CABLE OR HOME POWER FOR OFF-PREMISES ADDRESSABLES

by

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Introduction

In the saga of addressable pay TV services the inevitable problem of increasing theft of service is now in full bloom. One of the most effective approaches toward limiting theft of service has been the development of pay TV control equipment which is mounted outside the subscribers residence where tampering is extremely difficult. Authorizations are transmitted to these off-premises units from the headend while communications from the home are implemented with a low cost keypad unit. The off-premises units are, in many cases, simply "pole mounted converters". These units consume a considerable amount of power, typically in the range of 15 to 35 watts per converter. Other off-premises premium TV security equipments include addressable jammers and/or taps which require less power per drop however this requirement is not insignificant. Some manufacturers are offering off-premises equipment powered from the cable distribution power supplies and others utilize power from the home via the drop cable. Powering of these off-premises devices in either case provokes a number of technical and economic considerations.

Technical Considerations

The amount of powering required for off-premises addressables is a primary factor. A few numbers to illustrate the magnitude of the situation are appropriate. In a system with 75 homes per mile and an average of 1.5 TV sets per household, where 15 watts is required for each off-premises addressable (OPA) almost 1700 watts of extra power is required for each mile of distribution. Looking at what perhaps is the low side of 1 watt per subscriber drop this still amounts to over 100 watts per mile. Taking the high end number of 35 watts per OPA almost 4 kilowatts per mile is required.

These numbers are significant in terms of power costs, however the current handling capacity of other system components must be considered. Some amplifiers and passives are designed to pass a maximum of 4 amps. This limitation complicates the powering design for line extenders and OPAs.

Cable powering is a matter that is quite well understood by the cable industry. In the past serious problems were encounter due to the idiosyncrasies of cable powering but these have been overcome by the equipment manufacturers so that cable powering is quite reliable and universal today.

One of the more difficult problems was involved with what has been labeled "longitudinal sheath currents" [1,2]. Longitudinal sheath currents are those currents which flow on the sheath of the CATV distribution cable due to the cable system's close association with the public power system. Since the CATV cable is bonded frequently to the power company three phase neutral leg the power company neutral current is shared by the CATV cable in a manner determined by the relative resistances in these two members. If all loads on the public power system were balanced no current would flow in the neutral. This, however, is far from the practical case. Power company neutral currents can be in the tens or hundreds of amperes and often a significant part of this current is diverted to the cable system distribution cable sheath.

Since the CATV amplifiers are powered using the coaxial cable conductors for the power circuit, voltage drops occurring along the cable sheath add vectorially to the power supply voltages delivered to the equipment. This vectorial addition can increase or decrease the voltages delivered. In addition the power line components may inject other functions such as transients and power frequency harmonics.

These longitudinal sheath currents vary throughout the day depending upon the power system loads. It is possible for amplifier power supplies to be overdriven when the sheath currents result in a voltage increase causing failures due to overvoltage or heat. Power supplies may also be underdriven causing malfunction or extraneous ripples and transients. In certain cases operators have found amplifiers that would continue to run when the CATV power supply was shut off simply as the result of the power company contribution through longitudinal sheath current. Realization of these conditions has caused amplifier manufactures to more conservatively rate their units and to employ switching supplies that will accept wider ranges of input voltages.

Off-premises addressables powered from the cable system are also subject to these same problems, however solutions are well within the state-of-the art.

When considering powering from the home it would appear, at first glance, that these problems are less important. This may not always be true. The drop cable mechanism equivalent to longitudinal sheath current has somewhat different parameters. The drop cable may shunt some of the power company neutral current to ground through whatever CATV grounding configuration is employed. This is usually a secondary effect. The unbalanced currents in the ground side of the residential power system are not from three phase leads but largely the currents occurring in the ground leg of the 220 volt center tapped service. This means that 220 volt loads such as water heaters, air conditioners, etc., will not cause current to flow in the ground leg, however the return for all 110 volt circuits is through this leg where the components again add vectorially. The CATV drop cable shares current with the power company ground leg in a ratio based upon the relative resistances (including the respective ground resistances). This magnitude of this current changes as a result of varying electrical power usage within the residence.

