ADVANCES IN TECHNOLOGY AND NEW INSTALLATION CONFIGURATIONS SUGGEST MECHANICAL MODIFICATIONS IN CATV AMPLIFIER HOUSINGS

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ABSTRACT

While advances in amplifier technology (Power Doubling, Feedforward) have greatly altered the components a housing must contain, and new installation configurations (pedestal, vault) have altered the environment in which a housing must function, the housing itself has changed very little. Results from computer modeling suggest alternatives for housing design to meet these more demanding requirements.

INTRODUCTION

An amplifier housing performs several functions for the circuitry inside the mainstation or line extender. Four of the most important of these functions are:

- Establishing mechanical and electrical connections for the trunk and/or distribution cables.
- Acting as a shield from electromagnetic interference (EMI).
- Offering protection from the weather.
- Providing a heat sink for active devices.

The magnitude of these housing tasks has expanded over several years, primarily from changes in two areas: the amplifier circuitry technology and the housing environment. System bandwidth has spread in measured steps from 5-270MHz to 5-600MHz, placing new demands on the cable connection, the EMI shield, and the heat sink elements of the housing. The environment that the amplifier is exposed to has also changed. Installation in enclosures is now common for domestic systems. International business has increased significantly, with a commensurate broadening of weather extremes and installation configurations. These new environments create challenges to the cable connection and heat sink elements of the housing.

Responding to these changes by modifying the die-cast amplifier housing can become an expensive proposition in terms of engineering effort and tooling investment. A totally new design represents a major commitment of resources. A development program of either scope must start with a set of clearly defined objectives for housing performance for all four of the functions mentioned above. Recommendations for these objectives, or design goals, are introduced in the next few sections of this paper. The process of how the goals should be met follows each goal.

PERFORMANCE BASELINE

The housings currently being produced in the cable industry provide readily available vehicles for measuring the present level of performance, or baseline, of the four functions. These levels should be compared with the design goals to reveal which areas require modification and the magnitude of the modification from the baseline.

CABLE CONNECTIONS

The goal for this function is to provide maintenance-friendly trunk and distribution ports that are transparent to the forward and return signals at frequencies up to 1GHz. It is important to recognize that the historical trend toward greater bandwidth has not lost any momentum in the past few years. HDTV, on-demand services, and data will sustain this expansion. Due to the investment required by the manufacturer (in production tooling) and the system operator (in physical plant), the housing design must be prepared to embrace circuitry delivering these extended bandwidths for product longevity. Initial designs for circuitry are exercised on computers using models that simulate the response of the port as well as the seizure mechanism.

However, the dimensional parameters and material characteristics of the port components should be selected only after exhaustive bench testing to be certain that the difficult-to-characterize anomalies have been captured.

Varying the diameter of the center conductor of the cable from the optimum value introduces impedance changes that reduce return-loss performance. Designing for a pin-type connector permits the housing to achieve a consistently high level of performance in both trunk and distribution ports regardless of cable size. The standard length pin connector (1.60") should fit, without modification, into the housing. Ideally, the "nose" of the port should protrude from the wall of the housing far enough to allow heat-shrink tubing to be attached from the cable, past the insert, to the casting for maximum weather protection. The insert must provide stronger threads than the die-cast housing without creating galvanic incompatibility. A hexagonal or square cross-section would facilitate assembly at the factory as well as an opportunity to counteract, with a second wrench, the torque required to install or remove connectors. Options for cable access to the seizure mechanisms could be more flexible, reducing the contortions necessary for installation of housing and cables in the cramped quarters of enclosures.

EMI/RFI SHIELD

The goal for this function is to offer protection from interference or radiation from higher frequencies (1GHz) at existing signal levels. Even in rebuilds, signal levels have not increased significantly in the past few years. An approximate level of the seal's shielding performance can be established by testing prototype gaskets in simulated housing grooves. However, this limited evaluation does not confirm that the gasket construction can resist permanent deformation and possible loss of performance after the stresses of temperature and compression cycling. Long-term reliability of the seal's shielding effect is crucial for compliance with the cumulative leakage index (CLI) and radiation limits set by the FCC.

