The RF Bypass Converter
An Alternative Broadband Delivery Mechanism

Thomas F. Martin
Jerrold Communications
Carrollton, Texas

Abstract

The issue of compatibility between a cable converter and consumer electronics has led to the development of means to concurrently provide all authorized services to the subscriber. Interdiction systems are one example of such means. A significant drawback with interdiction is its use of deny security, which makes it difficult to gradually phase into a cable system.

An alternative approach is presented which provides addressable, concurrent delivery of all authorized services to the home while retaining supply (descrambling) security. This approach is well suited to the subscriber taking one pay channel and desiring access to pay-per-view programming. In some cases an additional, non-addressable trapped pay channel can be offered as well. Because there is a high percentage of single-pay subscribers, this approach might serve the needs of many subscribers while retaining excellent compatibility with consumer electronics.

An overview of a proposed bypass converter is given, and some technical considerations in its design are described.

Compatibility with Consumer Electronics

Consumers and cable operators are sensitized to the potential incompatibility between a cable converter and some consumer electronics devices. For example, the "record one channel while watching another channel" problem requires either a bypass arrangement or two converters, one for the television and one for the VCR. Other examples of incompatibility are with picture in picture, or multiple televisions in the home.

One proposed solution to this interface problem is off-premise control of signals into the home. Cable systems using outside traps are the classic example of broadband delivery of all authorized services to the home, but these, of course, are non-addressable. Other mechanisms for controlling access to signals with outside equipment include interdiction (jamming) and addressable control of trap switching. Both mechanisms allow the full spectrum of authorized signals to enter the subscriber's home, reducing or eliminating any compatibility problem.

Supply versus Deny Security

The interdiction systems generating interest today are typically jamming systems, which interfere with (jam) clear signals before they enter the home. This is an example of deny, or negative, security. The primary advantages of deny security are low distortion of authorized signals and flexibility in jamming non-standard or yet to be standardized signals (for example, HDTV). The clear disadvantage

of deny security is the inability to gradually introduce it into a system. With signals in the clear, every subscriber must be equipped with a mechanism to deny unauthorized channels before the service can be turned on. Another disadvantage cited by some operators is the increased risk of piracy with clear channels on the cable plant.

The descrambling converter is an example of supply, or positive, security that allows viewing of an authorized channel by descrambling an otherwise unwatchable picture. As such, the converter has the very significant advantage of being able to be gradually introduced into a system. New services or channels can also be added at any time, since they are secured by scrambling rather than any form of physical security (such as traps). Also, the signals on the cable plant are scrambled and thus less susceptible to piracy. The converter's limitation is its inability to descramble more than one channel at a time, and its single channel output to the television or VCR.

Proposed Bypass Converter

The desirable combination of supply (descrambling) security and broadband delivery of all authorized channels can be at least partially obtained with a bypass converter. This is a converter which can tune and descramble one pay channel, then insert that descrambled channel into the bypassed combination of all other signals. The

