PRELIMINARY RELIABILITY PREDICTION REPORT
K2 Single Board Computer Example

Prepared:
July 13, 2001
Mike Rader & Jeff Harms

INTRODUCTION

Crane is planning to perform a study on commercial hardware used in a military application to compare the reliability effects of two system cooling approaches. One is a conventional air-cooled environment and the other is a self-contained spray cooled environment. The goal is to assess the value of spray cooling. The study is planned as a two phase effort: the first will involve performing reliability predictions as a function of temperature and the second phase will include testing and data analysis for each cooling approach. Crane believes that the results of this study will be useful in helping to make system cooling trade-off decisions where spray cooling may be an option. This preliminary report summarizes an example of the first phase work, which involved the K2 single board computer made by SBS Technologies, Inc. This example was also intended to address the passive parts heating concern introduced by the spray cooled environment

APPROACH

The approach used to perform this example study can be summarized in the following general steps:

- Collect available information (i.e. board parts list, operating environment, spray cooling conditions, etc.)
- Perform initial assessment of part characteristics versus the operating environment (identify levels of risk for the parts in relation to temperature)
- Perform reliability predictions to compare failure rate values as a function of temperature

The reliability prediction for the K2 single board computer was modeled using Bellcore. The general assumptions made were that the environment is ground benign and the ambient operating temperature is 70°C.

RESULTS

The reliability prediction results are illustrated in figures 1-4 at the end of this report. Figure 1 shows the overall failure rate (failures per million hours) for the K2 single board computer over a temperature range from 25°C to 100°C. At the 70°C spray cooled environment operating point, the failure rate is approximately 16 failures/million hours.

The failure rate for the K2 single board computer was then graphed by part category. This graph, which is Figure 2, shows how each part type contributes to the overall failure rate. For each part category, the line represents a summation of all the parts on the module for that type.

Figure 3 is similar to Figure 2 except that for each part category shown, there is only one representative part included in the failure rate. This provides a better one-to-one comparison to identify potential problem parts.

The last graph, Figure 4, is the same as Figure 3, except that the three part categories with the highest failure rate were deleted to get more resolution in the chart.

By reviewing these four figures, some general observations can be made. The spray cooled environment does cause some non-heat producing parts to operate at a higher temperature than would be encountered in a convection cooled environment. Concern for the reliability impact on these components at elevated temperatures led us to look specifically at the passive components used in AAAV. The specified spray temperature for this system is 70°C and it was important to first determine if this temperature exceeds the maximum rated operating temperature of any part on the boards. All the passive electronic components reviewed had maximum rated operating temperatures in excess of 70°C and therefore no thermal overstress conditions exist with these parts.

The next issue to address was that of general reliability impact of the increased operating temperature. The first conclusion that can be drawn is that the passive parts (caps, resistors, inductors) contribute a very small percentage of the overall board failure rate. The failure rate numbers for active components dominate the board reliability calculation. By increasing the resolution of the reliability plots, as was done in Figure 4, we were able to look at failure rate as a function of temperature for the passive parts. In contrast to the active parts, passives had a nearly flat response curve in relation to temperature increases. From this data we would conclude that board reliability in not significantly impacted by operating non-heat producing components in the spray cooled environment. This conclusion however is only valid when the ambient temperature is maintained below the maximum temperature rating of the parts.

<u>Points of Contact Information:</u>

Mike Rader
NAVSEA Crane
Component Engineering Branch
Code 6024 Bldg. 2087
300 Highway 361
Crane, IN 47522

Jeff Harms
NAVSEA Crane
Component Engineering Branch
Code 6024 Bldg. 2940
300 Highway 361
Crane, IN 47522

