HYBRID ADDRESSABILITY -- A HYBRID COMBINATION OF OFF-PREMISES AND SET-TOP ADDRESSABLE EQUIPMENT

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ABSTRACT

Cable systems in metropolitan areas require addressable technology which satisfies the requirements for secure distribution of pay-TV signals simultaneously to both high-density areas and to individual residences. To date these differing needs have been filled separately by off-premises equipment (for high-density areas) and addressable home terminals (for individual residences).

This paper describes the system considerations for a hybrid addressable system optimized for both environments. Several alternative hybrid system arrangements are described, and based on discussion of their relative merits, a specific hybrid system is proposed. The proposed system merges the best operational and security features of both home-terminal and off-premises systems.

INTRODUCTION

Addressable technology is now firmly established as the means of delivering multi-tiered pay television services to cable television subscribers. There have been two recurring themes in discussions of the technology employed for addressability: security and in-home versus remote equipment.

Security

Security has become of paramount concern as the industry has found itself deprived of revenues by organized piracy - the marketing to the public of every conceivable way of circumventing existing control systems. Operators and equipment manufacturers have recently joined forces to specify and develop a level of security to thwart even the most technically sophisticated would-be pirate. The state of the art in highly secure scrambling methods is represented in the encrypted digital-audio technique employed in the Oak Sigma™ system (Figure 1).

Scrambled video is employed in the Sigma system, wherein complete horizontal and vertical synchronous pulse removal (as opposed to synchronized pulse suppression) is performed. Two channels of audio are digitized, encrypted, and embedded in the video. Two separate control channels are used: 1) a global FSK-modulated channel which all decoders continuously monitor and 2) an in-channel vertical blanking interval (VBI) data path which is channel-specific. The first contains general authorization and system-oriented control data, the second, program-specific data relevant to a given channel and time.

Separate service encryption keys are used for each channel and the keys are continuously varied. A multi-level key distribution system is employed in which

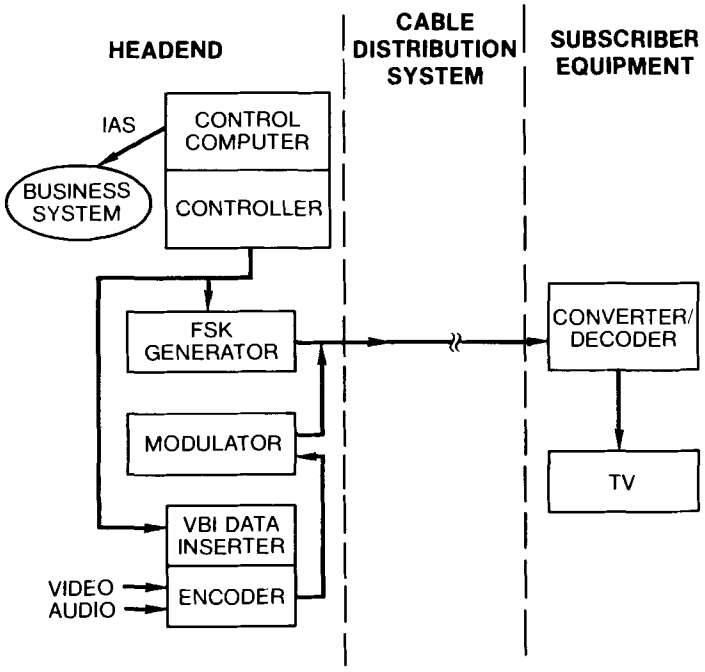

Figure 1. Sigma Home-Terminal System

three key variables are used. These include a box-specific key which is secret and unique to each box (unknown even to the system operator); a variable, second-level key common to all legitimate subscribers; and the service keys. Solid-state nonvolatile memory is used in the Sigma decoder to store key and authorization information (encrypted while stored). Each box also has a non-secret box address which is its addressing identification used by the headend computer to communicate to the box.

Off-Premises Versus Home-Terminal Equipment

Off-premises versus home-terminal equipment (HTU) for addressable control has been widely discussed. Off-premises systems have been developed to remove decoding equipment from the subscriber's home and to control availability of premium channels prior to delivery to the subscriber's premises. The Times Fiber Mini-Hub™ II (Figure 2) is an off-premises addressable converter system which secures pay programming by denying all but a subscriber-selected (and system-authorized) channel from entering the subscriber's home. Mini-Hub is a microcomputer-controlled local distribution system designed to provide cable television and other services for high-density urban areas.

Flexibility is provided in the Mini-Hub II off-premises switching unit through its capability of using a single drop cable to feed multiple television sets, each with its own subscriber interface unit (SIU).

Until recently no single comprehensive solution has been available to address the need for secure delivery of pay signals to the mix of multiple- and single-dwelling construction encountered in most metropolitan areas. This paper examines several alternative methods of satisfying this need, and proposes a specific hybrid system architecture.

ALTERNATIVES FOR THE OVER-ALL HYBRID ADDRESSABLE SYSTEM

The criteria considered in evaluating alternatives for a hybrid addressable system are:

- Number of distribution cables required
- Ease of control and business computer operation
- Capacity for premium channels
- Degree of security
- Cost

