USER FRIENDLINESS OF BASEBAND CONVERTERS

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ABSTRACT

Making home terminal equipment easier to operate and simpler to incorporate with consumer electronics equipment is an urgent need for the cable industry. The home video/electronics center needs ultimately to be engineered as a whole -- not left to chance, which has been the inevitable result of the different business motivations and technical directions of cable equipment designers and their counterparts in the home electronics industry.

This paper discusses the use of baseband video as the common single element in a systematic approach to the interconnect problem. The "user friendly" operation of the baseband converter is examined in relation to:

- EIA baseband decoder interface
- On-screen display for menu-driven event programming and other user features
- BTSC stereo and audio issues

INTRODUCTION

The most important decisions in the working lives of most cable system engineers are major equipment procurement decisions. Multi-million dollar capital equipment selections are never easy, especially when the factors to be weighed are as complex as in cable plant and component decisions. A good decision can assure a successful system start-up or rebuild; a bad decision can be costly for the system and can wreck a career.

Addressable converter decisions, in particular, can be some of the most agonizing. A commitment to a particular technology is a very long term commitment, sometimes 10 to 15 years. The factors to be considered are very different in character:

- security
- cost
- compatibility
- future growth
- performance history
- supplier profile
- user friendliness

This paper focuses on that overworked but important phrase "user friendliness," as applied to converters, especially baseband converters.

TECHNICAL DISCUSSION

Background

The converter has been around for almost twenty years. Indeed the patent which described the earliest (and still essential) application of the converter to avoid direct pick-up interference (DPU), has run a seventeen year course and expired (Mandell et. al., U.S. Patent 3,333,198, issued July 25, 1967). However the technology has changed radically. In addition to protection against DPU, other functions were added to the converter. It became convenient to use it for channel expansion by tuning non-broadcast channels. With the coming of cable, Pay TV, and scrambling of pay channels, a decoding function was added resulting in the converter/decoder. With an increase in the variety and value of pay services, increased demands have been made on the security of pay TV delivery systems. By the late 70's serious development had started [initially for broadcast subscription television (STV)], of scrambling techniques using baseband video signal processing at both encoding and decoding locations. The application to cable was inevitable and thus emerged the baseband converter.

Later generations of the baseband converter facilitated the intended increase in signal security. It also offered the possibility of increased customer satisfaction by being easier to use than its RF heterodyne forerunner. With access to baseband signals, in particular, audio, it was possible to add volume level to the remote control. Direct access to the baseband signal promised to make it easier to interconnect to a variety of other video equipment, especially VCR's. Other advantages will be realized as consumer electronics video technology matures.

"User Friendliness"

The cable engineer, in making an equipment selection decision, frequently makes a comparison of a variety of converter models from different cable equipment suppliers. Thus in making a comparative evaluation of "user friendliness," the comparison is with other cable converters.

By contrast, the consumer has relatively little experience with other cable equipment, but does have a television receiver(s), and probably has a VCR. The consumer can form both a relative opinion (relative to other consumer electronics equipment), and make an absolute judgement as the converter is used day by day, of how easy and convenient it is to use. And since he makes monthly payments for the services provided via the converter, he also has a way to express his opinion!

To the consumer, "user friendliness" can mean several things, including:

- o functional convenience
- o ease of operation
- o ease of connection to other equipment

Functional Convenience

Functional convenience refers to the kind and type of functions offered by the converter. Channel selection may be by rotary knob, slide-switch or keypad. Interaction between pieces of equipment may be required, for example between the converter and VCR for recording premium programs. The converter may offer remote control, with a few controls such as channel selection and volume control, or with more controls such as those required for a programmable timer.

Ease of Operation

Just providing convenient functions does not necessarily mean that equipment is easy to use; far from it, as most people who have used programmable VCR's will testify. Extremely important to the user are three factors:

- o How obvious is its basic operation?
- o How easy is it to learn to use all the desired features?
- o How easy is it to remember how to use it?

Some features (and for that matter some entire pieces of equipment) are seldom used because of the difficulty of learning and remembering the operation. Ideally, you never have to read a single instruction!