Phone: 812-854-2385
Fax: 812-854-3806
Email: rader_m@crane.navy.mil

Phone: 812-854-2398
Fax: 812-854-4248
Email: harms_j@crane.navy.mil

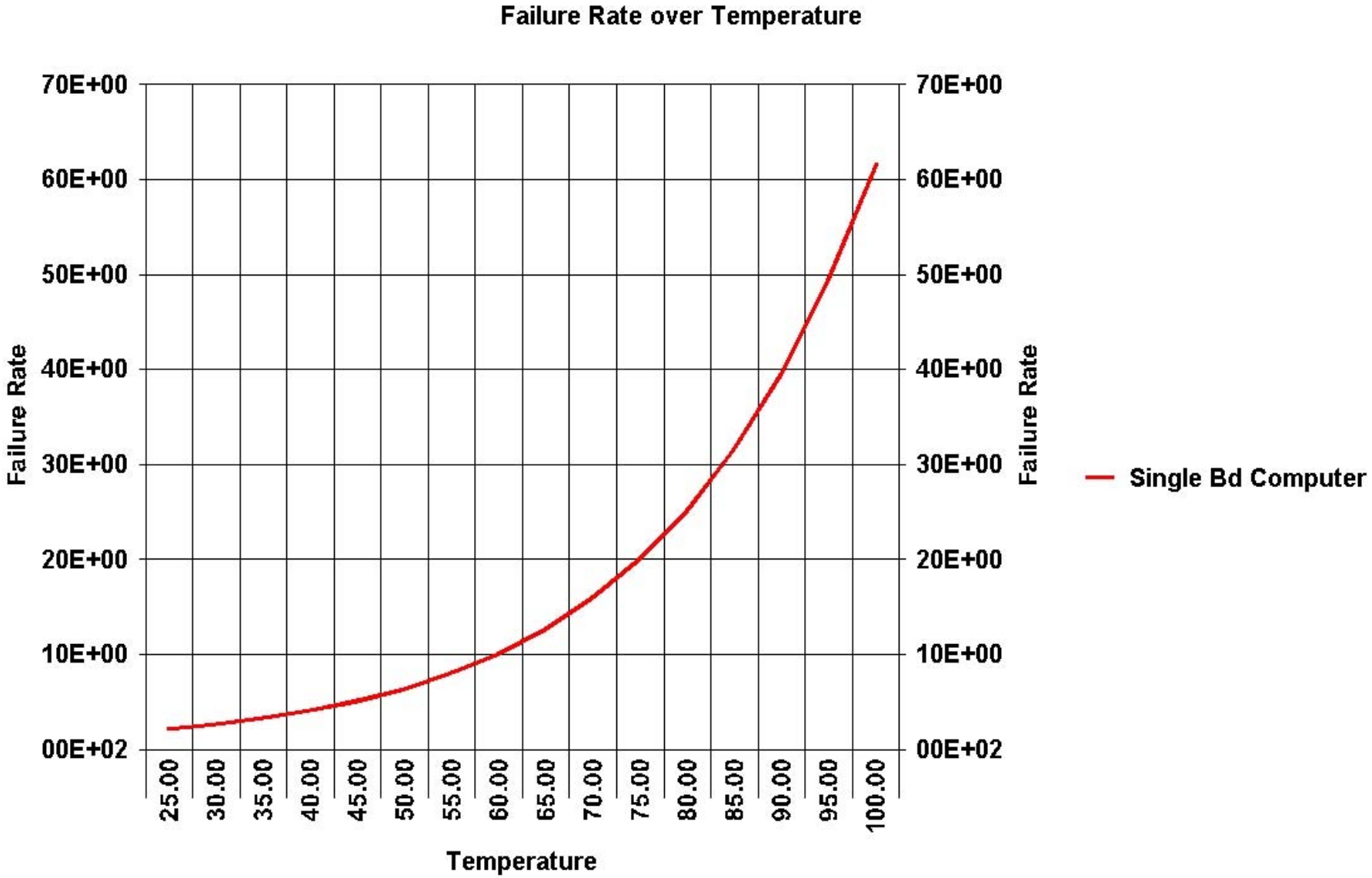
Failure Rate over Temperature
70E+00
60E+00
50E+00
40E+00
30E+00
20E+00
10E+00
00E+02
Failure Rate
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85.00
90.00
95.00
100.00
Temperature
Single Bd Computer

