D0 ENGINEERING NOTE

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D0 SILICON UPGRADE

CABLE POWER DISSIPATION IN THE D0 SILICON TRACKER

July 8, 1996

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D0 Silicon Tracker
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Readout cables extend from the ladder end to the outer barrel radius in the region where the F-disks are mounted. In this region it is difficult to know what the gas temperature will be due to the power dissipating components on the F-disks and power from all the cables. This region is convectively cooled by the barrel bulkhead and the F-disk cooling channel.

Power dissipated in the cable will not only warm the surrounding gas but will warm the hybrid to which it is attached on the ladders and disks. Just how much power goes into the hybrid will be estimated here.

Physically, the cable is composed of two layers of copper which are separated and encased by 3 layers of kapton. The central kapton layer is 0.001" thick, the outer two kapton layers are 0.0005" thick, and the two copper layers are 0.0006" thick. Mike Matulik estimated the power dissipation of the cables for the 3, 6, and 9 chip ladders. These estimates are based on the assumed cross-sectional area of copper in the cable and the current these cables will carry, for a 12" cable length. The assumed powers are 14, 49, and 114 mW, respectively.

The cable power dissipation is modeled using the finite difference technique. To determine the allowable node size for this simulation a 5" cable was simulated, with the same cross-sectional area and nominal power dissipation approximately equal to the power dissipated in the 6 chip ladder cable. Node sizes of 25, 50, and 100 mils are considered. Considering Figures 1 and 2, 100 mil nodes will be used for future simulations, considered adequately small to simulate the cable.

