necessary space
- Technical performance and equipment standards
- Maintenance and test provisions
- Design limitations

ADC Telecommunications is able to bring practical hardware solutions as well as system expertise to the needs of the multimedia service providers. ADC is one of the first telecommunications suppliers to develop and deploy systems capable of delivering integrated video, voice, and data over a broadband network to residential and business subscribers. Our strong background includes cable management, access systems, and high speed data and wireless transmission. This knowledge has been combined with CATV and systems integration industry experts. We already have several years experience building and turning up systems that meet today's rapidly emerging competitive environment.

This experience leads us to the conclusion that headends being modified or built today must be thoroughly planned to accommodate this radically new environment. We have developed a headend design philosophy that structures capabilities to incrementally meet service and technology needs. This solution will allow you to change or add service offerings quickly, and will allow you to offer those services geographically targeted to meet demand.

What The Future Means Today

Traditionally, the bulk of the design effort expended in a CATV system design has been for the distribution systems external to the headend. CATV providers study their customer's demographics and service territories in great detail. The CATV customer base is well understood. The focus is on maximizing plant performance and reliability, as well as minimizing noise and distortion. Fiber optic technology has moved further out into the cable plant reduing amplifiers in cascade,to improve reliability while reducing noise and distortion.

In contrast, headend floor plans and layouts reflect the same basic principles common ten years ago. The focus has been on improving signal quality and channel capacity. These headends may be severely limited in meeting new plant demands.

The time to build more capable headends is now. Their designs must serve as platforms to deliver advanced broadband services, profitably expanding as new customers and services are added, yet with minimal cost and disruption. The new design model should consider the following:

1. The CATV provider faces the challenge of successfully and cost-effectively adapting to become a provider of Broadband Services while competing against other telecommunications service companies. The new service possibilities include telephony, wireless personal communications, and Internet gateway access, as well as two-way video and targeted commercial insertion.

2. The ability to add and delete channels in the analog video line up with minimal disruption, lowest cost, and highest system reliability. Line-up changes in the past have traditionally meant rewiring major portions of the headend.

3. Service demands and available technologies will continue to evolve, often in unpredictable ways. The headends that are built today must be able to grow with these demands while protecting invested capital.

4. The take rate of new services may initially be small. As the popularity of the new service grows, a migration plan is required that will allow

smooth expansion at the lowest possible incremental cost. Moreover, the take rate may vary from area to area, and even from neighborhood to neighborhood. A headend design is required that will allow for geographically "spotty" growth with a minimal capital investment in new equipment. Service equipment should only need to be added to those pieces of the network that are supporting customers and generating revenue.

The ability to flexibly accommodate this migration requires new thinking about headend design. Traditional design principals and advanced hardware alone will not solve these challenges. While today's designs are delivering better and better signal quality, they are severely limited in meeting added near-term, and certainly longer-term, requirements The issues of flexibility, service migration, and protection of investment must be addressed by connecting available advanced hardware and new, tailored services, in innovative ways.

A New Philosophy In Headend Design

The headend of the future must accommodate not only video services, but also telephony, data, and wireless communications. The result is a facility which is not just a telephone central office or a video distribution office, but is a Broadband Services Distribution Office. The key elements in this concept include:

- Modularity of service provision, both in terms of services and where they are offered. Pre-designed equipment arranged in module bays focused on specific types of service or size of service area. They include Narrowcast modules for commercial insertion and Public, Education, and Government (PEG) services, as well as Advanced Services modules for telephony, Internet access, digital video, and PCS.

- Structured design and design rules that establish in advance how to accommodate change. The future design must allow you to insert new advanced services at the appropriate point in the network with minimal disruption to ongoing operations. This will result in a more reliable facility, lower maintenance and upgrade costs, and financial protection of existing equipment investment.

