Thermal Evaluation of the ChipSwitch in Programmable Controllers

AN-103

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Introduction

International Rectifier single in-line package (SIP) microelectronic power IC relays are commonly applied as AC output interface units in programmable controller output assemblies. The most typical mechanical configuration consists of eight or more SIP relays attached to a common heatsink. This heatsink is usually part of or thermally tied to the case of the AC output module. The current handling capability of such an output assembly must be determined under various combinations of load current occurring in the individual channels. Obviously, the effective current rating of a given output channel is greatest when only that channel is turned on and only its power dissipation is contributing to the temperature rise of the large heatsink. Several channels turned on simultaneously result in more heating and a reduction of the allowable current rating of the individual channels.

The SIP ChipSwitch

This application note presents the test technique for determining the allowable current ratings for a bank of ChipSwitch SIP solid state relays attached to a common heatsink. Actual current ratings under various conditions of loading are given for a typical output structure.

Specification Limitations

A maximum assembly dissipation of 15 watts into a 60°C ambient was selected as a representative operating limit. Various combinations were run to determine the relay limitations under these conditions. Two cases were then run to determine the safety margins in rating the assembly at 15 watts at 60°. A limit of 120°C was placed on maximum junction temperature, allowing a large safe temperature margin for proper junction operation.

Test Set-Up

Sixteen SP6210 ChipSwitch SIP relays were mounted in a typical industry AC output module. The structure of this module can be seen in Figure 1 and 2. Thermocouples were placed in key locations throughout the system as can be seen in Figure 3.

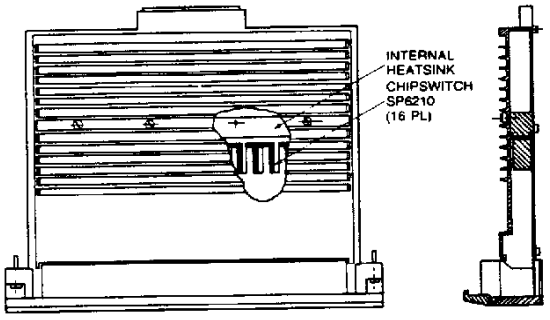

Figure 1. Typical AC output module

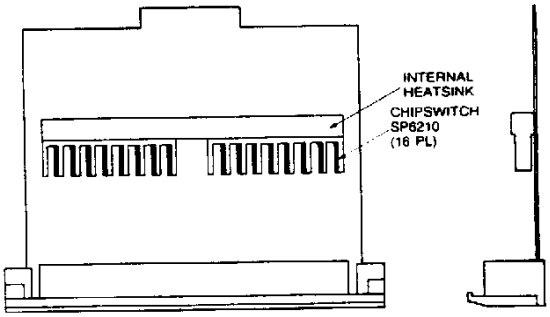

Figure 2. Heatsink configuration

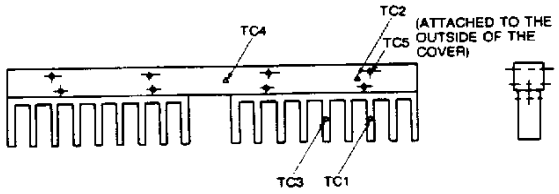

Figure 3. Location of thermocouples

Test Conditions and Parameters Employed

Ambient
Temperature = 60°C $^{+2}_{-0}$ (still air)

All readings were taken after thermal stability was achieved. For the calculations in the report, the following values were employed:

— $\theta_{J\text{-}HTSK}$ = 10°C/W
— P_D — See Figure 4
All loads resistive.

Tests

Case 1: 1 ChipSwitch relay at 2.0 amperes

TC1 = 69.0°C
TC2 = 63.2°C
TC3 = 64.0°C
TC4 = 61.9°C
TC5 = 61.7°C
P_D Total = 2.56W
T_J = 10 × 2.56 + 69 = 94.6°C

The single relay operated within specification at this current rating.

Case 2: 12 ChipSwitch relays at 1.0 ampere each

TC1 = 76.9°C
TC2 = 72.9°C
TC3 = 77.0°C
TC4 = 67.2°C
TC5 = 66.8°C
P_D Total = 12 × 1.05 = 12.6W
T_J (1) = 10 × 1.05 + 76.9 = 87.4°C
T_J (2) = 10 × 1.05 + 77.0 = 87.5°C

All ChipSwitch relays operated within specification at this current rating.

Case 3: 8 ChipSwitch relays at 1.5 amperes each

TC1 = 80.5°C
TC2 = 71.6°C
TC3 = 80.3°C
TC4 = 66.3°C
TC5 = 65.0°C
P_D Total = 8 × 1.7 = 13.6W
T_J (1) = 10 × 1.7 + 80.5 = 97.5°C
T_J (2) = 10 × 1.7 + 80.3 = 97.3°C

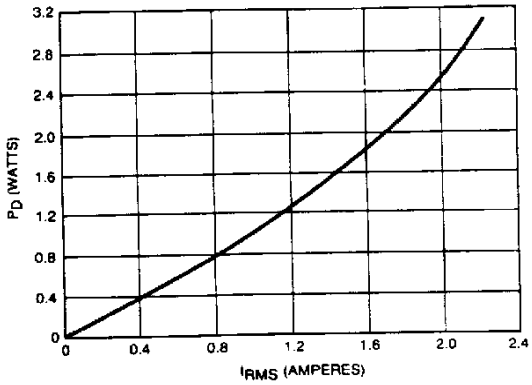

Figure 4. Power Dissipation SP6210

All ChipSwitch relays operated within specification at this current rating.

Case 4: 6 ChipSwitch relays at 2.0 amperes each

TC1 = 89.6°C
TC2 = 80.8°C
TC3 = 88.8°C
TC4 = 69.4°C
TC5 = 68.2°C
P_D Total = 6 × 2.56 = 15.36W
T_J (1) = 10 × 2.56 + 89.6 = 115.2°C
T_J (2) = 10 × 2.56 + 88.8 = 114.4°C

All ChipSwitch relays operated within specification at this current rating.

Case 5 and 6 were run in an attempt to determine the safety margin inherent in the assembly. Therefore, the power dissipation was increased beyond the target 15W maximum.

Case 5: 16 ChipSwitch relays at 1.0 ampere each

TC1 = 87°C
TC2 = 81.5°C
TC3 = 86.9°C
TC4 = 76.3°C
TC5 = 77.3°C
P_D Total = 16 × 1.05 = 16.8W
T_J (1) = 10 × 1.56 + 87.0 = 102.6°C
T_J (2) = 10 × 1.56 + 86.9 = 102.5°C

All ChipSwitch relays operated within specification at this current rating.

Case 6: 16 ChipSwitch relays at 1.5 amperes each

TC1 = 103.8°C
TC2 = 94.5°C
TC3 = 103.7°C
TC4 = 85.5°C
TC5 = 87.2°C
P_D Total = 16 × 1.7 = 27.2W
T_J (1) = 10 × 1.7 + 103.8 = 120.8°C
T_J (2) = 10 × 1.7 + 103.7 = 120.7°C

All ChipSwitch relays operated within specification at this current rating.

Conclusions

International Rectifier ChipSwitch* SP6210 solid state power IC relays meet the current handling requirements of a typical programmable logic controller. Current ratings of 2.0 amperes per channel at 60° ambient are possible under lightly loaded conditions. Under the worst case condition of all channels on simultaneously, a 1.5 ampere rating per channel can still be achieved.□