MOTOROLA
intelligence everywhere™

THE CANOPY SYSTEM APPLICATION NOTE

CANOPY SUBSCRIBER MODULE LIGHTNING PROTECTION GUIDELINES

September 20, 2002

CANOPY™
Motorola Wireless Internet Platform

TABLE OF CONTENTS

LIST OF FIGURES

NOTICE

The information in this publication is subject to change without notice. Motorola shall not be liable for technical or editorial errors or omissions nor for any damages resulting from the use of this material.

Each configuration tested or described may or may not be the only available solution. This test is not a determination of product quality or correctness, nor does it ensure compliance with any federal, state or local requirements. Motorola does not warrant products other than its own strictly as stated in Motorola's product warranties.

INTRODUCTION

This document provides lightning protection guidelines for the Canopy™ Subscriber Module (SM) product to satisfy the National Electrical Code (NEC). The requirements of the NEC focus on the safety aspects of electrical shock to personnel and to minimizing the risk of fire to the dwelling. The NEC does not address the survivability of electronic products to lightning surges. The recommended Surge Suppressor 300SS will provide some degree of lightning protection to the electronics inside the dwelling.

ANTENNA GROUNDING

Figure 1 shows an overall antenna grounding scheme according to the NEC. In most television antenna or dish television installations, a coaxial cable is used to interface the outdoor electronics with the indoor electronics. In order to meet NEC 810-20, one typically uses a coaxial cable feedthrough block that connects the outdoor coax to the indoor coax and has a screw for attaching a ground wire. This effectively grounds the outer shield of the coax. The block is typically mounted on the outside of the building in the vicinity of the AC main panel so that the ground wire of the block can be attached to the building's primary grounding electrode system. Further details regarding the NEC's Article 810-20 are contained in Appendix A of this document.

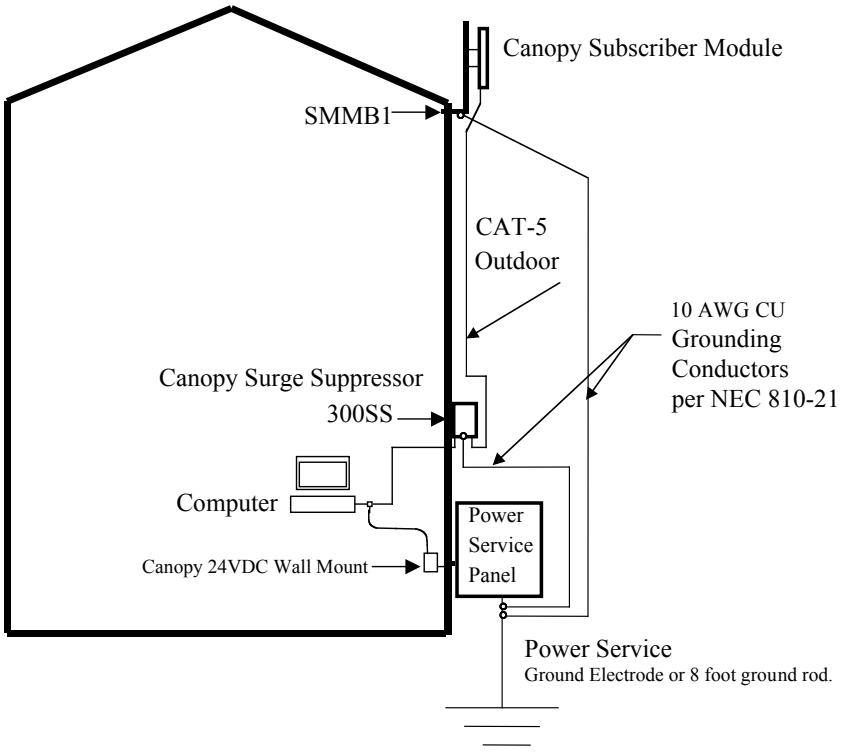

Figure 1. Antenna Grounding Scheme According to the NEC

SURGE SUPPRESSORS

In the situation of Canopy technology, Motorola uses an outdoor rated unshielded twisted pair (UTP) cable. In order to comply with the NEC, Motorola must provide a listed antenna discharge unit 300SS Surge Suppressor for each conductor of the cable. This 300SS should be located outside the building as near as practicable to the entrance of the conductors to the building. In addition, the 300SS unit can *not* be located near combustible material. The 300SS Surge Suppressor must be grounded in accordance with Section 810-21 which is contained in Appendix A of this document.