Ease of Connection

The connection between a converter and the home electronics equipment (the television receiver) used to be simple, a short length of RG 59 cable and a balun. With the explosive growth of the use of VCR's, however, the interconnection has become a nightmare involving multiple cables, switching boxes, and dozens of wiring diagrams to choose from. This has become a source of frustration to the consumer and of costly installation and service calls for the operator.

To the consumer, convenience of connection means simple, standardized, interconnections between all types of home video appliances, whether or not they are cable. The consumer ultimately has to be able to shop around for video accessories, and must be able to understand how to connect or plug them together. Equipment configurations, once installed by the operator, must be readily expandable by the consumer, without the need for special accessories (such as switchers).

Benefit of "User Friendliness"

The importance to the operator of the "user friendliness" of equipment installed in the home can not be understated. If the subscriber finds it difficult or inconvenient to connect or use the equipment through which cable services are provided, the end result is always the same; a reduction in the perceived value of the service.

A "user friendly" system will:

- o Assure retention for both basic and pay services.
- o Minimize service calls.
- o Maximize the use of services that are charged on a "per use" basis -- for example, Pay-Per-View (PPV).

Baseband converter technology, by virtue of the very techniques (detailed later) that facilitate enhanced security, also provides the opportunity to increase the variety of easy-to-use functions, and makes possible a standardized interface, ultimately compatible with all video components.

The Baseband Converter

Almost twenty years after their first introduction cable converters still serve an important function in relation to direct pick-up. Channels carried through the cable are still vulnerable to interference by broadcast television signals at the unshielded connection to television receiver tuners. The baseband converter still serves the same purpose of converting such channels (and usually all other channels carried on the cable) to a single output channel not subject to direct pick-up interference. It is almost invariably used to convert all channels carried on the cable, not only non-broadcast channels and pay channels. The consumer uses the converter for all program selections.

Baseband Security

The converter (Figure 1) is constructed with a wide-range tuner which selectively converts any input channel to an intermediate frequency, and then by demodulation to video and audio baseband signals. Baseband signal processing makes possible the use of some extremely secure scrambling/descrambling techniques. The converter illustrated in Figure 1 decodes a scrambled channel which has been encoded by means of:

- o video sync removal
- o video polarity inversion (time variable)
- o digitized encrypted audio transmitted in the horizontal blanking interval (HBI) (2 audio channels)