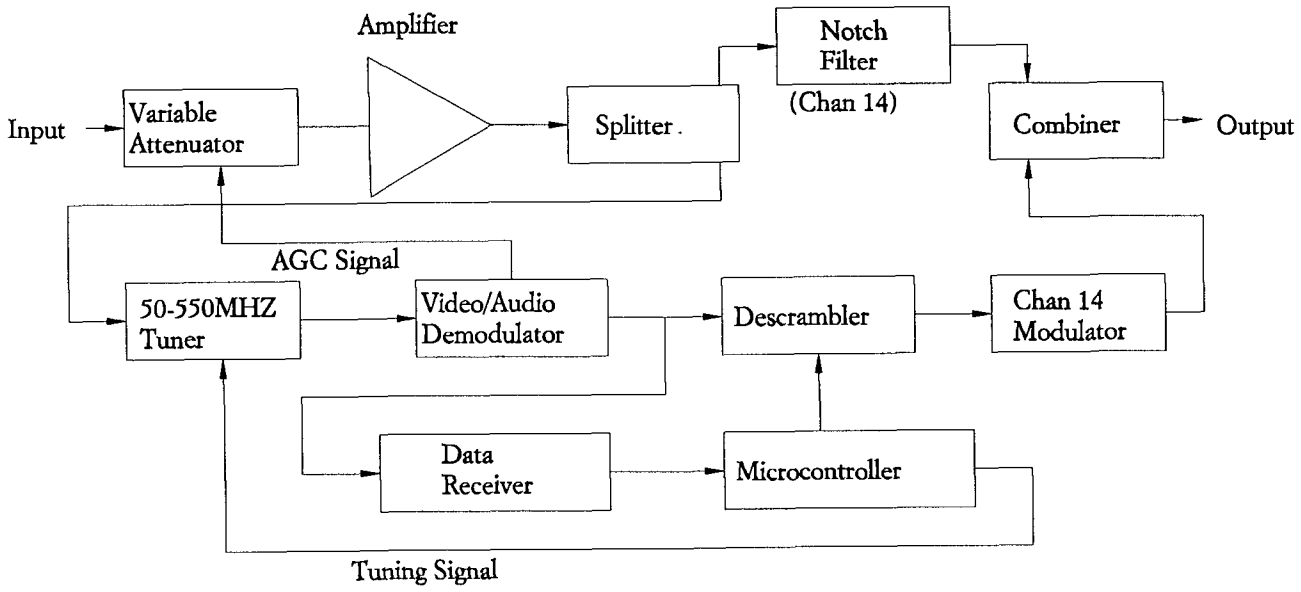

Figure 1: Bypass Converter Block Diagram

block diagram of Figure 1 outlines the basic approach to this type of converter. Such a converter is most applicable in a system with a large non-scrambled basic tier.

A clear understanding of the bypass converter can be gained by study of the block diagram. The input signals, typically in the 50 MHz to 550 MHz range, first pass through a variable attenuator to normalize levels at the input of the amplifier. The amplifier is used to make up for splitting and filter losses, and to set the noise figure of the converter. The output of the amplifier is then split, with one output of the splitter going to a 50 to 550 MHz tuner. This tuner selects the pay channel to be demodulated and descrambled. Tuning is controlled not by a remote control or keyset on the converter, but by a downloaded command from the headend. The descrambled signal is then remodulated to the output channel frequency, for example channel 14. This remodulated signal is then combined with the bypassed signals and presented to the television or VCR.

The bypass path signals are filtered by a band reject, or notch, filter (for example, channel 14), and are then combined with the descrambled and remodulated pay channel signal before being presented to the television or VCR. This filtering on the bypass path removes, for example, channel 14 from the cable plant, making room for the remodulated pay channel to be reinserted. Because this filter cannot have perfectly steep

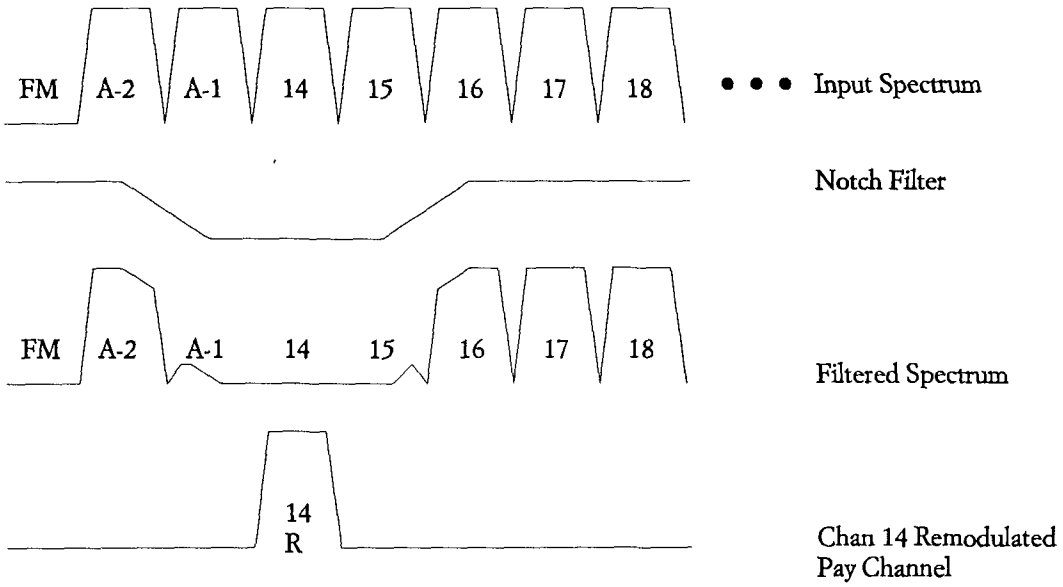

Figure 2: Impact of Notch Filter on Bypass Channels

attenuation skirts, there is some attenuation of channels plus or minus two channels away from the output channel (see Figure 2). The channels on either side of the reinserted channel are thus the ideal location for some of the scrambled pay signals, since they cannot be directly used by the television or VCR.

