IMPROVING CONSUMER FRIENDLINESS WITH ON AND OFF PREMISE ADDRESSABLE EQUIPMENT

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ABSTRACT

This paper will outline in detail the various On- and Off-premise approaches to addressability including: Interdiciton, Switches, and Hybrids. The current state of techniology for each of these approaches will be discussed, as well as what the future may hold in store.

The paper will also compare and contrast on- and off-premise from a conceptual perspective. The differences may be subtle, but are important in understanding why operators select one approach to another. Topics that will be covered include: Cost Sub vs Cost Per Port, Powering, and Deployment. Possible solutions to the limitations of both approaches will be presented.

Let's first define on- and off-premises. Both provide addressable control of services with equipment located outside the home; the difference is where you locate the equipment. On-premises approaches attach the equipment to a sub-scriber's residence in a secured, weatherized housing. Off-premises locates the equipment in a weatherized housing on the pole, strand or in a pedestal.

The reasons why an operator might want to consider on- or off-premises are virtually the same and can be segregated into three key areas: addressable control capability, consumer friendliness and improved operating efficiencies.

On- and off-premises equipment both contain data receiving and microprocessing memory circuitry necessary for addressable control. This circuitry enables the equipment to be remotely controlled by a computer located at the headend, office or some other remote site. While the functions performed by the circuitry will vary from one approach to another, the goal is the same: remote control of services and features. These generally include service connect or disconnect, pay-per-view and premium service upgrades or down-grades. Additionally, both approaches offer remote control of security devices, including interdiction (jamming) and traps (control through switches).

It may be helpful at this point to discuss an aspect of CATV technology that has long been misunderstood: The words addressability and security are not synonymous. Addressability, as outlined in the previous paragraph, can be defined as "the ability to remotely control services and/or features." Security, in the CATV world, is provided by the actual device used to supply or deny services or features. Most likely, the misunderstanding has come about as a result of the widespread use of addressable descrambling set-top converters, an in-home approach to security that utilizes a separate RF tuner and descrambling circuitry to supply or deny services and features.

On- and off-premises approaches are similar to the addressable descrambling set-top converter approach in that they both offer addressable control. The difference is in the type of security device used (jammers or switches vs. descrambling circuitry), the tuning function and the location of the device (inside vs. outside the home).

Having clarified "addressability" and "security" we can better understand the next reason why an operator might consider on- or off-premises technology: consumer friendliness. These technologies achieve the ultimate in friendliness by providing a transparent cable service delivery system (from the consumers' standpoint) to the entire house. The security devices utilized in on-/off-premises approaches (jammers or switches) do not require the inclusion of a separate RF tuner as is used in descrambling set-top converters. This enables the entire spectrum to be passed on to a cable-compatible television or VCR in the clear, thereby allowing all of their functions to be fully utilized (i.e., the TV's or VCR's handheld can be used to tune channels, viewing/taping combinations are unrestricted).

The potential savings arising from improved operating efficiencies is a third reason to consider on- or off-premises. These savings result from the fact that once the equipment is installed, one truly has an "addressable home." Since in-home equipment is not utilized, truck rolls are not necessary for connects or disconnects. Additionally, by minimizing the need for in-home equipment, equipment theft and abuse are minimized.

Turning now from the reasons why a cable operator may want to implement on-or off-premise equipment, we will attempt to outline the various approaches to on-/off-premise security.

<u>Trap Switching</u>

Positive and negative traps have been used for years to supply or deny a particular channel to a subscriber. Adding addressability to traps yields a low cost on-premise control mechanism.

A typical addressable control module for trap switching is based on a series of double-pole, double-throw (DPDT) RF switches. These switches must pass the entire 50-550 MHz spectrum, with flat frequency response. One leg of each switch connects to two "F" connectors, called a port. The trap (or series connected traps) connects to this port - signals are routed out one connector to the trap, then through the trap and back to the second connector. Therefore, whenever the DPDT switch associated with that port is in the "trap" position, all signals are routed through the trap.

The other leg of the DPDT switch is a through connection called the "bypass" path. With the switch in this position, the signals pass without modification to the next port. Another RF switch in a series connection allows disconnect of the drop.

Products currently on the market offer from four to eight ports, with corresponding differences in size and cost. The smallest device available measures only 1.5 by 2.5 by 7.8 inches, and is designed for use either in a single dwelling unit plastic box, or in a larger metal multiple dwelling unit enclosure.

The RF switches can be either relays or PIN diode circuits. Advantages of PIN diode switches include enhanced reliability and reduced current consumption. PIN switches also allow incorporation of the disconnect function in the basic switch, by making each of the RF switches double-pole, double-throw, center-off. This gives excellent disconnect isolation without the added size or expense of a separate switch.