Motorola's recommendation for grounding the 300SS Canopy Surge Suppressor is to mount it outdoors near the point of entry to the dwelling. A grounding wire must be attached to the Surge Suppressor via a screw terminal to serve as the grounding conductor.

17 AWG COPPER CLAD STEEL WIRE VERSUS 10 AWG COPPER WIRE

According to NEC 810-21 3(h), a 17 AWG copper clad steel wire or 10 AWG copper wire may be used. This specification appears to be based on mechanical strength considerations and *not* on lightning current handling capabilities. An analysis performed on 16 AWG copper clad steel wire and 10 AWG copper wire shows that the two are not equivalent when carrying a 1 microsecond rise by 65 microsecond fall lightning surge. The 16 AWG copper clad steel wire has a peak fusing current of 35,000 amps and can carry 21,000 amps peak at a temperature just below the ignition point for paper (454 degrees F or 234 degrees C). The 10 AWG copper wire has a peak fusing current of 220,000 amps and can carry 133,000 amps peak at a temperature just below the ignition point for paper.

Figure 2 shows the statistical probability of lightning peak currents. More than one-half of all lightning strikes exceed 20,000 amps and 25 percent exceed 35,000 amps. Less than two percent of all lightning strikes exceed 140,000 amps peak. Therefore, 10 AWG copper wire is a much better choice as a ground conductor.

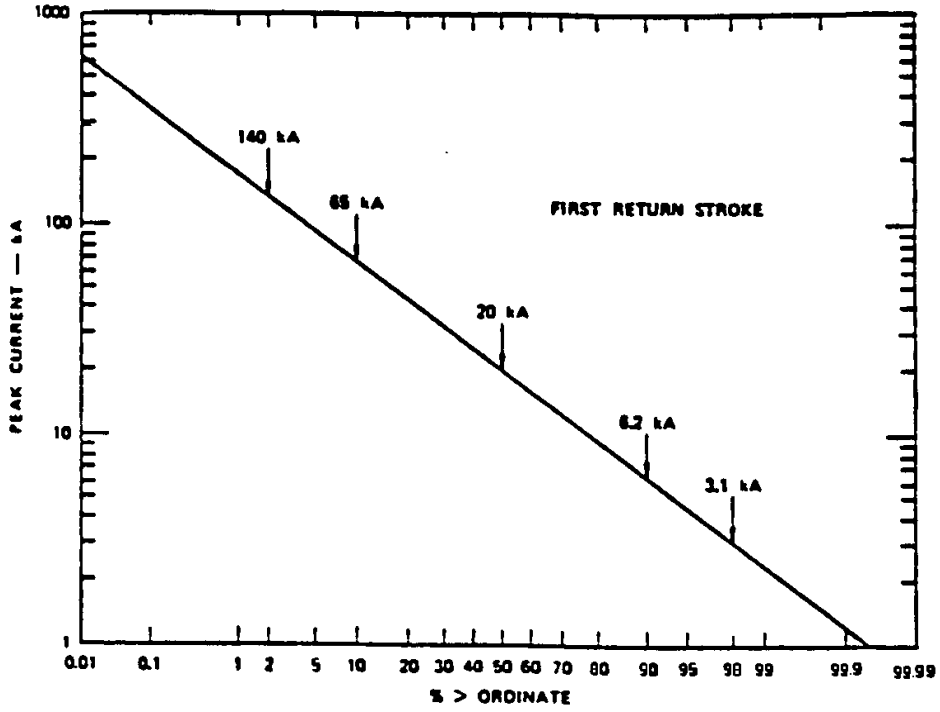

Figure 2. Cumulative Probability Distribution for Lightning Current[1]

Based on the electrical/thermal analysis of these wires, it is recommended that the 10 AWG wire be used for all grounding conductors.