The result for the subscriber is that the pay channel tuned at any moment is always output on the reinserted channel, while all other channels (many of which are non-scrambled and therefore tuneable by the television or VCR) are bypassed and appear to the television or VCR at their normal channel frequency. As previously mentioned, the tuning of the pay channel is controlled by downloaded data — there is no need for any human interface to the bypass converter. If desired, it can be located behind the set, or even at the cable entrance to the home, allowing service to multiple televisions and VCR's in the home.

The advantages to the subscriber are obvious — the converter can be forgotten and the television, VCR, and remote controls can be used as if in an off-premise system. The VCR can be connected in a straightforward series manner, between the bypass converter and the television, and any authorized channels can be viewed and/or recorded without limitation. The disadvantage is equally obvious — with only one tuner, descrambler and modulator, only one pay channel can be presented to the subscriber at any time. A change of pay service requires a call to the system operator to have the new channel tuning command sent.

While this single pay channel might appear to be quite limiting, many subscribers take only one pay service. An approach to further circumvent this limitation is to use non-addressable, negative trap security outside the home for any service or services which have high and stable penetration. These services don't necessarily need addressability if churn and spin are low, and negative security is appropriate when penetration is very high — only the small percentage of non-subscribers need a trap.

Pay-Per-View Considerations

A bypass converter can be a good choice for those subscribers desiring one (or two, if trapped) pay channels and access to pay-per-view programming. Pay-per-view authorization is accomplished by downloading an event number authorization to the bypass converter, prior to a pay-per-view event. The converter then continuously reviews a list of events on the system and their respective channel numbers. When an event number on the system matches a previously downloaded event number, the bypass converter automatically tunes

away from the normal pay channel and to the pay-per-view channel, for the duration of the event. This happens with no input from the subscriber at all, other than a request for the event via CSR, ARU, or ANI. The pay-per-view event automatically appears on the reinserted channel at the proper time.

Technical Issues with a Bypass Converter

There are several technical issues related to a bypass converter that are not issues in the design of a normal converter. These issues include AGC of the bypassed channels, the impact of tilt in the system, control of the relative level of the bypassed channels and the remodulated channel, and the transmission of tagging data to allow preauthorized pay-per-view.

AGC of the bypassed channels as a group is necessary for two reasons — first, to meet the FCC requirement that the output level of a cable system terminal device (CSTD) be limited, and second, to insure a reasonably good level match between the remodulated channel and its adjacent (6 MHz away) and alternate (12 MHz away) bypassed channels. The first requirement must be complied with for FCC acceptance of the device. The level match is required because of the imperfect selectivity of televisions and VCR's. If the channels adjacent or alternate (plus, minus, or plus and minus 6 MHz or 12 MHz from the tuned channel) are much higher than the channel tuned, interference in the picture will result from distortion in the tuner preamplifier or mixer. This interference appears as a beat on the screen.

Televisions are much more tolerant of alternate channel levels higher than the tuned channel, since the broadcast environment uses an alternate channel plan for any geographic area (12 MHz spacing between channels, minimum, except 10 MHz between channels 4 and 5). In this broadcast environment, the level difference between alternate channels can be very significant, as when tuned to a distant channel in the presence of a much stronger local alternate channel. Tolerance of strong adjacents, on the other hand, is not as good.

The adjacent channels can be intentionally reduced in level by the band reject filter at the remodulated channel frequency, easing the accuracy requirement on the AGC. For example, if it is determined that a typical television can tolerate an alternate channel at +20 dB and an adjacent at only +10 dB, the band reject filter can provide the additional 10 dB required rejection of the adjacent. The AGC would then need to keep the bypass channels only within 20 dB of the remodulated channel.