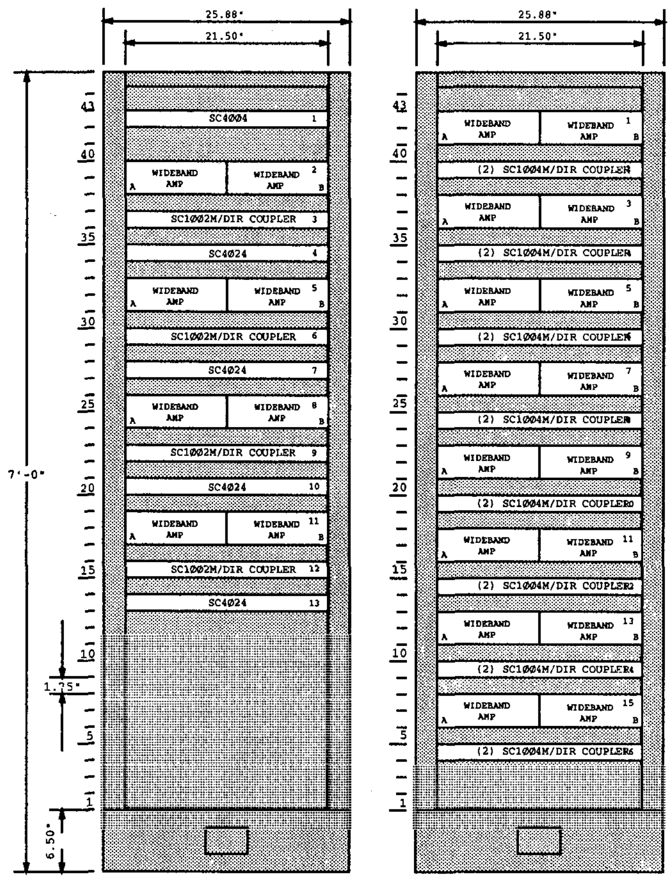
- Combining CATV know-how and RF expertise with the best quality and performance standards from Telco networks. This includes planning likely network requirements for test, access, and system reconfiguration. Achieve maximum service reliability through redundant circuit routing for lost satellite feeds and off-air signals, the failure of video and audio processing equipment, and the loss of commercial power.

- Begin with the end in mind. Reasonably plan for the full services and customer base the facility will be called upon to support. Design, but do not necessarily initially equip, to accommodate a full channel and service line-up. With full feature needs allocated within the scope of the modularly structured facility, future floor space, power and other limitations can be recognized. Actual near-term building and installation is scaled back to a portion of overall capabilities. The service provider is now positioned to meet change with matched, and planned, investment.

- Include open racking and bays for efficient maintenance and system reconfiguration. By eliminating cabinets and doors in the headend, today's complex headend can be packaged in a smaller facility. Technicians will be able to add and re-arrange hardware and locate trouble much more quickly.

- Plan for signal and cable growth and routing using racking systems. New video offerings require many more pieces of equipment, and thus much more cabling than a few years ago. The use of under-floor systems often results in a tangled mess of power, video, audio, and fiber cables. This means tracking problems in locating cables, kinks and microbends in fiber cables, and crosstalk. Tugging and pulling on cables as the means of circuit tracing stresses connections on other equipment, further hurting network reliability. Finally, open floor panels can be a safety issue in facilities that are undergoing a constant configuration change.

- Identify and focus on critical details, such as grounding systems. Careful attention to grounding, for example, reduces the incidence of ground loops, resulting in higher audio quality with less AC hum, and ease of trouble shooting. Poor grounding



SPLITTER/COMBINER BAY
FOR LEVEL 1
7'-0" UEF EIA RACK
FRONT VIEW

SPLITTER/COMBINER BAY
FOR LEVEL 2 & 3
7'-0" UEF EIA RACK
FRONT VIEW

Figure 1

practices may work in a traditional headend, but will prove to be a disaster when broadband telephony or digital services are added to the CATV network. In addition, poor grounding practices cost the service provider money as electrostatic discharge transients reduce equipment reliability.

- Integrate the splitter/combiner networks into the overall system philosophy of planning for service and technology insertion (figure 1). The network is placed close to related equipment and the module insertion point to achieve easier access. The typical field experience with this has shown labor savings of a factor of 4 in installation time, while maintaining 0.33 dB frequency response variation from 5 MHz to1 GHz, and 35 dB isolation port-to-port up to 450 MHz.

Group over several actual projects. This experience shows that the investment in the structured Broadband Services Distribution Office is 5% to 7% higher than recent, but less capable, industry designs. It will typically deliver savings of at least 20% annually when compared with Headend operations and maintenance costs of today. Of course, the demand on headend facilities is not static, but is increasing significantly. As a result, structured plant savings of greater than today's 20% are likely.