The 10 AWG copper wire must be routed from the 300SS staying on the outside of the dwelling and be bonded preferably onto the AC main power ground electrode. This will require locating the 300SS in close proximity to the power service entry panel of the dwelling. Alternatively, the grounding conductor from the antenna discharge unit can be attached to a grounded water pipe. It is *insufficient* to merely use the green wire ground in a duplex electrical outlet box for grounding of the antenna discharge unit.

The metal structural elements of the antenna mast will also require a separate grounding conductor. Section 810-15 of the NEC states:

> ***810-15. Grounding***
> *Masts and metal structures supporting antennas shall be grounded in accordance with Section 810-21.*

As shown previously in *Figure 1,* Motorola's recommendation for grounding the metal structural element of the Canopy mounting bracket (SMMB1) is to route a 10 AWG copper wire from the SMMB1 down to the same ground attachment point as is used for the 300SS discharge unit.

[1] Cianos, N. and Pierce, E.T., *A Ground Lightning Environment for Engineering Usage*, Technical Report 1, Standford Research Institute, 1972.

SOURCES & AVAILABILITY

The 16 AWG copper clad steel wire is available from Daburn Electronics & Cable Corporation. The 10 AWG copper wire is available from a number of sources. Allied Electronics offers a 10 AWG THHN/TFFN wire (stock number 876-157N) manufactured by Olympic Wire. This cost is approximately double that of the copper-clad steel wire but it can handle about six times the surge current from lightning.

Shielded & Unshielded Cabling

The preceding design guidelines are based on using unshielded twisted pair (UTP) cabling. One may ask, "Could a shielded twisted pair cable be used and thereby eliminate the need for a 300SS discharge unit?" A search for braid shielded 10BaseT cabling was unfruitful. There exists foil shielded, Cat 5, 100BaseT cabling that includes a 24 AWG drain wire, e.g., Foiled Shielded Twisted pair (FTP). This cabling is considerably more expensive than UTP, e.g., $0.50 per foot versus $0.30 per foot. Also, would grounding the 24 AWG drain wire with a 10 AWG copper wire at the entrance of the dwelling satisfy the NEC 810-20 requirements of using a metal shielded cable that is effectively grounded? This is not an easy question to answer and there are probably differing answers depending on the expert one might ask. NEC 810-21 states in part:

> *"A lightning arrester is not required if the lead-in conductors are enclosed in a continuous metal shield, such as rigid or intermediate metal conduit, electrical metallic tubing, or any metal raceway or metal-shielded cable that is effectively grounded. A lightning discharge will take the path of lower impedance and jump from the lead-in conductors to the metal raceway or shield rather than take the path through the antenna coil of the receiver."*

In the case of FTP, the drain wire will need to withstand the lightning current without melting, i.e., fusing open. If the drain wire fuses open, then the current may follow the twisted pairs into the building. A 24 AWG copper wire will fuse at 8,500 amps from a surge with a 1 microsecond by 70 microsecond waveform. More than 80 percent of all direct lightning strikes have a current that exceeds 8,500 amps as seen previously in *Figure 2*. Therefore, given a direct strike to the Canopy SM, we would expect the 24 AWG drain wire to fuse open 80 percent of the time thus creating the possibility that the lightning current will travel through the twisted pairs into the dwelling. Hence, the reliance on a 24 AWG drain wire to meet the intent of NEC 810-21 is questionable.