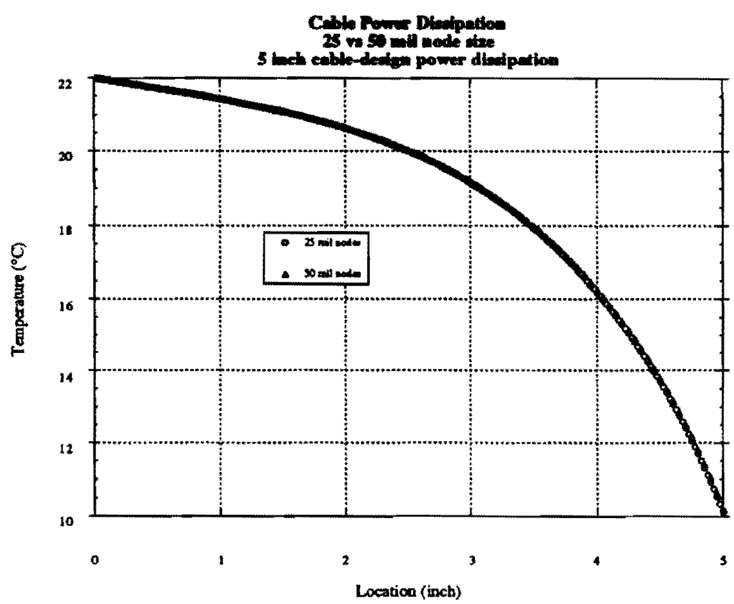

Figure 1

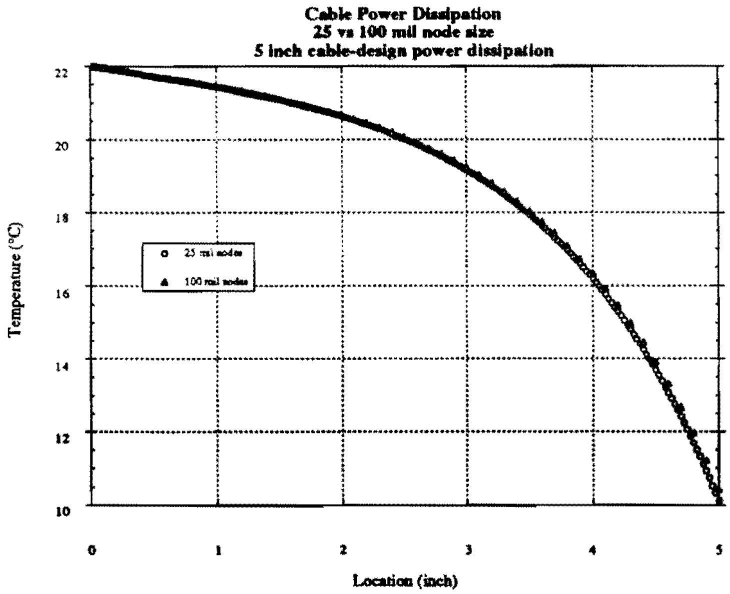

Figure 2

The following 9 figures (3-11) show the temperature profile of the cable during operation under a variety of assumptions. As stated previously, the cable powers are 14, 49, and 114 mW for a 12" cable. The cable end is assumed to be at a temperature of 22°C and the ladder temperature is assumed to be 10°C. The assumed gas temperatures are 22, 15, and 10°C and film coefficients of 5 and 10 W/m^2-K are considered*. The assumed SVX II power (for purposes of considering the percentage of the total load on the ladder which are due to the cable) is 0.4 W.

The total cable power load per barrel will now be considered. Two power extremes will be calculated based on the expectations of how the barrels will be constructed. For instance, D0 is considering barrels in the 3 chip wide region with both 3 chip (single sided) and 6 chip (double sided) ladders. Each barrel is comprised of 36 five chip wide ladders for a total cable load of 36*114 = 4104 mW. There is room for 36 three chip wide ladders, which will be either 36*14 = 504 mW or 36*49 = 1764 mW. The total cable power per barrel will be between 4104 + 504 = 4608 mW and 4104 + 1764 = 5868 mW.

This power will either be convectively carried away by the disk support or the barrel support structure. It also contributes to the large uncertainty in the gas temperature in this region. The barrel cables will be tightly packed along the bulkhead surface which may result in higher gas temperatures between cables, increasing the effective temperatures that the cables see, which will drive more of the cable power into the hybrids.

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*The film coefficient varies under a variety of conditions, to include the orientation of the surface to be cooled, the temperature difference between the gas and the cooled surface, amount of gas flow (or lack thereof), type of gas, etc... Natural convection typically results in film coefficients in the range of 5-10 W/m^2-K.

