TRANSIENT AND OUTAGE ELIMINATION IN CATV SYSTEMS

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The nature of CATV system transients is discussed and the devices used for system protection are evaluated and compared. Methods of employing protective devices to the best advantage of the system are discussed and a multi level field proven protection scheme is presented.

The causes of system outages are explored and the impact of protection schemes on fusing and related outage problems is discussed. It is shown that proper fusing together with judicious protective device application can eliminate all but the most catastrophic outages, excepting, of course, loss of primary power. For outage protection with loss of primary power the various means of standby powering are explored and a new concept in standby power source implementation is presented.

NATURE OF TRANSIENTS AND SURGES IN CATV SYSTEMS

Abnormal operating voltages introduced into CATV systems fall into three basic categories:

1. Short duration ($<$ 10 ms) usually 2 to 20 times normal voltage (caused directly by lightning strikes or lightning induced power surges).

2. Medium duration (10 ms to 1 second) usually 2 to 4 times normal voltage (turn on surges of main power and/or power supplies of the CATV system).

3. Long duration ($>$ 1 second) usually 2 to 20 times normal voltage (caused by accidental contact between cable system and power system primary or high voltage lines).

Short duration surges usually have a fast rise time, typically 2 μs, and a fall time of 100 μs to 1 ms. Extensive observation by Bell Northern Research teams[1] indicates that 99.9% of all lightning caused surges induced or conducted into coaxial cable had peak voltage less than 1000 volts. Approximately 2% had rise times less than 20 μs or fall times greater than 4 ms.

METHODS OF SURGE ENTRY INTO THE CATV SYSTEM

The prime means of introduction of abnormal operating voltage is by the powering system, although surges can be generated within the CATV system itself. A summary of intrusion points is given below and depicted graphically in Figure 1.

1. Surges introduced via the ac power line having been introduced to the power line by lightning or very high fault currents.

2. Surges produced by the CATV ac power supply when the primary power is switched on and off during power fault conditions.

3. Sheath currents due to lightning or other high level currents such as power faults, which are coupled into the system via any small resistance.

4. Inductively coupled currents which are set up due to lightning or power fault currents, which exist in proximity to the system.

5. Transients which might occur in the amplifier power supply due to power off-on switching.

PROTECTION DEVICES FOR CATV SYSTEMS

There are many surge protection devices now available that can be used in various combinations to achieve a high degree of surge immunity. Some of the more useful devices are discussed below.

1. Miniature Gas-filled Surge Suppressor

These devices offer low capacitance ($\sim$2 pF), bipolar clipping for voltages $\gtrsim$90 V. Lower breakdown voltages are not possible because of the characteristics of Paschen discharge in low pressure gases. Gas-filled surge suppressors have an intermediate response time ($\sim$1 μs turn-on time). They can handle large current surges of low duty cycle ($\sim$1-5 kA) for 100 μs but do not stand up well under continuous current discharge over 1 A. If their discharge current is limited to $\sim$10 A peak with low duty cycle, they have a long life.

2. Zener Diodes

Zener diodes have intermediate capacitance values (~30 pF for 1 W devices) and relatively fast switching time (~40 ns, depending on junction capacitance). They have low surge current capability (~0.1 A) because of their power dissipation limitations.

Breakdown voltages range from 1 to 200 V and zener diodes are frequently used to trigger other devices which can handle large surge currents (such as SCR's).

Zener diodes can also be used in tandem to provide bipolar limiting to any voltage from 2 to 200 V.

3. Solid State Switches (e.g. Diac, Triac, SCR's)

These devices usually rely on external circuitry (resistors and zener diodes) to provide accurately controlled turn-on. They have moderate power dissipation capability (~100 W) and find wide application for power supply protection.

4. Variable Resistance Devices

a. Varistor

These are metal oxide devices that have a voltage variable resistance. They have high capacitance (~1000 pF) and fair peak current capability (~1 kA for 7 μs). Breakdown voltages range from ~30 to 1400 V. Limiting characteristics are fair.

b. Thyristor, Thyrector, Thyrite

These are mainly silicon carbide devices. They have high capacitance and good surge current capability but poorer limiting characteristics than varistors.