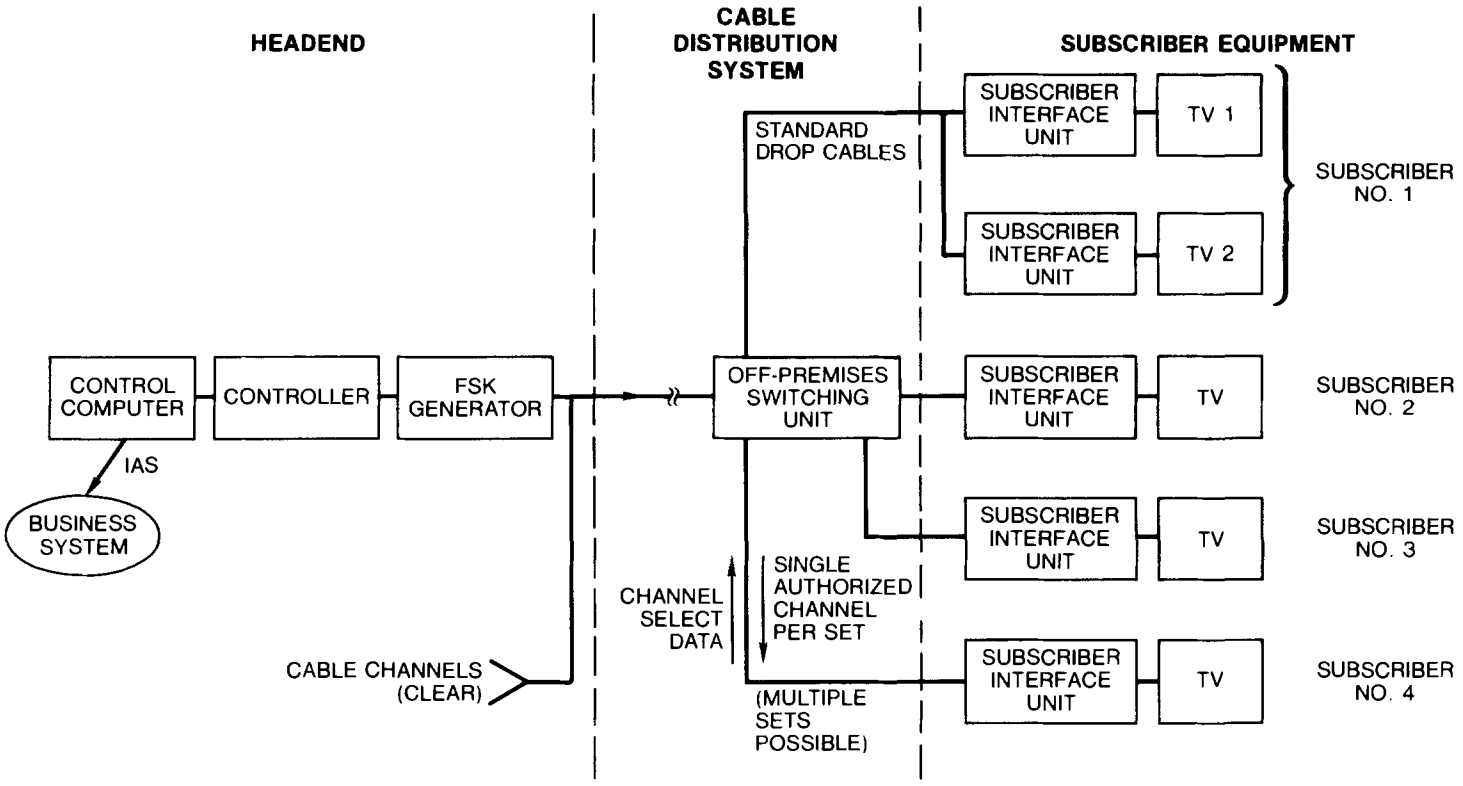

Figure 2. Mini-Hub Star-Switched Off-Premises System

The simplest way, conceptually, to employ both off-premises and home-terminal addressable methods would be to provide two independent systems using dual cable and separate control computers (Figure 3). A system of this type is clearly feasible, but would present operational difficulties because of the complete separation of computer functions.

An alternative is to provide a common control computer (linked to a common business system) controlling off-premises and home-terminal equipment fed by separate cables (Figure 4). In this case the first cable would carry all channels in the clear to the off-premises equipment; a second cable would carry clear basic-service channels and scrambled premium channels to single dwellings. This system is very secure as long as both cables are free from tampering. If the cable that feeds Mini-Hub is restricted in geographical coverage this system can be cost effective; if both cables must cover most of the cable system area this technique may be prohibitively expensive.

A system could be designed using a single cable carrying both clear and scrambled premium channels (Figure 5). In this alternative the clear premium channels must be eliminated by means of traps

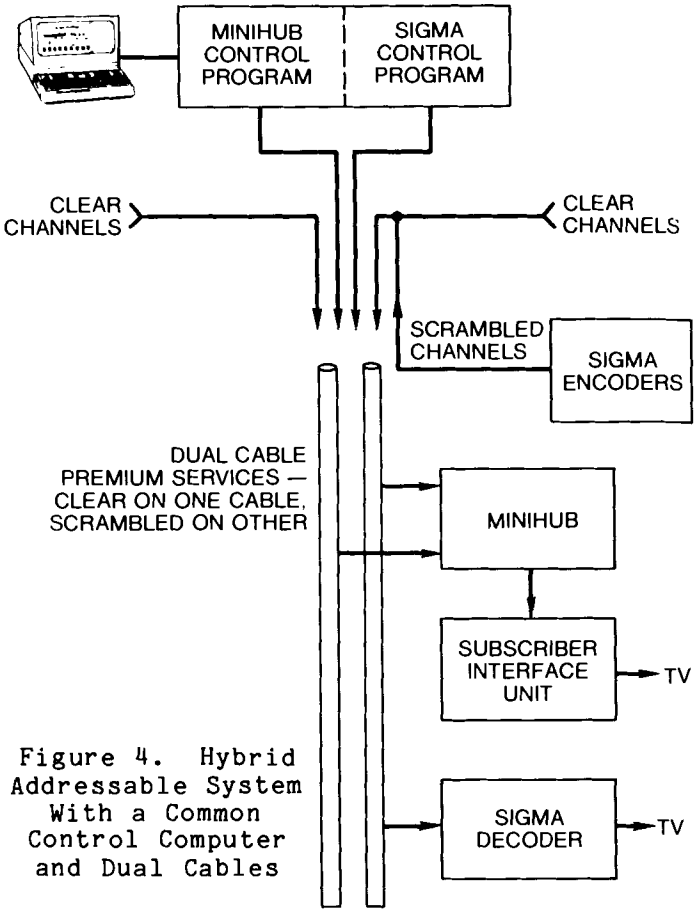

Figure 4. Hybrid Addressable System With a Common Control Computer and Dual Cables