When the mainstation base and cover are designed to conform to American Die Casting Institute guidelines, the space between flanges could vary from 0.000" to 0.109". Machining the surfaces of these flanges would significantly improve the flatness. Although widely used in producing military equipment, this approach is too expensive for cable TV products. The gasket must be designed to accomodate the flatness and surface finish variations created by the die-casting process.

WEATHER PROTECTION

The goal for this function is to provide a seal that protects the circuitry from water ingress over repeated temperature, atmospheric, and compression cycling, yet requires a minimal clamping force for easy access. The extremes of temperature and atmospheric pressure can create positive (9.5 p.s.i.g.) or negative pressure (-5 p.s.i.g.) within the housing. A soft rubber gasket would initially provide an adequate seal under these conditions. Unfortunately, a low durometer rubber will typically take a "set" when subjected to a clamping force over time. The "set" is partly a densification and partly a deformation of the gasket material. The net result is a reduction in clamping pressure, possibly leading to a leaky housing during the next summer rainstorm. Increasing the torque on the clamping bolts offsets the reduction in pressure, but may lead to further deformation.

The gasket material must also withstand temperature and humidity extremes as well as chemical attack by ozone and industrial pollutants. Extensive evaluation, starting with prototype gaskets in simulated housing grooves, is essential to establishing the long-term reliability of the seal.

HEATSINK

The goal for this function is to maximize heat-sinking of active components regardless of horizontal or vertical orientation of the housing. This performance will be limited by various restrictions on the weight, size, appearance, and cost of the die casting, as well as upward and downward product compatibility.

Advances in amplifier technology have reduced the distortions required for expanded frequency response; however, these same advances have increased the heat, or thermal, load on the housing. A mainstation loaded with a Feedforward trunk module, a Power Doubling bridger module, a return module, a complete control module with status monitoring, and a switcher-type power supply must dissipate two times more heat (36.5 more watts) than a station with push-pull technology.

Amplifier housings installed at ground level in enclosures shield the housing from the direct rays of the sun, but restrict the free flow of cooling air. Use of a pedestal enclosure forces the casting into a vertical orientation. The fins on the housing are perpendicular to the air flow, which reduces their ability to dissipate heat. This situation was simulated by attaching heaters to the back side of a 6" x 6" piece of heat sink extrusion with 3/4" tall fins. At a surface temperature of 25° Centigrade (C) over ambient, the material dissipated 13.5 watts with the fins in a vertical position. Rotated by 90 degrees, it could only handle 7.6 watts at 25° C over ambient. Another piece of extrusion was cut to the same dimensions with the fins at a 45 degree angle. This piece dissipated 13.5 watts at 25° C over ambient in both 0 and 90 degree positions.

Heavily instrumented housings were installed in a simulated field situation in aerial, pedestal, and vault configurations. A data recorder provided temperature information for the construction of a mathematical model of the housing and modules. The model permitted in-depth study of various design options in any environment without the expense or time required to build and evaluate prototypes. This model quantified the thermal impact of various alternatives for housing design. A thicker housing wall reduces the conduction resistance between the heat source, amplifier modules, and the fins. Deeper fins, optimally spaced, assist convective heat transfer from the fin surface to the surrounding air by increasing the effective surface area of the housing.

Applying a finish to the housing surface will alter the radiation coefficient. This may improve or impede heat flow -- depending on the color and type of coating. As mentioned earlier, angling the fins allows free air flow in either vertical or horizontal configurations and reduces the temperature rise of the circuitry and housing in pedestal applications.

CONCLUSION

A housing designed for the 1990's must be ready for expanded bandwidth, extreme weather conditions, EMI at higher frequencies, and various installation configurations. These demands can be met through innovative design concepts, computer modeling, and exhaustive evaluation.