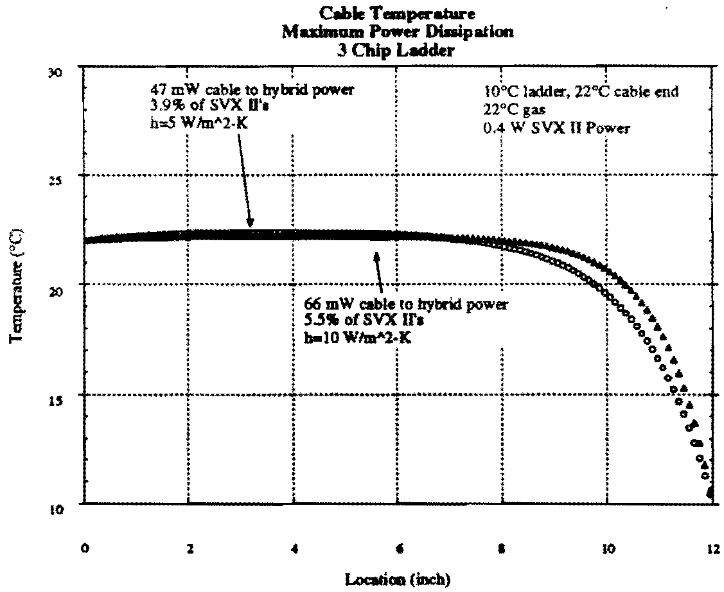

Figure 3

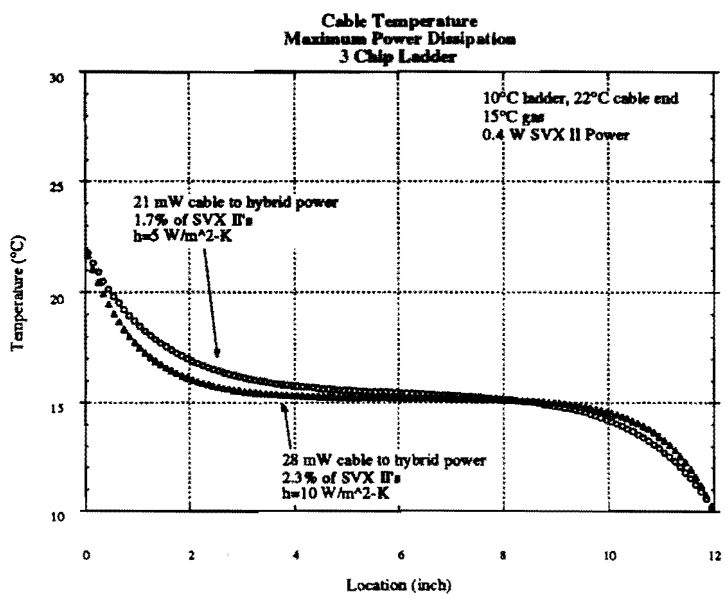

Figure 4

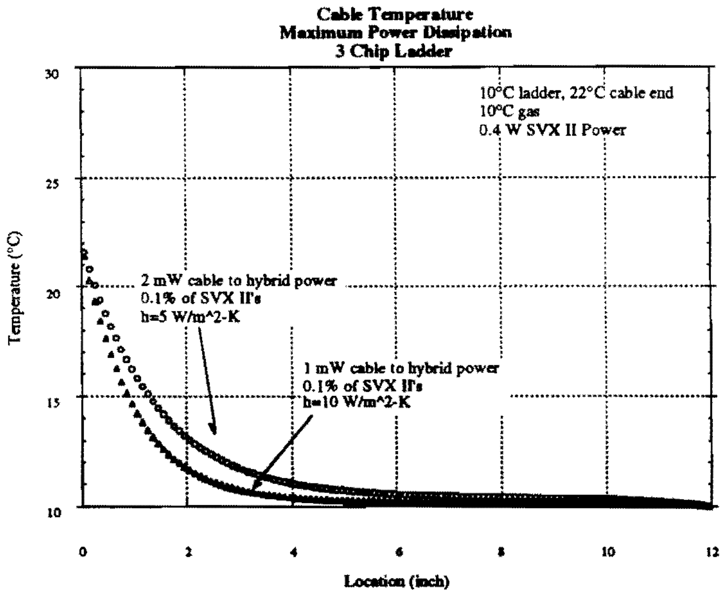

Figure 5

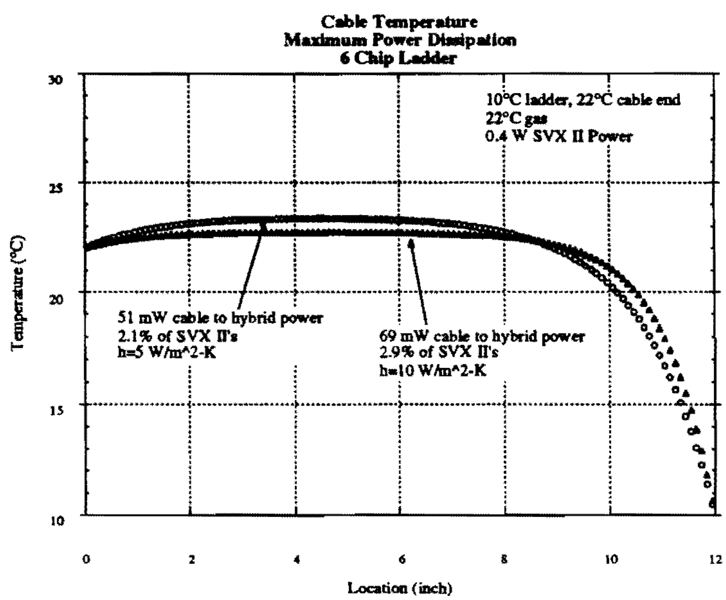

Figure 6

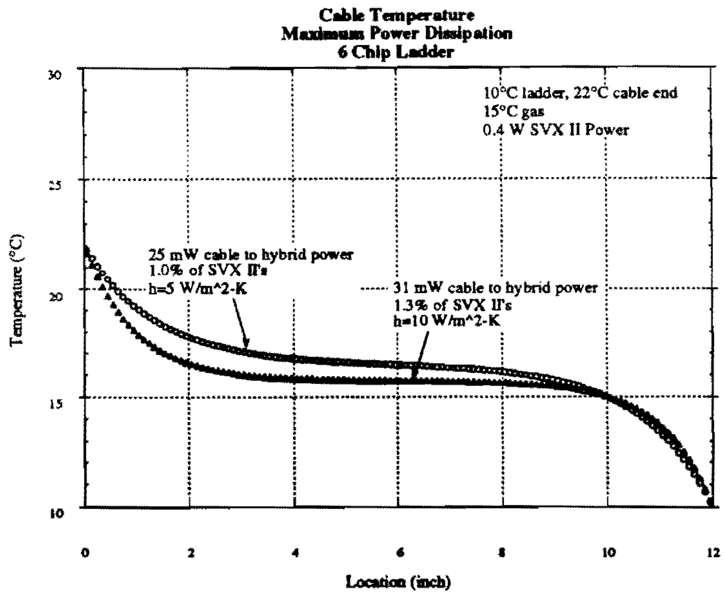

Figure 7

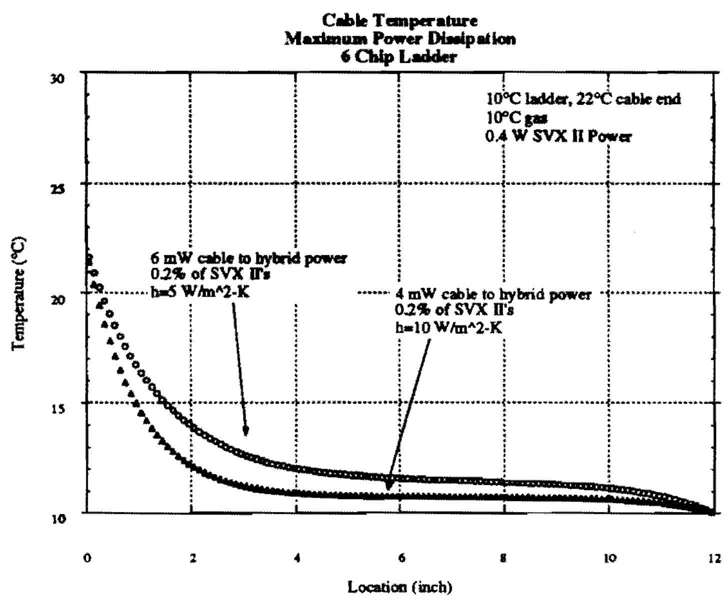

Figure 8

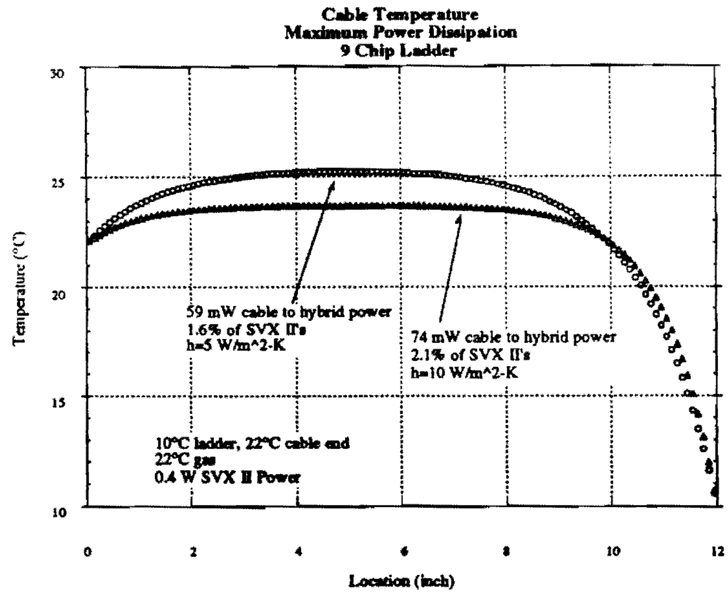

Figure 9

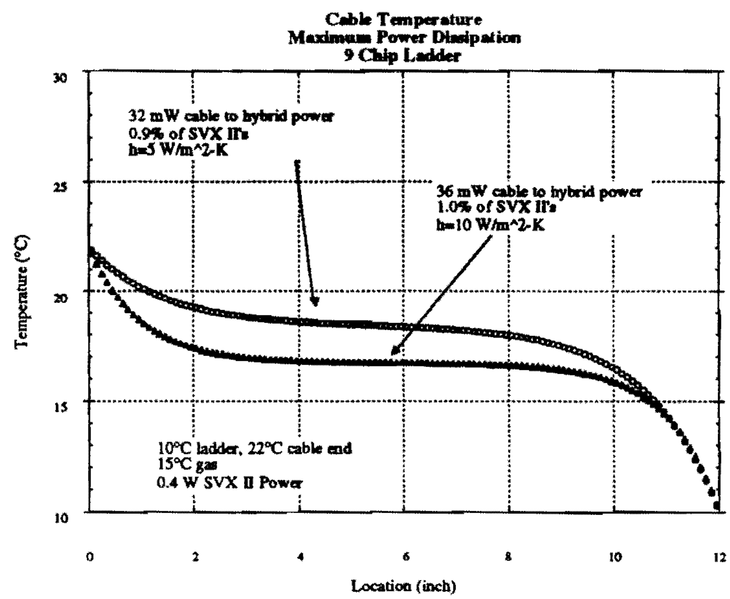

Figure 10

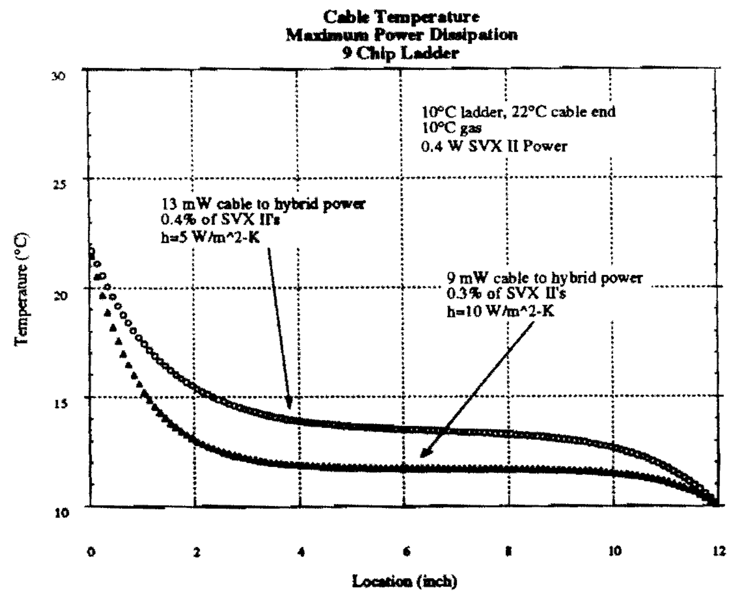

Figure 11

Based on the previous 9 figures, the maximum *percentage* of cable power occurs in the 3 chip ladder, at 22°C gas temperature and a film coefficient of 10 W/m^2-K. The cable power is 66 mW, which is considerably higher than the assumed 14 mW of power dissipated in the three chip cable. This additional power is a result of the high temperature (22°C) assumed in the cable region. Effectively, under these assumptions, the cable is convectively cooling the surrounding gas. The 66 mW is an additional heat load on the ladder at the connection point to the hybrid. 66 mW is 5.5% of the total SVX II load of 3*0.4 = 1.2 W.

Since the cables can contribute to cooling the gas temperature in the barrel/disk region, it appears that the surrounding gas will not be as high as 22°C. The bulkhead temperature will likely be at or below 0°C, further contributing to cooling the gas in this region. For these reasons the gas temperature is likely to be ~10-15°C, which will significantly reduce the power dissipation of the cables into the ladders.