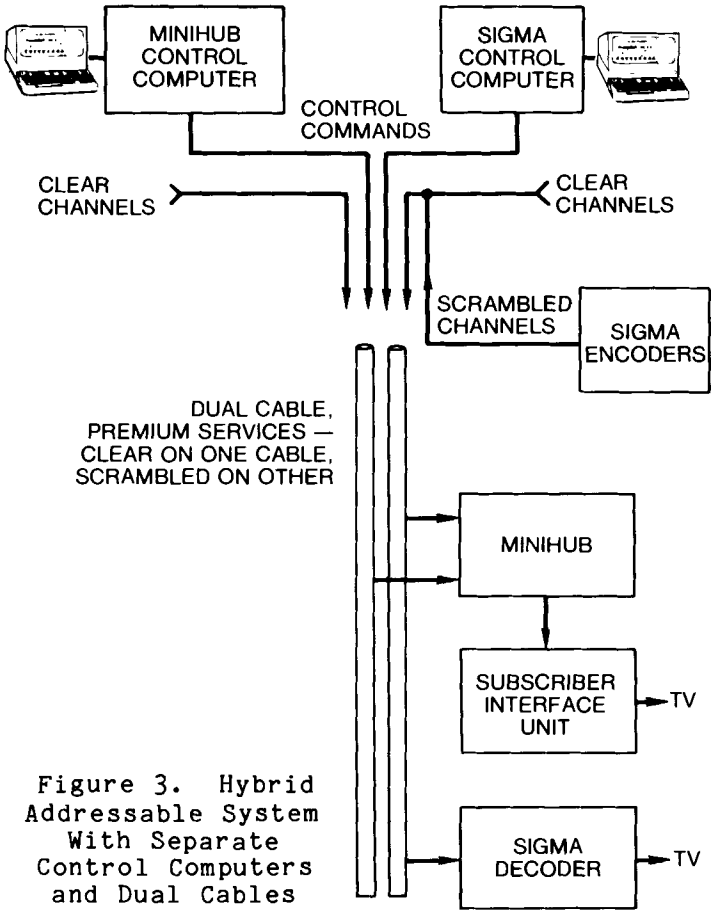

Figure 3. Hybrid Addressable System With Separate Control Computers and Dual Cables

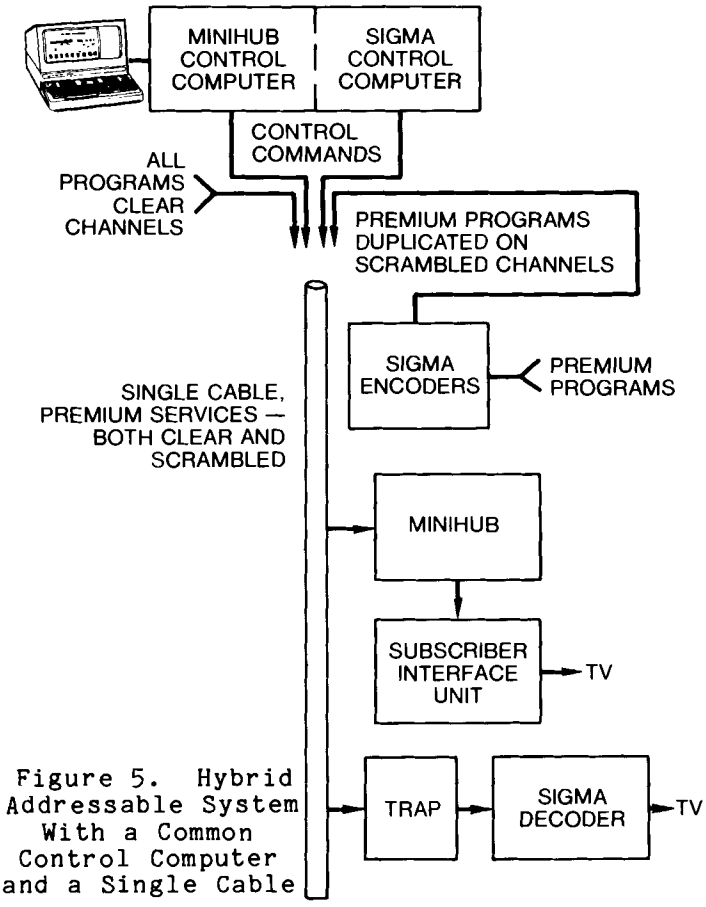

Figure 5. Hybrid Addressable System With a Common Control Computer and a Single Cable

before being fed to homes destined to receive the scrambled channels. This system must be rated poor for over-all security. In addition, duplication of premium channels seriously reduces the total channel capacity.

To provide complete flexibility of premium channel assignments without reducing channel capacity, a hybrid system could provide a Mini-Hub with a descrambler for each subscriber drop (Figure 6). A block diagram of a descrambler-equipped Mini-Hub is shown in Figure 7. Although this system has complete flexibility of channel assignment and excellent security, it is high in cost and consumes the most power.

The preferred system described in this paper is a single-cable system, in which the premium channels are all scrambled but which does not require descramblers in each Mini-Hub (Figure 8). Signals are delivered to the subscriber by means of either an individual Sigma converter/ decoder, or, in the case of multiple-dwelling locations, through Mini-Hub units. A master decoder, installed between the trunk cable and a group of Mini-Hubs, descrambles the premium channels and reconverts each to an otherwise unoccupied frequency. In the Mini-Hub itself, these channels are converted and switched to the subscriber in the same manner as non-premium channels. Additional control signals do, however, direct frequency agility of the converters in the master decoder, permitting flexibility of premium channel assignments. Any number of scrambled premium channels can be accommodated and converted to frequencies above 450 megahertz for local distribution to Mini-Hubs. In order to satisfy filtering requirements, alternate channels would be employed at the output of the master decoder.