5. Mechanical Switches (e.g. Time Delay Power Relays)

During a power surge these devices disconnect the applied power. They are slow acting (~0.1 to 1 second) and can be programmed to reconnect power to the system after a prescribed waiting time from return of primary power.

SYSTEM PROTECTION TECHNIQUES

Since surges can be very severe and can be introduced at practically any location in the system, it is very desirable to locate protection devices at scattered locations in the system. These should:

1. Minimize and/or attenuate the surge injected into the system.

2. Protect the electronic equipment from any residual surge that inevitably does intrude.

Some of the protection points and methods are listed below:

1. At power input, filtering and a high energy breakdown device to absorb power transients. Attention to grounding to minimize ground coupled transients.

2. At power supply output, where the transformer transients are introduced, use time delay relays and/or energy absorption devices to limit output voltage.

3. At amplifier input and output, gas diodes attenuate transients that otherwise could be capacitively coupled to the RF transistors.

4. At the transformer secondary of dc power supply (which is very vulnerable because of the low frequency direct conduction path to the transformer). This is the only protection point that prevents sheath currents from affecting the amplifier station. Use SPM and filter capacitors for protection.

OUTAGES IN CATV SYSTEMS

1. Causes of System Outages

The basic cause of most system outages is usually abnormal operating voltage conditions - either an excess of it or lack of it. Protection of the system from lightning caused transients and power line surges is highly desirable but if it alone is done, outages will still result. One of the problems is the system fusing must be closely examined and adjusted to prevent nuisance blowing when protective devices are activated, yet prevent loss of stations when catastrophies such as accidental contact of cables with live HV transmission lines occur. With the CATV system fusing properly adjusted the other major outage cause, the primary power source, needs to be examined.

2. Prevention of System Outages

There are several existing techniques for maintaining system power when primary power fails. The technique most used to date employs a dc to ac inverter at the constant voltage supply with two principal variations in the form of a "non-interruptable" and "interruptable" output. There are, in fact, some problems with standby powering as it exists today. A few experiences have been so bad as to generate comments to the effect that the standby system is less reliable than the primary power source!

Some basic considerations on standby powering are as follows:

1. For unattended operation, the standby power source must use some form of storage battery.

2. All batteries produce dc power.

3. Batteries require dc for charging.

4. It would be logical to use these dc features of the battery in conjunction with the amplifier power supply itself, eliminating the need for dc to ac conversion by an inverter, the attendant power loss in the ac distribution system and the additional loss sustained in reconversion of the ac to dc for use by the amplifier.

With this in mind, a new concept in standby powering has been developed which would operate from the raw dc present at the individual station power supply regulator input. Using this point for dc standby power injection, the dc to ac and ac to dc conversion losses are eliminated. Further, upon loss of primary power, the switchover to standby power can be instantaneous with no change whatsoever in the regulated dc output. When primary power is restored, switchover to the float charge mode is also instantaneous and automatic. The raw dc voltage is passed through a simple current limiting, constant voltage regulator to restore the rechargeable batteries to their fully charged condition and hold them under float charge with very little power consumption. The overall concept is depicted in Figure 2.

Although the total number of standby power sources will be larger with this approach than inversion at the ac supply, the inherent simplicity and efficiency of this approach appears to offer greater reliability and cost effectiveness, especially for standby powering critical runs of existing equipment. Normally these standby power source units would be placed at all critical trunk locations and possibly selected external bridgers. When a power failure is localized, it also affects power to subscribers in the nearby distribution area. Therefore it would appear unnecessary to provide standby powering for line extenders. The fundamental purpose of standby powering is to prevent a local outage from causing the remainder of the system to be without signals.

SUMMARY

CATV system equipment damage caused by transients and surges can be eliminated for all but direct lightning hits, however, good system grounding and construction techniques are a MUST. How extensive a protection scheme is incorporated depends on the severity of lightning in the area, local power system characteristics and terrain.

Outages caused by transients and surges can be prevented by proper equipment protection and system fusing. Outages caused by loss of primary power can only be eliminated by use of a standby power source that is omnipresent and omnipotent - especially critical on the main trunk line. A new concept in standby powering has been presented for this application for consideration.

REFERENCE

(1) "Lightning Surges in Open Wire, Coaxial and Paired Cables", E. Bennison, et al, International Conference on Communications Proceedings, Philadelphia, 1972.