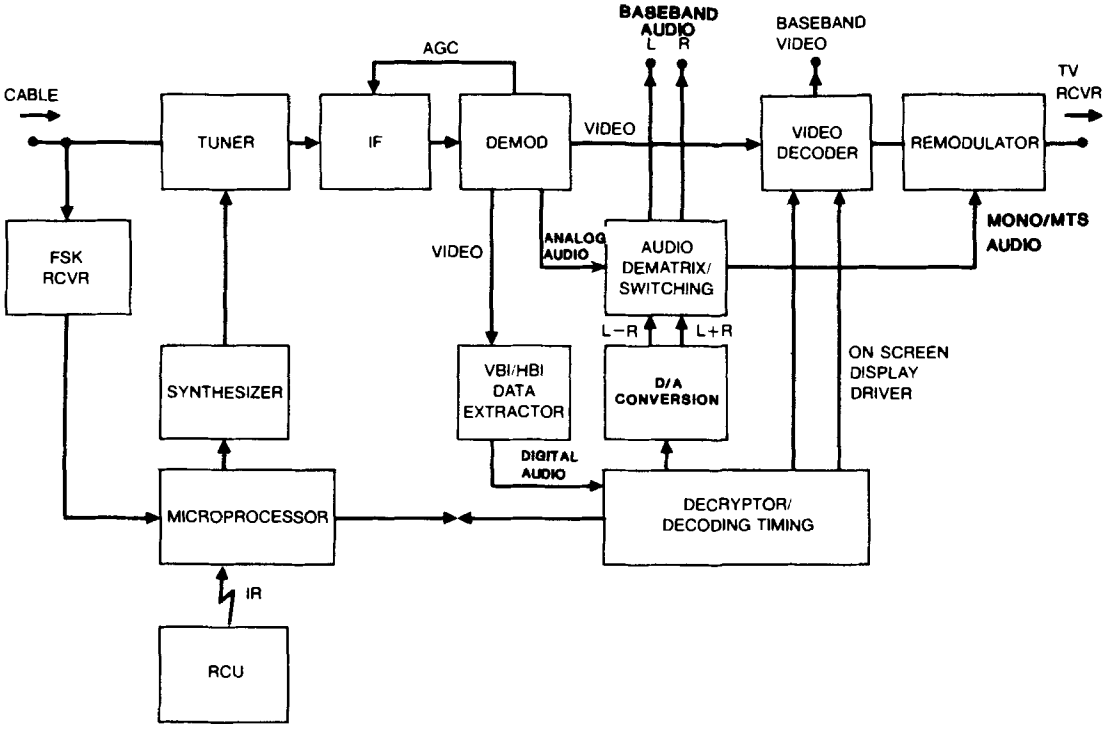

FIG. 1. BASEBAND CONVERTER/DECODER
WITH STEREO OUTPUTS

The audio carrier is not used for premium programs, but is available as a "barker" channel. Addressing is carried out by means of a separate FSK data channel (104.75 MHz or 112.7 MHz). Program identification signals (tags) are sent within the vertical blanking interval of each scrambled channel. All control signals are encrypted for transmission.

Flexibility

This decoder has three kinds of signals accessible at baseband:

- o video
- o audio carried on the audio carrier (including BTSC stereo subcarriers)
- o two channels of audio derived from the encrypted transmission in the HBI.

The use of scrambling techniques employing baseband signal processing for decoding makes possible two developments.

- o the direct connection to other equipment: TV monitors, VCR's, etc. of baseband video and audio signals.
- o baseband-only descramblers for use with television receivers (and VCR's) that are equipped with appropriate interface connectors.

The accessibility of baseband signals implies not only their availability for connection to other equipment, but also the opportunity to modify or substitute other signals for them. Volume (and mute) control of the audio signal is thus made simple. Character generation for on-screen display, is facilitated by access to the video signal and to precision timing signals.

Because the scrambled audio signal is carried as high speed data, the tuner and IF section of the converter are designed for superior frequency response when compared with a television receiver. Used with a video monitor, a baseband converter can avoid the double RF signal processing (and frequency response degredation) inherent in an RF converter connected to a television through the receivers's tuner.

Prior to the announcement of broadcast BTSC stereo, baseband converters were designed to pass only the normal audio spectrum through to the sound carrier of the output channel. Such converters do not pass the BTSC encoded channel. Later generations of baseband converters solve this problem by use of expanded-bandwidth audio demodulator and remodulator circuits.

The availability within the converter of the BTSC subcarriers makes it possible to add an optional BTSC stereo decoder.

On-Screen Display

Because it provides direct access to video signals, the baseband converter provides an opportunity to superimpose additional information on the active video portion of the signal delivered to the television receiver. For this purpose access to video is not the only requirement. The generation of characters to be superimposed upon an active television picture requires precise timing. Timing jitter as small in magnitude as 30 nanoseconds is annoyingly visible. Decoding of scrambled signals requires precise timing circuits, and these same circuits are used to advantage to control the timing of on-screen display characters for both scrambled and clear channels.

It is simple (and cost effective) to provide on-screen display of channel number and time as well as prompting commands and error codes. Upon channel selection the converter/decoder illustrated in Figure 1 displays the channel number followed by time of day (Fig. 2a,b). Each is displayed for 3 seconds, then the display fades from the screen. For minimum cost, display generation circuits are built into the LSI device used for decoding and decryption. The display can be recalled by use of a "recall" button on the converter's remote control unit. The time clock is automatic and is extremely accurate, being periodically downloaded through the addressing channel.

Access to video for generation of superimposed characters can also be used for text display such as teletext, menu-driven-instructions, or captioning, but at additional cost. Instruction screens for such purposes as event pre-programming (time and channel) are becoming available in VCR's, and are likely to become attractive for similar purposes in converters and PPV devices.