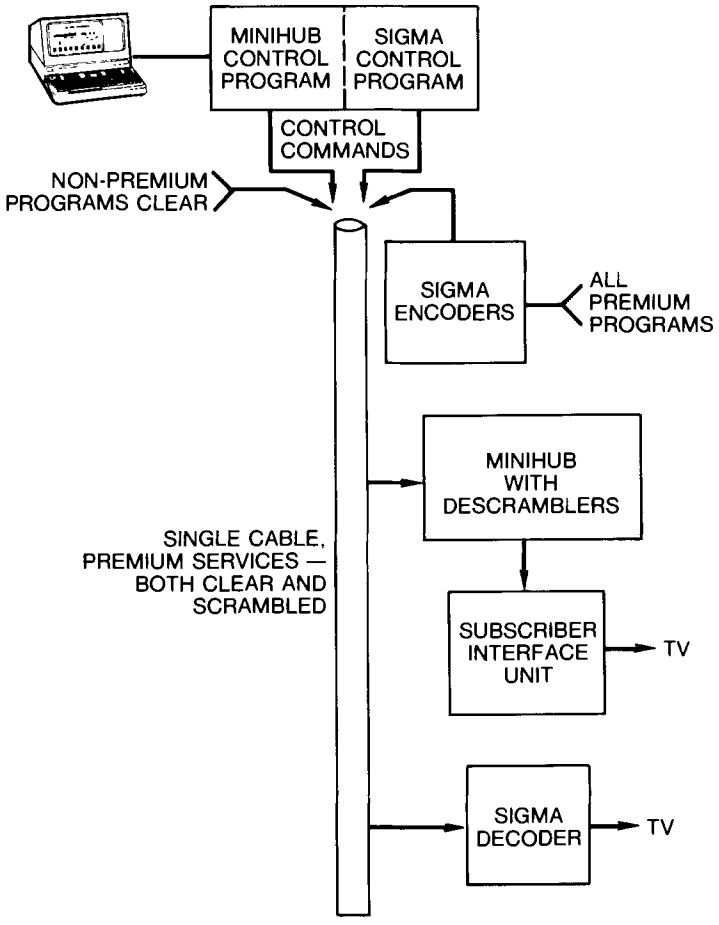

Figure 6. Hybrid Addressable System With a Mini-Hub for Each Subscriber

Table 1 summarizes the factors considered in evaluating these five alternate approaches to a hybrid addressable system

COMPUTER SYSTEMS - ALTERNATIVES

A typical computer architecture for an addressable pay-TV system includes:

- Business system
- Standard communications interface
- Control computer
- Controller which delivers a serial control data stream

There are variations of this architecture, depending on whether the business software is resident in the "control" computer or in a separate business machine. Assuming that the cable operator already has a business computer, either on-site or provided through a service bureau, a communication link and a separate control computer are required to operate the system.

Integrating the overall system allows both operation of the business functions and commands for addressing subscriber equipment to be done from the same business computer terminal. Subscriber status information contained in the business system data base is used to formulate control commands and the business data base, in turn, is updated in real time as changes occur. Thus, the business system's interface must contain all the necessary information to control the subscriber decoders. The interfaceable addressable system (IAS) link is shown connecting the business and control computers in Figures 1 and 2.

Control functions for the Sigma home-terminal systems and the control functions needed for Mini-Hub off-premises systems have some similarities and differences.

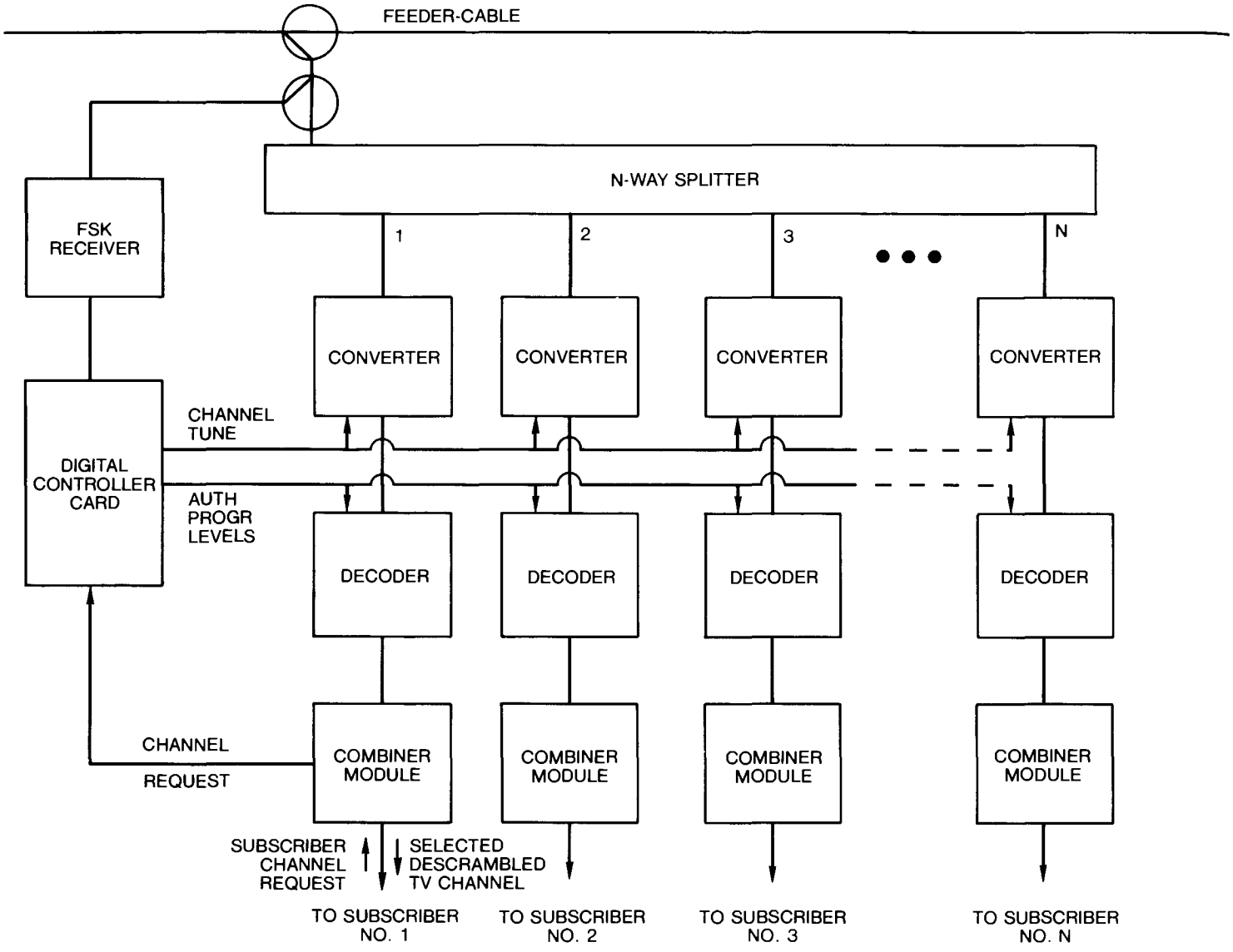

Figure 7. Descrambler-Equipped Mini-Hub Block Diagram

Each control system contains the following form of data files:

- Customer
- Converter or decoder
- Site location
- Special event
- System parameters

The control systems organize this data differently, however. The home-terminal communication system relies on a single address per decoder, whereas the off-premises system uses three forms of address: site, local distribution unit, and subscriber control. The Sigma home-terminal systems also use preauthorization and "data tag" matching for control, while Mini-Hub off-premises systems use downloaded mapping of authorized channels.