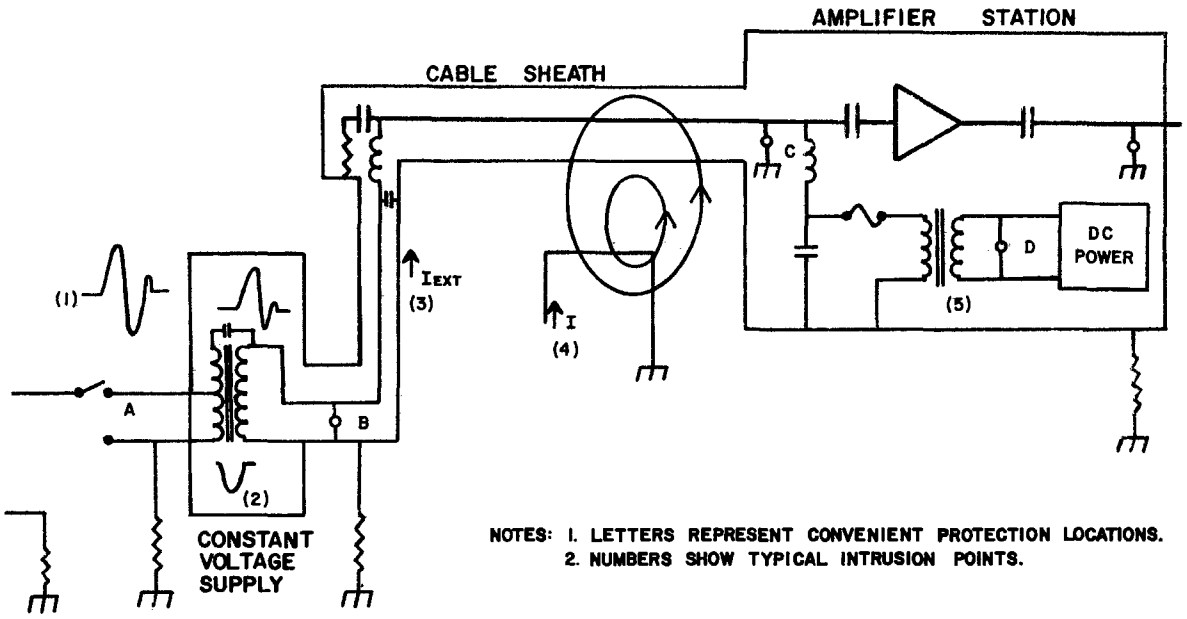

FIG. 1. SCHEMATIC REPRESENTATION OF TRANSIENT INTRUSION INTO THE C.A.T.V. SYSTEM.

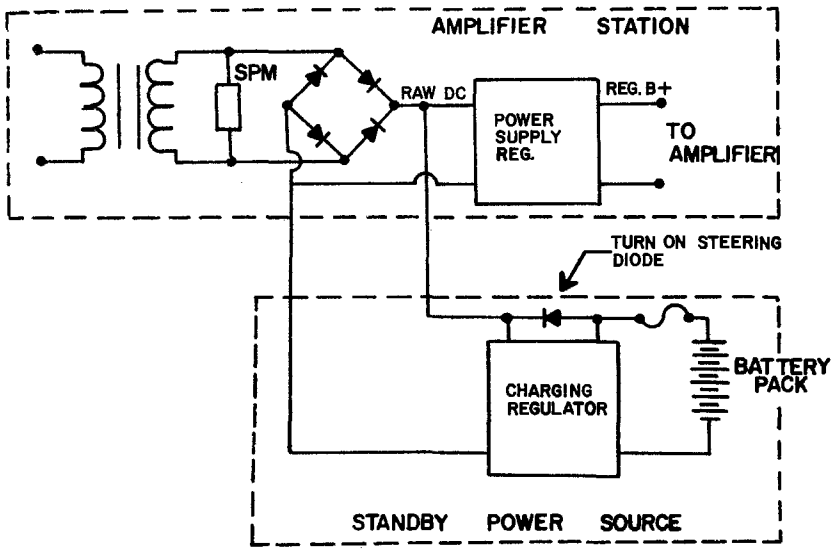

FIG. 2. BLOCK DIAGRAM OF SPS STANDBY POWER SOURCE CONCEPT.