The benefits of on-screen display are:

- o easy to read
- o freedom to locate the decoder other than on the television receiver
- o user promoting and the ultimate availability of menu-driven instructions.

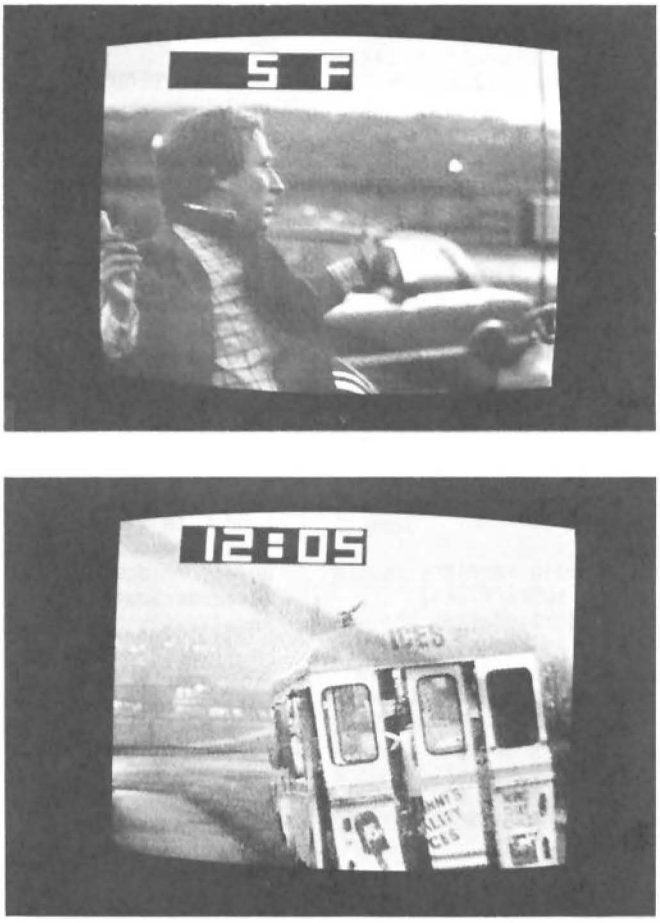

FIG. 2a,b. ON-SCREEN DISPLAY -- CHANNEL NUMBER; TIME

The Baseband Converter and Audio; Opportunities and Challenges

Opportunities. For the baseband converter, dealing with audio, especially stereo audio, provides some unique opportunities and some interesting challenges.

Access to baseband scrambled video makes available an additional communications medium for premium audio. The audio signal can be digitized and encrypted (for very high security) and transmitted as high speed data during the time interval normally occupied by horizontal sync. The result is more audio channels. Two digitized audio channels can be accommodated in the HBI and used with scrambled signals for either stereo or bilingual operation. For stereo the two audio channels are transmitted as (L+R) and (L-R) and are dematrixed in the decoder into left and right baseband audio outputs. The (L+R) channel is retained for the monaural RF output to the television receiver. Bilingual operation uses the two audio channels completely independently with the consumer convenience of remote control selection of either channel. In addition, the normal audio carrier (and BTSC subcarriers if desired) is available for transmission through the cable.

Transmission of premium channel audio as encrypted digital information not only assures the cable operator of a high degree of security, it also provides the consumer the confidence that undesired channels will not accidentally be overheard while tuning scrambled channels with a conventional television receiver.

Control of baseband audio signals in the converter makes available to the consumer the volume control and mute functions that have become very popular with television receivers. The mute function finds additional use in the baseband converter in elimination of the harsh and annoying sounds which sometimes accompany channel changing with RF converters. With an RF converter an interruption of the RF signal to the television receiver is usually experienced when a channel selection is made. The baseband converter provides an output signal continuously; only the video and audio content changes on channel selection.

The baseband stereo outputs of the converter can be addressably controlled for increased revenue. The circuit architecture also provides for a relatively inexpensive BTSC stereo decoder option, also under addressable control.