Despite these differences, and although home-terminal and off-premises systems have been developed independently, the computer system architectures are quite similar. For example both systems are multi-user/multi-tasking, allowing many terminal users to address decoders or off-premises converters, and to perform file inquiries on the installed customer base. This similarity makes it possible ultimately to develop a single computer system to control both kinds of hardware.

Conceptually the easiest way to control the set-top subsystem and the off-premises system in the same CATV operation would be to provide two dedicated control computers (Figure 9).

This system concept results in some rather onerous disadvantages. All control

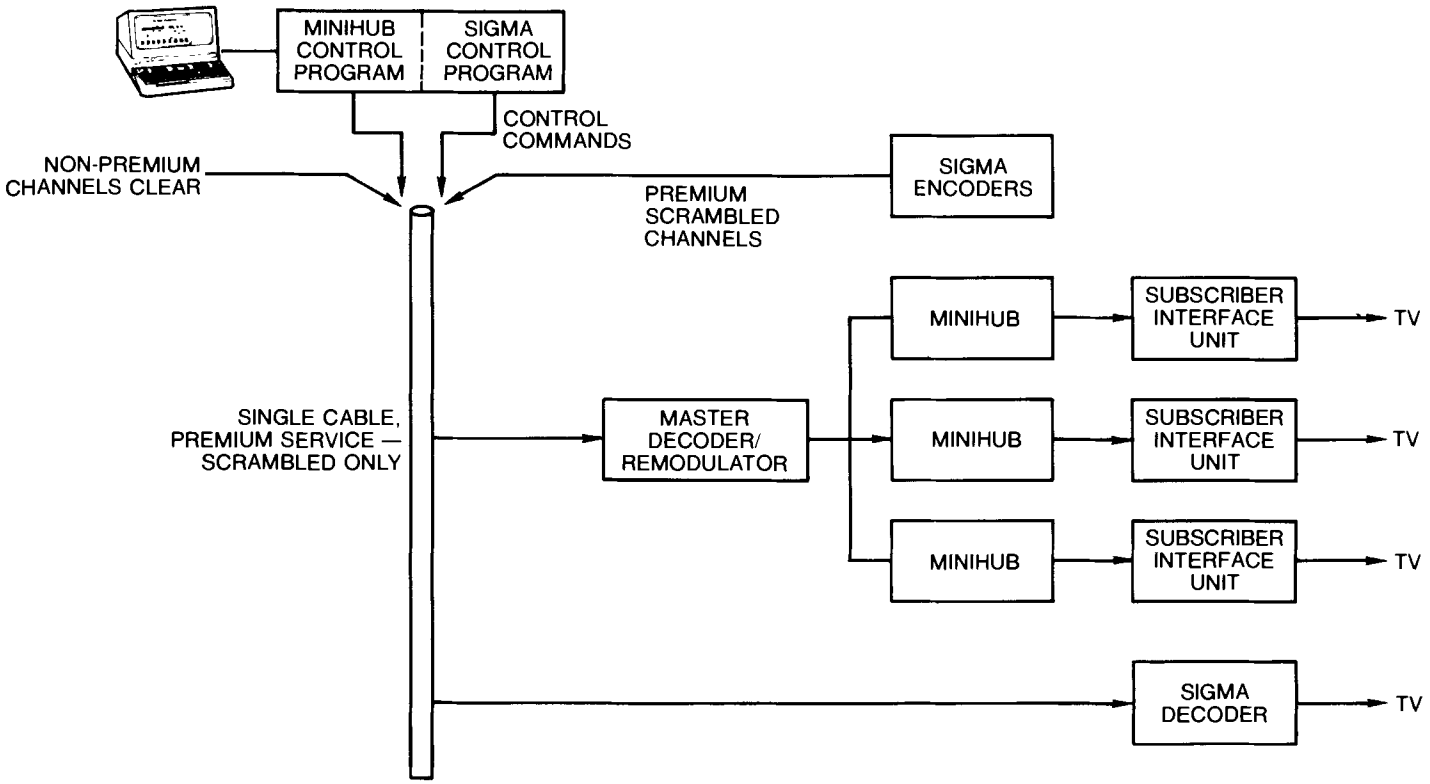

Figure 8. Preferred Hybrid Addressable System

Table 1. Hybrid Addressable Systems - Comparison of Configurations

System Configuration	No. of Cables	Operational Factors	Channel Capacity Factors	Security Factors	Cost Factors
Separate computers, separate cables (Figure 3)	2	Business system interfaces to separate computers/independent control systems	Two cables; but premium channels must be duplicated on both cables	High if Mini-Hub feeds are physically secure	Dual cable/two computers
Common computer, separate cables (Figure 4)	2	Consolidated business and control system	Two cables, but premium channels must be duplicated on both cables	High if Mini-Hub feeds are physically secure	Dual cable
Traps in cable drops (Figure 5)	1	Consolidated business and control system	Premium channels duplicated on one cable	Poor - traps easily circumvented	Potentially lowest cost
Descrambler per drop in each Mini-Hub (Figure 6)	1	Consolidated business/control system	Complete flexibility for premium channels	Very high	Potentially highest cost
Master Descrambler feeding multiple Mini-Hubs (Figure 7)	1	Consolidated business/control system	Restriction on number of premium channels	Very high if Mini-Hub feeds are physically secure	Cost effective if master decoders shared between multiple Mini-Hubs