The Signal Flow diagram

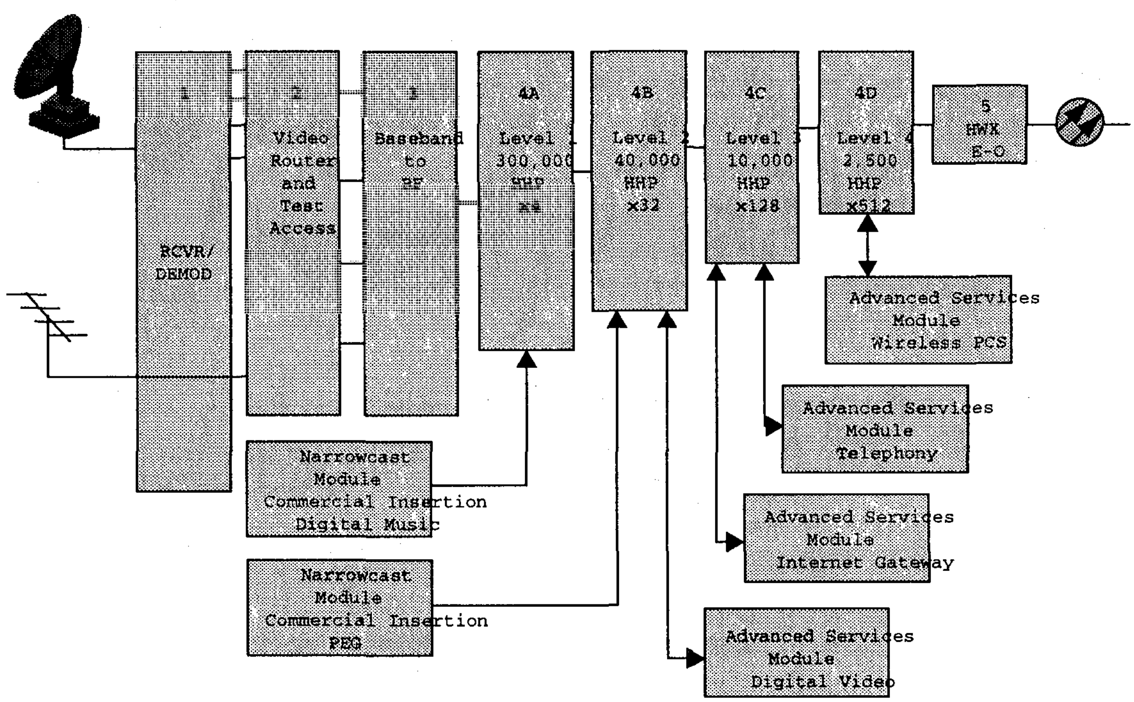


Figure 2 (Signal Flow)

What Does It Cost? How Does It Work?

This design approach has evolved within the ADC Systems Integration (figure 2) represents the design of the Broadband Services Distribution Office network. It is divided into sections, or levels, that represent increasingly smaller geographical areas. The capacity of each of the modular levels is:

Level 1 - 1.2 million homes passed.
Level 2 - 300,000 homes passed.
Level 3 - 40,000 homes passed.
Level 4 - 10,000 homes passed.
Level 5 - 2,500 homes passed.

Satellite channels and off-air channels are converted into baseband signals and routed through an Audio/Video Patch Panel. The functionality of this panel allows for high density packaging for testing and alignment procedures. It also provides the capability for manual patching of circuits around devices and to reroute circuits during equipment failures.

From the Audio/Video Patch Panel, channels are directed to a baseband crosspoint routing switcher. The purpose of the switcher is to automate channel line up changes and provide an insertion point for system-wide services. For example, the Emergency Broadcast System will be added to the network at this point, as would commercial insertion sources, and PEG sources that are common to the entire serving area. From the routing switcher, the baseband-to-RF conversion section, consisting of video encoders, scramblers, BTSC encoders, and modulators, converts each channel to an individual RF channel, which is combined into one line for splitting into geographic levels.

The first split breaks the signal into Level 1 and Level 2. Level 1 signals are common to all subscribers. These common channels are the analog broadcast channels from the satellite feeds, off-air broadcast stations, and the Emergency Broadcast System. Up to 1.2 million homes may be served by this point in the network.

Level 2 splits the channels into 4 parts, each of which can serve up to 300,000 homes. This level would typically serve a metropolitan area. Commonly, this is where narrowcast services, such as commercial insertion, would be injected.

The Level 3 split breaks each of the Level 2 channels into 32 parts, each leg serving up to 40,000 homes. This level would typically serve smaller cities or areas within a metropolitan area. PEG channels are typically inserted at this level.

Level 4 splits Level 3 into 4 parts, serving approximately 10,000 home serving areas on each leg.

Level 5 splits each of the Level 4 legs into 4 parts, and can serve up to 2,500 home neighborhood areas on each of its legs.