Challenges. However, besides providing opportunities for improved "user friendliness" and increased revenue generation, the baseband converter has brought a challenge to the designer. Baseband converters were designed only to pass monaural signals to monaural television receivers, the standard at that time. With the later introduction of the BTSC signal format, it was found that baseband converters would not pass the BTSC subcarrier information to stereo-capable television receivers and stereo adaptors.

Manufacturers of baseband decoders have solved this problem by re-designing the converter's demodulator and audio processing circuits in such a way that the BTSC subcarriers can be by-passed within the converter. The output signal will drive a stereo-ready television receiver. There is a degree of compromise however. To achieve volume control without the added costs of stereo decoding and re-encoding, the amplitude of the entire audio signal, including sub-carriers, is varied. In consequence stereo separation varies with volume level. In the converter described here, optimum separation occurs at maximum volume level.

SIGMA Converter/Decoders

To suit various revenue-generation applications, three versions of the OAK SIGMA converter/decoder have been designed:

- SIGMA 1 -- monaural, digitally encrypted.
- SIGMA 3A -- monaural and digital encrypted stereo.
- SIGMA 3C -- monaural/digital stereo and BTSC decoding.

All three versions are designed to pass a BTSC signal through to the RF output terminal. The following table shows the outputs at both RF and baseband terminals for various scrambled and clear types of input signal.

User Benefits

With baseband outputs, direct connection to the consumer's stereo equipment can be provided. In the Spring of 1985 a test was conducted in a large cable system of converter/decoders of the type 3A configuration. Sixty system employees participated, and installed the equipment themselves. Table 2 is a summary of answers to questionnaires completed by a number of the participants.

From the standpoint of "user friendliness" the results were interesting. In order to make use of stereo equipment with the television receiver a significant number of participants had to relocate furniture within the living room. Once having done that, however, most used the stereo to listen to all program material regardless of whether it was stereo or not.

To the consumer, the audio benefits of the baseband converter are:

- volume control and muting
- freedom from channel-change noises
- bilingual operation
- privacy of scrambled channels
- availability of signals to connect to home stereo equipment
- the option of a built-in BTSC decoder so that stereo may be enjoyed without purchase of a stereo TV.

TRANSMITTED AUDIO	SIGMA 1 OR 3A, REMODULATOR OUTPUT	SIGMA 3C REMODULATOR OUTPUT	SIGMA 3A BASEBAND OUTPUTS		SIGMA 3C BASEBAND OUTPUTS	
CLEAR			LEFT	RIGHT	LEFT	RIGHT
MONAURAL	MONAURAL	MONAURAL	MONAURAL	MONAURAL	MONAURAL	MONAURAL
MTS	MTS	MTS MONAURAL OR SAP	MONAURAL	MONAURAL	LEFT OR SAP	RIGHT OR SAP
DIGITIZED/ ENCRYPTED			LEFT	RIGHT	LEFT	RIGHT
MONAURAL	MONAURAL	MONAURAL	MONAURAL	MONAURAL	MONAURAL	MONAURAL
STEREO	MONAURAL	MONAURAL	LEFT	RIGHT	LEFT	RIGHT
BILINGUAL	LANGUAGE 1 OR LANGUAGE 2	LANGUAGE 1 OR LANGUAGE 2	LANGUAGE 1 OR LANGUAGE 2	LANGUAGE 1 OR LANGUAGE 2	LANGUAGE 1 OR LANGUAGE 2	LANGUAGE 1 OR LANGUAGE 2