There are some further differences. The resistance of a 3/4" CATV hard cable sheath is less than 1/2 ohm per thousand feet while the resistance of the sheath of RF-59 drop cable may be as high as 20 ohms per thousand feet. As in the case of strand mounted amplifiers power voltage to drive the off-premises converter is applied to the drop in the home and is also affected by the vectorial addition of the voltage developed by the current on the drop cable outer conductor. Transients and harmonics can also be present. These currents which can be many amperes at times which must also flow through the F connector crimp joints as well as the threaded contacts. Poor contacts, corrosion, etc., can increase these resistances thereby increasing the contribution of the sheath current as well as the normal IR voltage drop.

There is one other subtle factor. The power supply voltage fed to the off-premises device is probably in the order of 30 volts or less rather than the 60 volts used on the cable distribution system. This means that any effects caused by sheath currents will be magnified in their percentage effect since the basic voltage is lower.

Measurements have been made simply by using a clamp-on meter to find the typical values of power company current flowing on the drop. These values vary greatly with the area of the country, power company grounding system, CATV house grounding technique, time of day and year and other factors. For purposes of discussion let us assume that a home powered OPA requires 15 watts, utilizes a 30 volt AC supply, the drop cable sheath resistance equals 1 ohm and the loop resistance equals 15 ohms (RG59 cable is typically 50 - 70 ohms per thousand feet center conductor resistance). The converter will require 1/2 amp of current at 30 volts assuming that the power factor is unity (this is unlikely, particularly with capacitive input filters).

The first problem is that 1/2 amp must flow through the 16 ohms drop cable resistance producing a voltage drop of 8 volts. In order to work with a line voltage 10 percent low (-3 volts) the minimum voltage supply will be 30 - 8 - 3 or 19 volts. Assume now a constant 4 amps of sheath current in a phase which subtracts from the power supply voltage (-4 volts) which now lowers the minimum voltage to 15 volts. Throw in an occasional 10 amp transient and the minimum voltage on a short term basis could be as low as 5 volts. If the power supply does not have the filter capacity to supply power over the duration of the transient the addressable may lose its memory and require reinitialization and cause an interruption of customer services. With 15 volts at 1/2 amp. only 7.5 watts is delivered to the OPA so we must supply more input voltage or more current to power the device. If the phases of the sheath current and transients add it will help maintain the voltage at the off-premises device, however. In some cases excess voltages will be present increasing the range over which the device must operate. The numbers used in the above example are much closer to being typicals than extremes so that one may well see that there are potentially serious power supply problems in powering from the home. Even if DC is employed the same effects are present plus the threat of electrolytic problems at contact points.

The whole matter of grounding a CATV system is an enigma in itself. The electrical codes try to establish a good ground to which the drop cable is connected as it enters the house through the grounding block. Under these conditions, when a failure occurs in the power company ground conductor, extreme currents can flow on the CATV drop. In such a case the CATV drop cable becomes the only power company ground return path and all the current must flow in that path. These currents can reach levels over 100 amperes and have, in some cases, heated the drop cable to the point where a fire was caused and structural damage was done.

The other side of the coin in seeking a technical solution to these grounding problems is not to ground the cable at all. In the case of a falling power line which touches the drop cable and pulls it from the tap, high voltages can be present and become extremely hazardous. It seems to boil down to the choice between fire and electrocution. The various safety organizations such as the National Electrical Code and the National Electrical Safety Code seem to have opted for fires by selecting good grounds.

As a result of this conflict, there have been various suggestions for devices that would in some way ameliorate the problem. One approach which is being worked on by at least two manufacturers, interrupts the drop cable for the power line frequencies. This device is essentially a capacitor in series with the sheath. This capacitor is small enough to be a high impedance at 60 Hertz. Such a device, when perfected, may be widely used in the industry. This type of device, however, is totally incompatible with providing DC or 60 Hertz power to off-premises devices through the drop cable.