At each point in the splitting network, combiners are installed which provide insertion points for advanced services. For example, the first deployment of telephony into a CATV network might serve 500 homes spread throughout the entire serving area in a "friendly" field trial. In this case, one Host Digital Terminal (HDT) would be required, and could be installed on a leg at the level 2 split through a 1:8 combiner, taking into account transmission delay limits on the telephony system. Additional HDT's would be added at this level during the early stages of commercial deployment. Once the telephony offering gains a "significant" customer base and sign-up rate, the decision would be made to move the HDT's down to the level 3 split, where many more combining ports are available. The same HDT's can be reused and additional units added. Since the insertion ports were designed into the network from the beginning, there is no major rewiring of the Broadband Services Distribution Office and no unexpected impact on end-of-line performance. With further growth in the telephony service take rate, the HDT units would be moved down to level 4, continuing to link costs to revenue. Again, rewiring and disruption of the facility is minimal.

An alternate scenario might be that the majority of initial Internet customers can be served at Level 3 for Internet access. However, suppose that one of the 2,500 home neighborhoods has a much higher take rate than other neighborhoods. Because of system flexibility, an Internet Advanced Services Module can meet this neighborhood demand at Level 4. This minimizes the capital investment while growing the system, even if the growth is not geographically even.

In addition to growth flexibility, the combining networks at each level permit insertion of other advanced services. In addition to telephony, many carriers have indicated a requirement for wireless Personal Communication Services. The roll-out and growth pattern of PCS services may be similar to that for cable telephony. The Remote Antenna Signal Processor (RASP) will be connected at a combiner panel for communication with Remote Antenna Drivers (RADs). A typical PCS Module (figure 3) will serve approximately 10,000 homes passed. Similarly, downstream Internet traffic from data bridge/routers will be inserted into the combiners using the Internet Advanced Services Module. Other services, such as SEGA, Digital Music Express, and

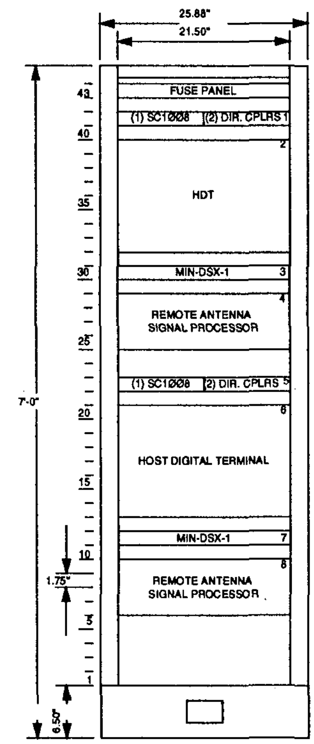


Figure 3

NVOD are accommodated in exactly the same way. This tailoring of equipment provides maximum flexibility while minimizing investment.

Location

The Broadband Services Distribution Office may be in a single physical facility, as represented in figure 2, or the levels may be in different geographic sites. For example, the TVRO function and Level 2 split may be in one central facility. If we assume digital super trunking, with a 30 dB optic loss budget and 0.4 dB/km total loss, the Level 2 channels may be transported up to 85 km at 1550 nm without optical repeating. The Level 2 split can serve up to 4 smaller facilities in a metropolitan area. Some systems may require further transport down to a Level 3 facility. Using available equipment with analog DFB lasers, a transmit level of 8 mw and an optic path budget of 9 dB, lower level facilities can be extended a further 36 km. The flexibility in the dispersal of facilities is appropriate for the CATV provider that serves many areas or cities that are not adjacent to each other.

Performance

Of course the end-of-line requirements are a critical element of the overall design. We recommend that the Structured Headend/Broadband Services Distribution Office be designed to better performance levels than currently required by the FCC. The limits are shown in the following:

FCC Requirements	Recommended Goal
C/N = 43 dB	C/N = 49 dB
CTB = 51 dB	CTB = 53 dB
CSO = 51 dB	CSO = 55 dB

With standard headend and outside plant amplifiers and fibertransmitters/receivers, achievement of these goals is possible. Calculations show that in an overall CATV network, with end-of-line performance standards equal to the recommendations, the headend contributes less than 1.5 dB for CTB, and less than 0.2 dB C/N. So it is possible to design a headend that is flexible and expandable without sacrificing quality and performance.

Summary

The competitive telecommunications environment is filled with opportunity for new services and profits. Building headends and networks to meet the range of possible services means levels of system complexity and uncertainty never before seen in this industry. Competitors, however, continue to make their own decisions and investments to drive the new telecommunications markets.

While operating in this new environment is a challenge, the Broadband Services Distribution Office and its structured, modular approach makes laying the infrastructure for these services today not only possible, but optimal. Rather than a "solution of boxes", this standard design offers pre-planned integration that serves now and in to the future. This solution maximizes the return on headend investment by allowing service offerings to be added or changed quickly, with maximum reliability and performance.