Any AGC works by driving some measured signal to a reference level. The

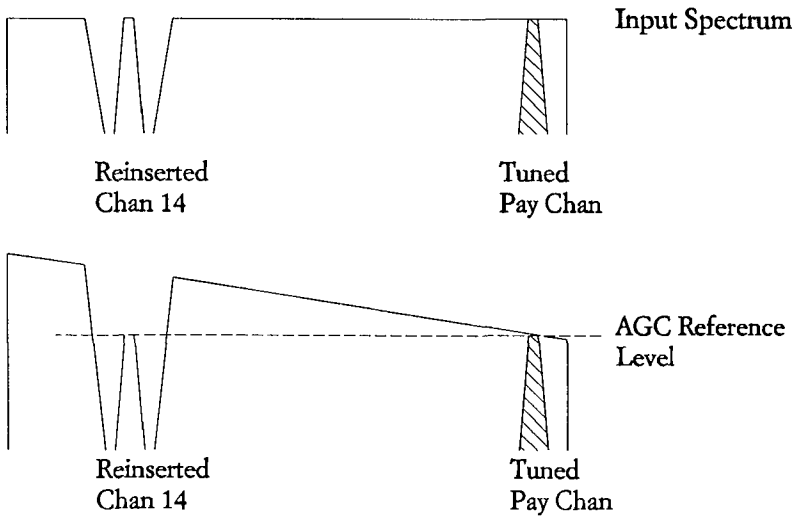

Figure 3: Impact of Tilt on AGC Operation

choice of measured signal to be used for AGC in the bypass converter depends on several factors. CATV amplifiers have used pilot frequencies as the measured signal, sometimes at more than one frequency in the band. The bypass converter cannot rely on the availability of pilot signals, however, so another choice must be made. If the bypass converter is a baseband design, the IF amplifier prior to the video demodulator has an integral AGC detector. This AGC signal provides an accurate measure of the level of the pay channel tuned at any given time. This AGC signal can be conditioned and used to control the wideband attenuator in the bypass path, driving all signals in the bypass path to a known and controlled level equal to the fixed level of the remodulated channel (see Figure 3).

In the absence of tilt on the system, this AGC method has no significant problems. However, if there is frequency response tilt on the system at the input to the bypass converter, the AGC accuracy will be degraded. AGC accuracy can be defined as how closely the channels adjacent and alternate to the remodulated channel are matched to the level of the remodulated channel. Consider the example, shown in Figure 3, of 5 dB of tilt between channel 14 (reinserted pay channel) and a tuned pay channel 61, near the top of the input spectrum. The

AGC drives channel 61 level at the output to match the remodulated channel 14 level. Because of the tilt, however, the channels adjacent to 14 are actually 5 dB higher than channel 14. A positive tilt on the system would have the opposite effect, with channel 14 output 5 dB higher than its adjacents.

Measurement of the alternate channel selectivity characteristics of a number of televisions indicates that tilt is not a major factor in the AGC design. Assuming that the AGC can match the tuned channel output level and the remodulated channel output level with reasonable accuracy, the channels adjacent to the remodulated channel are attenuated enough by the band reject filter to prevent visible interference, even if the adjacents are up to approximately 10 dB higher than the remodulated channel due to tilt on the system. The opposite case, where the remodulated channel ends up 10 dB higher than the adjacents, is of no concern because the television cannot directly tune the adjacent or alternate channels.

Tagging data must be handled differently with a bypass converter than with a regular converter. With a regular converter, tagging data specific to the tuned channel is picked up whenever that channel is tuned. The most important part of this data is the service code or event number. It is this data that tells the converter what service or event is on the particular channel. A check for match with previously downloaded authorized service codes and event numbers is made each time a channel is tuned, and if there is a match the descrambling is allowed. In the case of a pay-per-view channel, the event number is changing with each event.

The bypass converter is not tuned by the subscriber, however, so it must have some other means of knowing what events are on channels it is not tuned to, to allow the comparison to its previously authorized event numbers. This is accomplished by repeatedly sending a list of event numbers and their corresponding channels, on every pay channel. Therefore, regardless of which pay channel the bypass converter is tuned to, it will know what events are "playing" on all other channels. A constant comparison is then made between events on the system and authorized event numbers in the converter, and if a match is found, the corresponding channel is automatically tuned and descrambled.

Summary

The issue of compatibility between a cable converter and consumer electronics continues, and various approaches to improve this compatibility have been proposed or offered to the marketplace. One of these alternatives is interdiction, using jamming carriers. A significant drawback to interdiction is its deny

security, which requires fully populating a system with interdiction devices before service can begin.

One primary benefit of a converter is its use of supply, or descrambling, security. A bypass converter has been proposed which combines the advantage of the converter's descrambling security with the consumer electronics compatibility of off-premise systems. The bypass converter is best used in those systems with a significant number of non-scrambled basic channels, and for those subscribers who take one (or possibly two) pay services. It is also an effective method of offering pay-per-view programming to those subscribers.