Based on these results, it is mandatory to have the SMMB1 (Canopy mounting bracket) grounded with a 10 AWG copper wire connected by the most direct path to the ground bonding point (where the ground of the AC power service utility entry is, or eight foot ground rod). This would better assure that lightning would take the 10 AWG wire route to earth ground and most likely not fuse open and meet the NEC 810-15 section. It is a good practice to have the SMMB1 mounting pipe located even or higher than the top of the Canopy SM. Use at least a 10 AWG copper wire from the Canopy Surge Suppressor 300SS ground lug to the same ground bonding point as above or have a separate eight foot ground rod so as to meet NEC 810-21.

APPENDIX A
NATIONAL ELECTRICAL CODE (NEC)
810-20 AND 81-021

810-20. Antenna Discharge Units — Receiving Stations

(a) Where Required. Each conductor of a lead-in from an outdoor antenna shall be provided with a listed antenna discharge unit.

Exception: Where the lead-in conductors are enclosed in a continuous metallic shield that is either permanently and effectively grounded or is protected by an antenna discharge unit.

(b) Location. Antenna discharge units shall be located outside the building or inside the building between the point of entrance of the lead-in and the radio set or transformers, and as near as practicable to the entrance of the conductors to the building. The antenna discharge unit shall not be located near combustible material or in a hazardous (classified) location as defined in Article 500. A lightning arrester is not required if the lead-in conductors are enclosed in a continuous metal shield, such as rigid or intermediate metal conduit, electrical metallic tubing, or any metal raceway or metal-shielded cable that is effectively grounded. A lightning discharge will take the path of lower impedance and jump from the lead-in conductors to the metal raceway or shield rather than take the path through the antenna coil of the receiver.

(c) Grounding. The antenna discharge unit shall be grounded in accordance with Section 810-21.

810-21. Grounding Conductors — Receiving Stations

Grounding conductors shall comply with (a) through (j).

(a) Material. The grounding conductor shall be of copper, aluminum, copper-clad steel, bronze, or similar corrosion-resistant material. Aluminum or copper-clad aluminum grounding conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum or copper-clad aluminum shall not be installed within 18 in. (457 mm) of the earth.

(b) Insulation. Insulation on grounding conductors shall not be required.

(c) Supports. The grounding conductors shall be securely fastened in place and shall be permitted to be directly attached to the surface wired over without the use of insulating supports.

Exception: Where proper support cannot be provided, the size of the grounding conductors shall be increased proportionately.

(d) Mechanical Protection. The grounding conductor shall be protected where exposed to physical damage, or the size of the grounding conductors shall be increased

proportionately to compensate for the lack of protection. Where the grounding conductor is run in a metal raceway, both ends of the raceway shall be bonded to the grounding conductor or to the same terminal or electrode to which the grounding conductor is connected.

(e) Run in Straight Line. The grounding conductor for an antenna mast or antenna discharge unit shall be run in as straight a line as practicable from the mast or discharge unit to the grounding electrode.

(f) Electrode. The grounding conductor shall be connected as follows:

1. To the nearest accessible location on the following:

   a. The building or structure grounding electrode system as covered in Section 250-50

   b. The grounded interior metal water piping system as covered in Section 250-104(a)

   c. The power service accessible means external to enclosures as covered in Section 250-92(b)

   d. The metallic power service raceway

   e. The service equipment enclosure, or

   f. The grounding electrode conductor or the grounding electrode conductor metal enclosures; or

2. If the building or structure served has no grounding means, as described in (f)(1), to any one of the individual electrodes described in Section 250-50; or

3. If the building or structure served has no grounding means, as described in (f)(1) or (f)(2), to an effectively grounded metal structure or to any of the individual electrodes described in Section 250-52.

(g) Inside or Outside Building. The grounding conductor shall be permitted to be run either inside or outside the building.

(h) Size. The grounding conductor shall not be smaller than No. 10 copper, No. 8 aluminum, or No. 17 copper-clad steel or bronze.

(i) Common Ground. A single grounding conductor shall be permitted for both protective and operating purposes.

(j) Bonding of Electrodes. A bonding jumper not smaller than No. 6 copper or equivalent shall be connected between the radio and television equipment grounding electrode and the power grounding electrode system at the building or structure served where separate electrodes are used.