The state of each switch is controlled by a microcomputer which receives addressing and tagging data from an out-of-band FSK data receiver, in a manner very similar to addressable converters. Authorized channels or events are stored in non-volatile memory to avoid any problem with power interruptions.

Because the RF switches have some loss, an input amplifier may be used to overcome this loss and provide net gain for the module. This gain is especially beneficial in light of the increasing number of TV's and VCR's in the subscriber's home. This amplifier must be designed with low distortion and low noise figure for optimum results.

Powering for the addressable control module in an on-premise, single dwelling unit application typically is from the home. A small, plug-in wall transformer near the TV provides low-voltage AC which is routed to the addressable control module over two-conductor wire. This power wire can be messengered with the coax for a cleaner installation. The addressable control module would then have internal rectification, filtering, and voltage regulation, assuring clean and stable DC voltage to operate the unit, regardless of voltage drop between the transformer and addressable control module.

<u>Limitations of Trap Switching</u>

While the switched-trap approach to addressability has many benefits, a review of its limitations is necessary in an objective evaluation. There are three significant limitations with this technology - first, the limitations of the traps themselves; second, the physical size problem as more traps are added; and third, the inflexibility of addressable channel lineup.

Traps, being high-frequency passive filters, have limited "Q" or quality factor. This is the measure of filter sharpness, expressed as the filter center frequency divided by its bandwidth. For a given "Q" (which is a function of physical constraints in a passive filter), the higher the operating frequency, the wider the bandwidth of the filter. In the case of a negative trap (notch filter), this means the notch width will become so wide that it will affect the adjacent channel. Because the negative traps are typically centered on the picture carrier, the lower adjacent channel, only 1.25 MHz away, is affected first. Similarly, a positive trap, which is simply a notch filter to remove an interfering signal injected at the headend, distorts the frequency response of the channel because of its finite "Q". This inherent limitation of traps has limited their use to frequencies well below the upper limit of today's 550 MHz cable plants.

Physical configuration of an addressable control system using traps poses a difficult packaging problem. The volume available in either the single dwelling unit enclosure or multiple dwelling unit enclosure is quite limited, and four to eight traps and associated cabling occupies most of that volume. Therefore, the addressable control module must be as small as possible to be effectively used.

Channel lineup flexibility is compromised somewhat by a switched-trap approach, since the traps on each port are fixed-frequency filters for a specific channel. Once the traps are installed, there is no way to change the frequencies (channel number) of the controlled channels. The addressable control is over whether or not a channel is authorized; there is no way to redefine those channels short of replacing traps.

<u>Interdiction with Jamming Oscillators</u>

An approach to on-premise or off-premise addressability that overcomes most of the limitations of switched traps is interdiction with jamming oscillators.

The video, and to some degree the audio, on a channel can be severely disrupted by summing a jamming carrier into the channel at the subscriber location. This approach, like a negative trap, is a form of deny security. Jamming gives a high degree of masking or concealment, as well as high signal security. The limitations of trap switching are also overcome.

The problem of limited-Q traps and their effect on adjacent channels is not an issue with an interdiction system. The jamming carriers are well controlled as to frequency and spectral content, so jamming energy can easily be contained within the channel being jammed. This is true regardless of frequency of the channel, so jamming of channels anywhere in the spectrum is possible.

Physical configuration can be less of a challenge with interdiction. Typically eight to sixteen channels can be controlled using a device considerably smaller than an addressable control module plus eight to sixteen traps. There are also far fewer RF interconnects with interdiction - two (input and output) versus eighteen (for an eight-port addressable control module). There is also the obvious advantage of not having the expense of eight or more traps.

Perhaps the biggest advantage that interdiction offers is the flexibilty it gives an operator. As with the switched-trap system, addressable control of each of many channels is available. Unlike the switched-trap approach, the frequency of each jammed channel can also be addressably controlled (within certain limits). The typical oscillator used in an interdiction device can cover approximately a 1.4 time range. For example, an oscillator might be designed to cover the entire midband, from channel A (121.25 MHz) to I (169.25 MHz), a 169.25 / 121.25 (1.4) range. This one oscillator could then be addressably moved to any channel within the midband, by a simple download of data from the headend.

Various approaches to interdiction are possible, with the biggest differences being in the oscillator deployment. A limited form of interdiction would simply use a crystal controlled, non-agile oscillator for each controlled channel. These oscillators would be switched on or off in a manner similar to the switched-trap. The advantage of no interference to adjacent channels would remain, but there would be no flexibility to change controlled channels.