TABLE 1. SIGMA 1 AND SIGMA 3 OUTPUT MATRIX

		Percent
1.	Did you have problem connecting the converter terminal to TV set?	Yes -- 11 No -- 89
2a	Do you have a component stereo system?	Yes -- 100 No -- 0
b	If yes, did you connect 2 audio jacks to the stereo?	Yes -- 95 No -- 5
c	Is your component stereo located close enough to TV for convenient connection?	Yes -- 68 No -- 32
d	Were 6 foot cables long enough?	Yes -- 56 No -- 44
e	Did you have to move any furniture?	Yes -- 35 No -- 65
3.	Rate degree of difficulty in connecting converter to stereo.	No difficulty ------ 89 Slightly difficult - 0 Moderately difficult 11 Very difficult ----- 0
4a	Did you listen to TV sound using stereo system?	Yes -- 100 No -- 0
	If yes, did you listen to...	All -- 74 Channels Stereo -- 26 Channels Only
b	Which channels did you listen to in	MTV -- 47 TMC -- 68
5.	Could you tell the difference between stereo and monaural programs just by listening to the audio?	Yes -- 76 No -- 12 Sometimes ---------- 12
6.	For stereo programs how would you rate the quality?	Very good ---------- 44 Good, better than TV 56 Indistinguishable from monaural -- 0

TABLE 2. SUMMARY -- SPRING 1985 FIELD TEST

The Baseband Interface

Television receivers are now generally available with the capability of tuning most cable channels. An EIA committee (the Television Systems Committee R4), with help from the cable industry (Ref. 1), has been working on the problem of receiver compatibility with signals which must be descrambled. The committee has defined an interim standard (known as IS-15, Ref. 2) which defines the interface between a wide variety of consumer video devices, with special emphasis on the interface between a television receiver and a decoder.

The approach selected defines a baseband interface in which audio and video signals together with appropriate control busses and an AGC signal are exchanged between the television receiver and a baseband-only decoder. The physical interface is a 21 pin connector known as a Cenelec connector. The receiver and decoder, each equipped with a Cenelec connector, are joined by an interconnecting cable. The connector pin diagram is illustrated in Figure 3. The same interface may be used with other television peripheral devices such as video tape recorders, teletext decoders, DBS decoders, and personal computers.