Power supplies used in off-premises devices generally rectify AC to supply the DC requirements of the circuitry. Operation of these power supplies from the normal 60 volt quasi-squarewave cable system supplies is easily accomplished since the amount of filtering required is minimal due to the square voltage waveform. On the other hand, supplying power from the drop generally assumes sinewave power, therefore larger capacitors and some increases in size and cost are necessary to achieve adequate filtering. Extra capacity is also required to protect against the short term interruptions previously mentioned in connection with sheath current transients.

Last but not least in the technical considerations, it appears that off-premises powering from the home may require UL approval whereas powering from the cable does not invoke this requirement since it is not a residential device.

Economic Considerations

The first economic consideration that draws the attention of the cable operator is the cost of power. Traditionally converters have been powered from the residence and have not been an expense to the cable operator. Powering of off-premises addressables from the cable system immediately incurs two economic disadvantages. The first is the cost of the power and the second is the cost of the additional power supplies which will probably be required due to the significant extra load. (The following approximations ignore the fact that certain OPAs serve multiple sets on a single drop). A 15 watt off-premises converter will consume (ignoring efficiency, etc.) approximately 130 kilowatt hours of electricity per year which, at 5 cents per kilowatt hour, is about $6.50 per year. Using the figures before of 75 homes per mile and 1.5 TV sets per home this amounts to about $740 per mile per year in power cost. This is not insignificant. In a device consuming an average of 2 watts per drop which is about $0.87 per drop or $100 per mile.

Assuming a standard CATV power supply delivers 800 watts and costs $400 the additional cost of power supplies will be 50 cents per watt or $7.50 for the 15 watt unit and $1.00 for a 2 watt unit. The biggest factor then is the power cost which will vary in different parts of the country. Unfortunately this cost goes on forever.

There another penalty for in-home power. Let's say that a 15 watt supply costs $15 and a 2 watt supply costs $7.50 then the fixed cost of installing an OPA system with home power is greater than installing one with cable power. If the power for the converter is picked up in the basement, there will be many cases where an outlet is not readily available and additional wiring expense will be incurred.

The biggest disadvantage to home power, however, seems to be the intangible matter of service calls. It is likely that there will be many situations where the plug is inadvertantly removed or some local power failure within the residence disables the OPA and generates a service call. If a service call costs $30, one service call can be traded off for a good deal of power (600 KWH which is 5 years for a 15 watt OPA or 34 years for 2 watts consumption). Refer to Table 1 for a summary of these economic factors.

Conclusions

Off-premises addressables are fairly new in the CATV field so that there is not a broad background of experience on which to base conclusions. It does appear, however, that there are a number of subtle problems inherent in home powering which should be carefully considered by the cable operator. The economics of cable powering can be somewhat disturbing, however, a realistic evaluation of the contingent costs relative to home powering, such as service calls, have considerable weight. Cable powering of the higher power off-premises addressables seems to be self defeating by virtue of the very magnitude of additional power supplies and power costs, perhaps forcing the decision to home power. Cable powering of the lower power devices on the other hand, may well be the optimum decision and already seems to be the preference of many in the field .

FOOTNOTES

1 James C. Herman, Jacob Shekel, "Longitudinal Sheath Currents in CATV Systems", presented at the 24th Annual NCTA Convention, April 1975.

2 Norm Everhart, "Protecting CATV Equipment against the Effects of Longitudinal Sheath Currents", presented at the 24th Annual NCTA Convention, April 1975.

	Cable Power		Home Power	
	2 W	15 W	2 W	15 W
1. Consumption per yr./drop	17.5 KWH	131 KWH	--	—
2. Power cost per yr./drop @ $.05/KWH $.87	$.87	$6.50	—	--
3. Consumption per yr./mile	2025 KWH	14738 KWH	—	—
4. Power cost per yr./mile	$98	$740	—	--
5. Power supply cost/drop	$1.00	$7.50	$7.50	$15.00
6. Period of cable powered operation equivalent to cost of in-home power supply	—	—	8.5 yrs.	2.3 yrs.
7. Period of cable powered operation equivalent to one $30 service call	33 yrs.	7.6 yrs.		

TABLE 1

SUMMARY OF ECONOMIC FACTORS