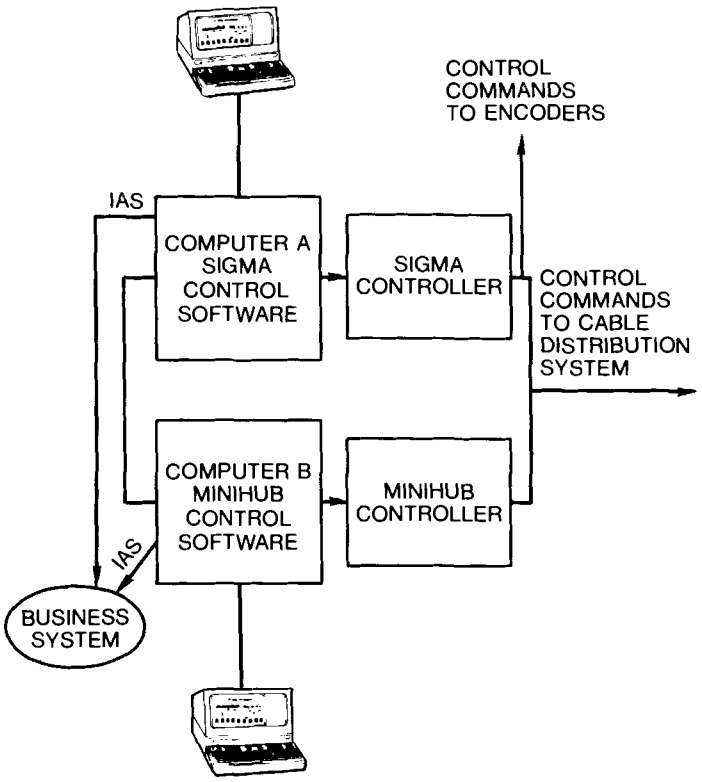

Figure 9. Separate Computer Configuration

and communication hardware must be duplicated; hardware and software maintenance, training, and operational costs are all significantly increased over a single machine system. Furthermore, if the customer and/or decoder data bases are on separate machines, the operational side of the business is less efficient.

A more attractive approach is to combine both control systems on one machine. This simplifies headend maintainability and conserves equipment dollars for both terminals and the control processor. However, just placing an assortment of control programs on one machine is not sufficient to achieve economies of scale.

Let's look at two alternative control software configurations in which a single control machine is used for the entire hybrid system.

The simplest means of merging two control software systems onto a single CPU is to allow the operating system to be the only common element between the two systems (Figure 10). For example, the Sigma control programs could reside side by side with the Mini-Hub control programs operating under a single operating system, such as VMS or RSX11M+ on the Digital Equipment Corporation's VAX or PDP-11 computer families. In this scheme, the design of each control program can be kept separate and the system is thus easy to implement. A common log-on menu is provided and both control software programs are accessed from any terminal in the control system. There are several disadvantages to this arrangement, however, including the lack of software integration which results in a higher maintenance cost; redundancy of code for such functions as screen handling, report generation, and transactions; and perhaps most important, the need to provide two data bases for user information.