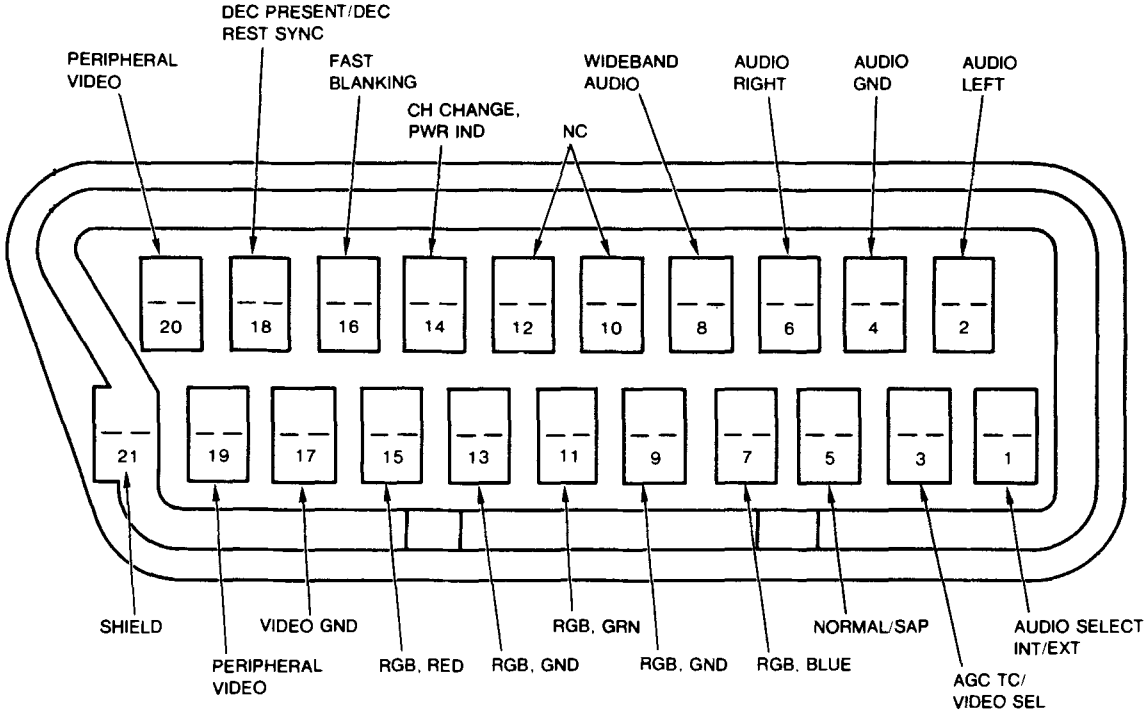

FIG. 3. CENELEC CONNECTOR -- CONNECTIONS

The approach selected is illustrated in Figure 4. Interfacing circuits and the Cenelec connector are added to an otherwise normal television receiver, with all of its customary features. The decoder is much simpler and smaller (Fig. 5) (and less costly) than a converter/decoder; it too contains special interfacing circuits. These circuits normalize the baseband audio and video signals and generate control signals to be exchanged with the receiver.

Channel selection is performed by the tuner contained within the television receiver. Baseband video from the receiver's video demodulator passes through the receiver interface circuit to the decoder. Both scrambled and clear video signals are handled in the same way.

Video received through the decoder interface circuit passes to the video descrambling circuits. The descrambled output is returned to the television receiver in standard NTSC (CCIR-M) format through a similar path.

The decoder determines the status of control signals which are used in the receiver to define the mode of AGC operation, and to select the audio source, dependent upon whether the received signal is clear or scrambled. In the clear mode receiver AGC is developed internally and audio derived from the receiver's internal demodulator. With scrambled signals, AGC is derived from the decoder, and audio may be provided by the decoder if the sound channel is encoded for high security (as illustrated).