A second approach to oscillator deployment is to have a limited number of oscillators available for each subscriber. Each oscillator can then cover a fairly wide frequency range (hence, number of channels). Each of these oscillators is considerably more expensive and complex than a fixed-frequency oscillator, so typically no more than four are devoted to a drop. To control more than four channels, each oscillator is quickly hopped from channel to channel, in a move, turn on, turn off, move sequence.

The advantage to the hopping oscillator is that one relatively expensive oscillator can be used to cover many channels, as long as they are within the tuning range of the oscillator. The disadvantage is that, as more channels are jammed by one oscillator, the dwell time (duty cycle) on each channel gets shorter. The masking or concealment of the video becomes less than excellent after (typically) four channels are jammed. Another potential problem with hopping oscillators is the sidebands that are generated by the rapid on/off switching of the oscillator. These modulation sidebands, if not carefully controlled in the design, will cause interference in adjacent channels.

A third approach to interdiction is to use more oscillators per drop. To do so cost effectively, each oscillator must be low in cost yet retain frequency agility. With eight to sixteen oscillators per drop, each agile over a wide range, great flexibility for deployment is possible. Those channels requiring absolute concealment can be served by dedicated oscillators. Other channels which require less masking can share an oscillator. If channels sharing an oscillator are adjacent, an entire tier of service might be controlled with a single oscillator.

An alternative to control of a tier of service is a hybrid approach, combining an interdiction jammer with switched control of a limited number of traps. For example, a hybrid with eight oscillators and two ports for tier traps could be an excellent combination of cost-effectiveness and flexibility.

Now that we have defined on-/off-premise technology and outlined the reasons why a cable operator may want to implement the technology, it is appropriate to point out the differences between the two.

The first area of difference, cost per subscriber, results from the single-home design of on-premises vs. the multihome design of off-premises. With off-premises, devices typically have four or more ports, each port serving a single sub. Typically they consist of shell or base electronics and plug-in modules for each sub that it is capable of serving. The cost generally relates to the base electronics, in that the per subscriber cost is minimized only if all the ports are utilized (100 percent penetration). Conversely, the cost per subscriber rises if all the ports are not fully utilized. For example, one off-premises device currently being offered has four ports and $180 in base electronics, with each plug-in module costing $65. Assuming a 100 percent penetration, the cost per sub is $110. Now assume a 50 percent penetration level; the cost per sub rises to $155. Given that the national average is around 55 percent penetration, the economics become very critical.

Assume the equipment is to be deployed in a system that passes 40,000 homes and has a 65 percent penetration level (26,000 paying subs). The initial capital outlay for the off-premises equipment would be $3.5 million.

With on-premises, the cost per sub is minimized since equipment is initially installed for paying subs only. So with 65 percent penetration, the initial capital outlay would be $2.8 million (assuming comparable equipment costs of $110/sub). On-premises offers a savings of $700,000 in initial capital costs over off-premises. However, in either approach, the average cost per sub may be higher, depending on whether or not the equipment is left in place or redeployed when a paying sub disconnects.

The second area of difference is the issue of powering. Off-premises equipment is typically powered from the cable plant. This raises two concerns: First, since the operator pays for the power that the cable plant uses, a substantial increase in annual power costs will occur. Second, at a minimum, the feeder lines of the system will have to be rebuilt (repowered and adding appropriate power passing capability) to accomondate the additional power requirements. In the previous example, 10,000 active devices would be added to the system.

On-premises equipment, on the other hand, is typically powered from the sub's home by a low voltage wall transformer. The power is either added to the coax or run on separate power wires. The advantage here is that the cable system's power bill is unaffected. The potential disadvantage (at least with coax powering) is the possiblility of damaging other consumer electronics equipment connected to the coax.

The third area of difference is deployment. This is directly related to the level of commitment by the operator toward deploying one approach over the other. A much higher level of commitment is required when deploying off-premises, in that significant construction or rebuild activities are required to perform a field trial, let alone a full-scale deployment. These activities are not only costly in terms as dollars and cents but also in distruption of services. Assume, for example, that you are going to field trial 25 off-premises devices. In the best-cast scenario, all 25 devices would be installed on the same feeder line. The installation process will automatically cause service disruptions to all subs on that line-test and non-test subs alike.

On-premises devices offer clear advantages in terms of deployment. Target subs can be selected regardless of where they live on the system. Installation does not affect any other subs, since the equipment is connected to the drop line, as opposed to the feeder.

Today, the on-premises approach has the advantage in cost per subscriber, powering and ease of deployment. However, ongoing engineering design efforts are expected to produce reductions in the cost of base electronics, reduced power consumption and easier system integration. This will then make it possible for these two approaches to be much more competitive in the future.