A fully integrated system is shown in Figure 11. In this option, all user

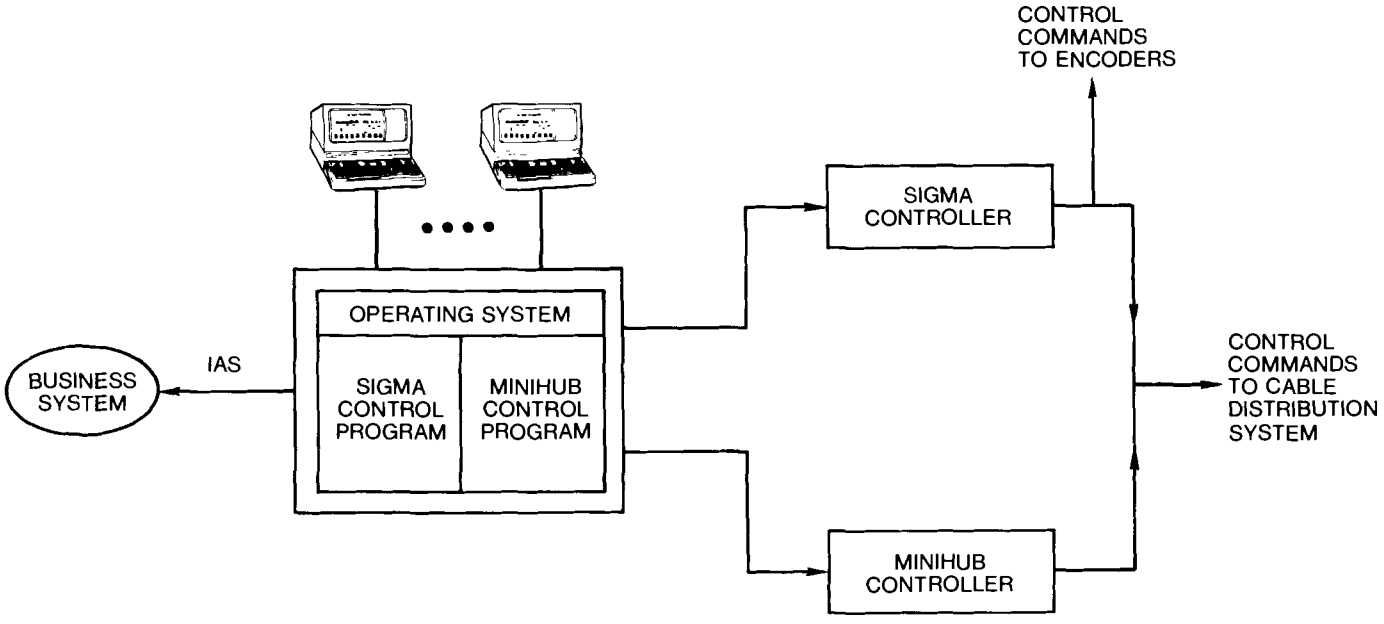

Figure 10. Common Computer - Separate Control Programs

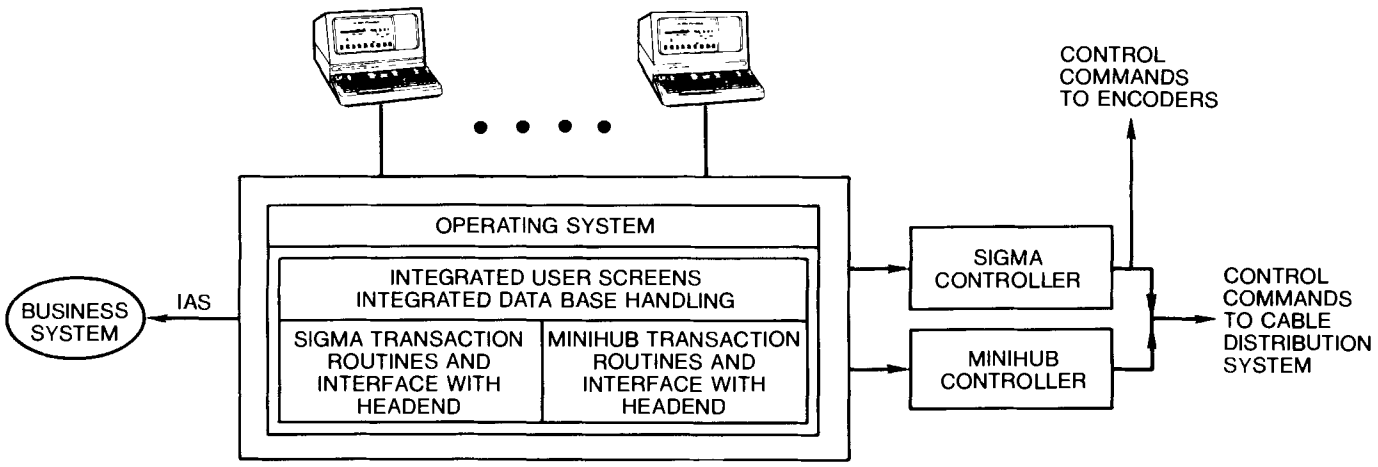

Figure 11. Common Computer - Integrated Screens and Data Base

screens are integrated as well as all of the customer and decoder information data bases. This provides for efficiency of maintenance, optimum terminal response time, and reduced data storage requirements. The integrated system is also much easier to use, since the equipment used to deliver the TV signals (whether off-premises or in-home) is transparent to the terminal operator. This is the preferred architecture described in the proposed hybrid addressable system.

A RECOMMENDED HYBRID ADDRESSABLE SYSTEM

The preferred system (Figure 12) provides Sigma-level security for all premium channels. Although the example of Figure 12 shows only five premium channels, any number of the cable system's channels could be encoded. At the headend the scrambled channels are combined with other, non-premium, services and system control signals. A common computer feeds separate control data channels, each individually optimized for data communication throughput based on the differing message requirements of Sigma home terminals and Mini-Hub off-premises equipment.

Conventional trunk and feeder lines distribute premium and non-premium channels to both master decoders and individual decoders. Each master decoder feeds descrambled signals locally to the Mini-Hub units. The master decoder (Figure 13) selects each scrambled channel, descrambles and decrypts video and audio content, and modulates/upconverts each signal to an otherwise unoccupied frequency. The master decoder is modular, each tuner/converter / descrambler / upconverter being self-contained and including its own digital control receiver. The tuners are frequency agile, tunable to any cable channel as directed by the control data channel from the headend. Similarly the upconverters are frequency agile, although their tuning range is more limited.

Each descrambler has the encryption security features of the Sigma home-terminal unit. The Mini-Hub units tune the descrambled and upconverted premium channels as well as the clear channels carried throughout the cable system. The subscriber requests channels by means of the SIU located in his home. For each subscriber an authorized channel map is down-loaded to the logic system of the Mini-Hub. Only if there is a match between the requested channel and the channel map does the subscriber receive the program.

CONCLUSION

No longer is the cable operator faced with the choice of exclusively off-premises or exclusively in-home equipment for his addressable system. Cable systems are not constructed in cities or towns which consist entirely of single-family homes or entirely of high-rise apartments. What is needed is an architecture tailored to cable systems serving a variety of population densities and types of dwellings.

The recommended hybrid addressable system satisfies this need without compromise to signal security. Integration of the control system has been achieved allowing business system operation without regard to the type of hardware used to deliver premium programs to the subscriber. The system hardware configuration is designed for economy and flexibility of channel assignments.