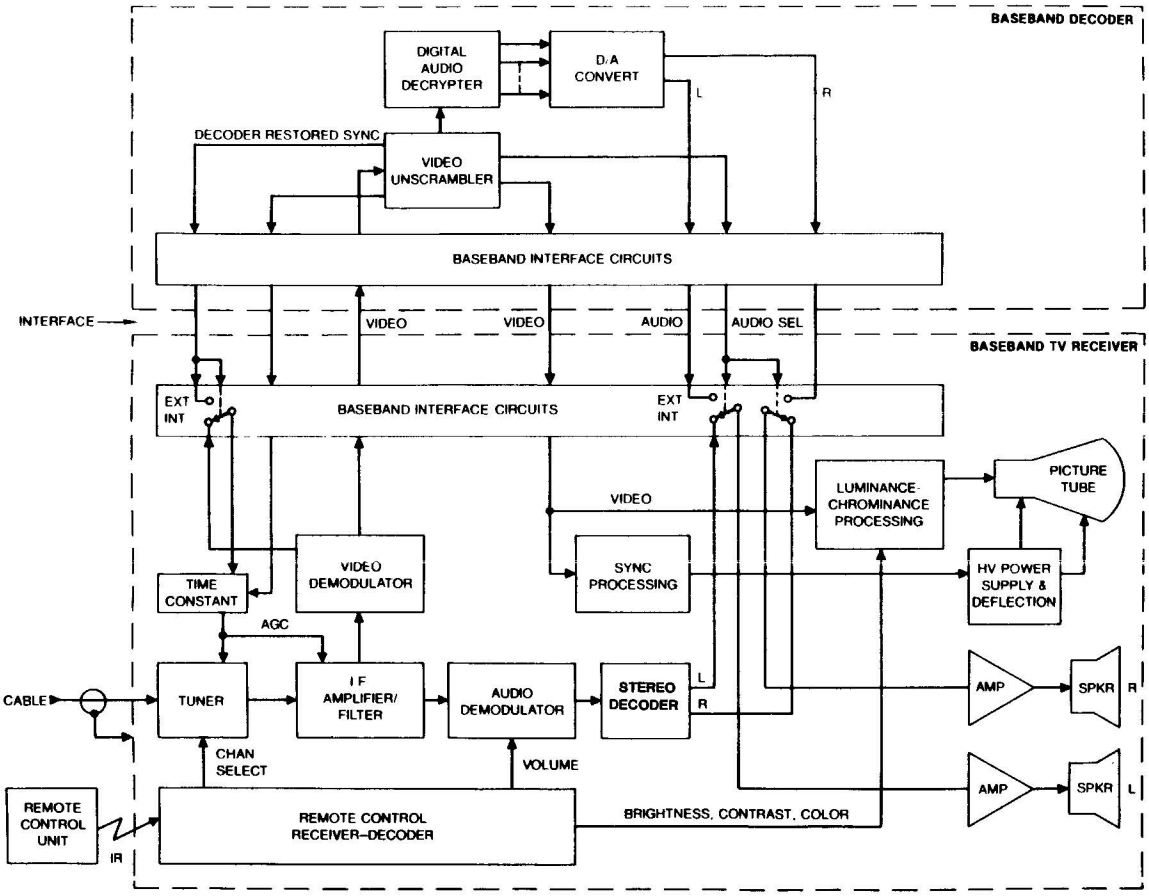

FIG. 4. BASIC BASEBAND CABLE DECODER AND TV RECEIVER FUNCTIONS

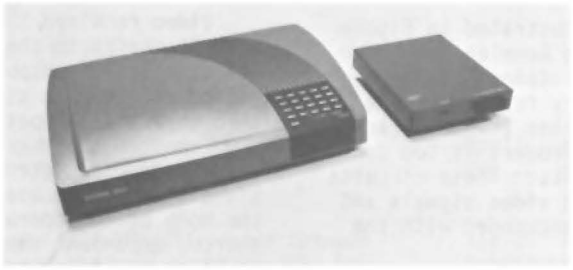

FIG. 5. SIGMA CONVERTER/DECODER AND THE BASEBAND ONLY DECODER

The television receiver/decoder baseband interface makes maximum use of the advantages of baseband scrambling, but with simple interconnection, functional convenience to the consumer, and reduced cost.

The selection of a baseband addressable system is important because of the future availability of baseband-only decoders compatible with the IS-15 interim standard. While RF scrambled signals can be decoded at baseband, and appropriate decoders are likely to emerge (Ref. 2), only baseband scrambled systems can take maximum advantage of the features of IS-15.

With IS-15, baseband video will become the common interconnecting signal format for all components of home video systems including cable devices. IS-15 will benefit the cable operator, who ultimately needs to have less capital invested in fully featured converter/decoders, and the subscriber who will enjoy the ease of installation and convenience of operation. However, as noted in Reference 2, these benefits will only occur if and when IS-15 is adopted and implemented. Cable operators will play a role in providing the incentives to fuel consumer demand for IS-15 equipped receivers, VCR's and other video components.

CONCLUSIONS

In comparison with the RF heterodyne converter, the use of baseband signal processing in a baseband converter provides much superior functional convenience and ease of operation. In making an addressable converter equipment selection decision every key technical factor is in the favor of the baseband system:

- o security
- o technical development parallel to other consumer video electronics
- o interconnections to other equipment

User friendliness is more difficult to quantify than these technical factors. It is also more difficult to put an exact value on it. This paper has attempted to summarize the many ways in which the baseband converter/decoder is demonstrably more user friendly than its RF heterodyne counterpart.

- o On-screen Display
  - -- channel
  - -- time
  - -- menu driven instructions
  - -- eliminates the need to locate the converter on the TV
- o Audio
  - -- bilingual
  - -- stereo outputs
  - -- volume control and muting
  - -- quiet channel changing
  - -- privacy for scrambled material
- o Interfacing
  - -- stereo
  - -- compatible baseband-only decoder maximizing the opportunities to interface with other home video equipment
  - -- baseband video is the ultimate interconnection buss

Ultimately a decision about the "user friendliness" of an addressable converter is a "bottom-line" decision. By influencing customer retention, customer satisfaction (and the effect on service calls), and customer use of equipment for chargeable services, these characteristics of a converter significantly affect the profitability of a cable operation.

In the future the IS-15 interface may permit increased use of addressability with the simpler baseband-only decoder. At that time the economic advantages will be three-fold:

- o reduced capital investment
- o reduced installation and maintenance costs
- o the benefits of increased consumer satisfaction

And who knows? Perhaps the consumer will ultimately own the decoder.

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