ACKNOWLEDGMENTS

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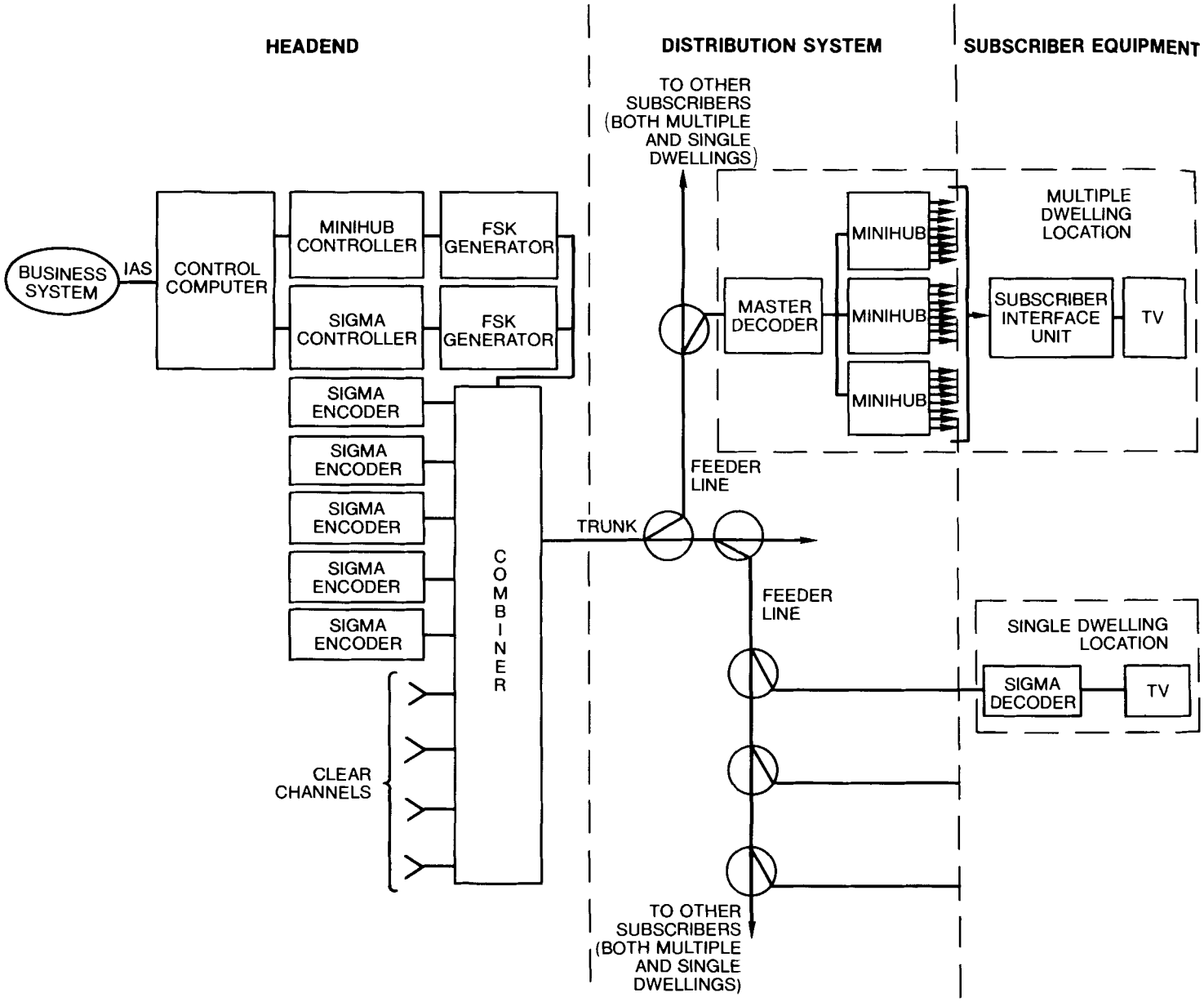

Figure 12. Hybrid Addressable System With Master Decoders

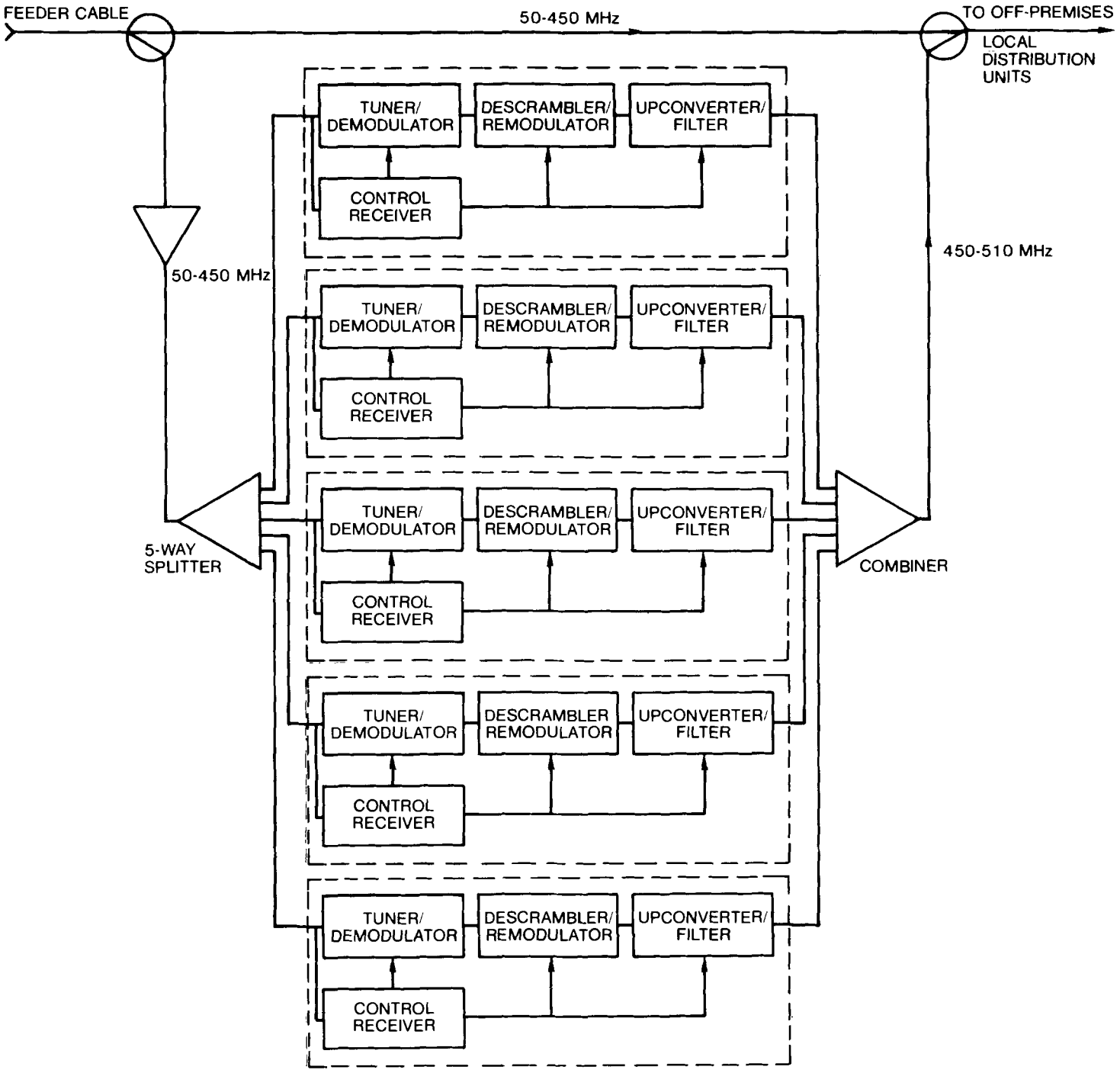

Figure 13. Master Decoder Block Diagram