Figure 1

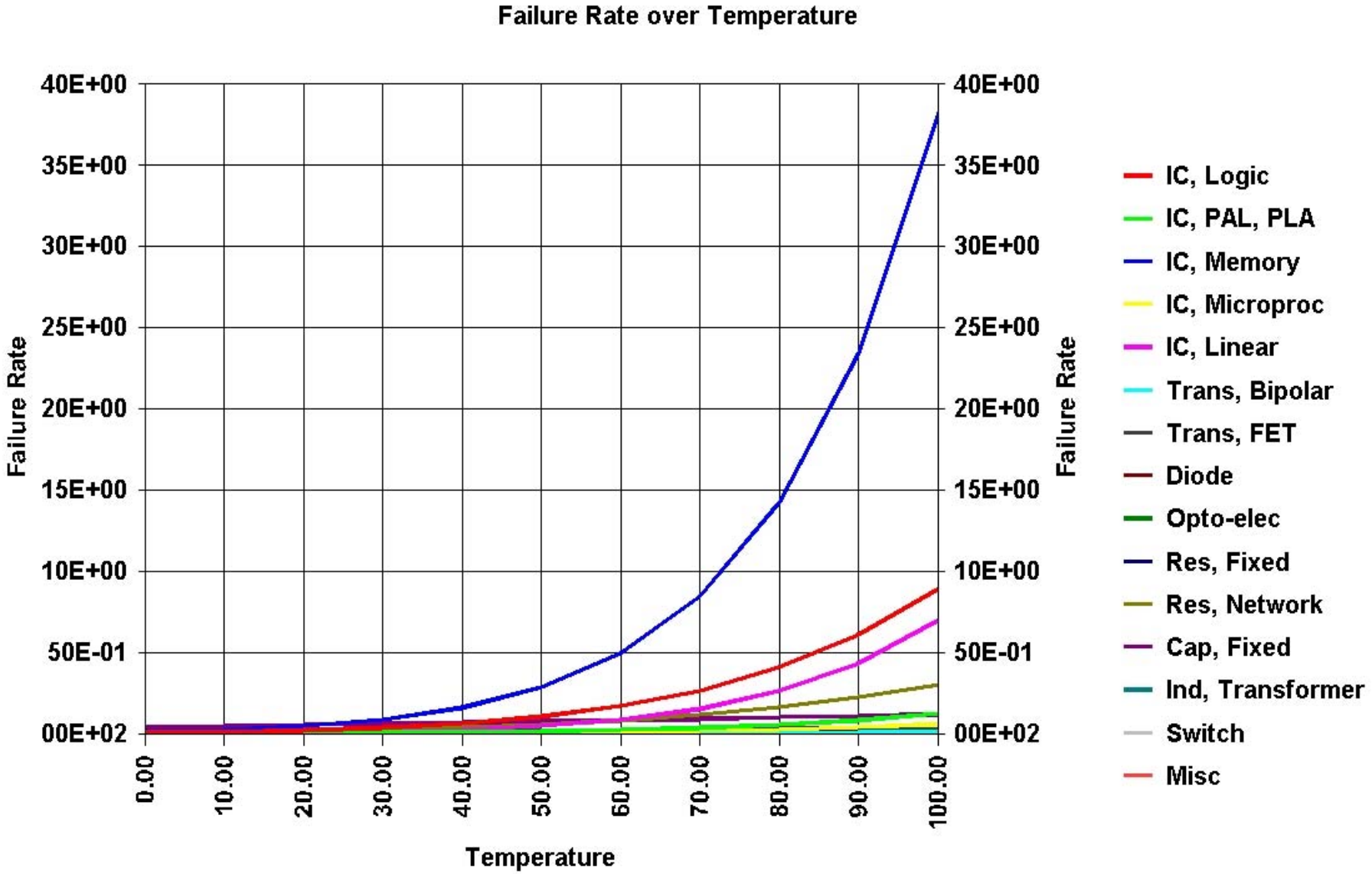
Failure Rate over Temperature
40E+00
35E+00
30E+00
25E+00
20E+00
15E+00
10E+00
50E-01
00E+02
Failure Rate
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Temperature
IC, Logic
IC, PAL, PLA
IC, Memory
IC, Microproc
IC, Linear
Trans, Bipolar
Trans, FET
Diode
Opto-elec
Res, Fixed
Res, Network
Cap, Fixed
Ind, Transformer
Switch
Misc

Figure 2

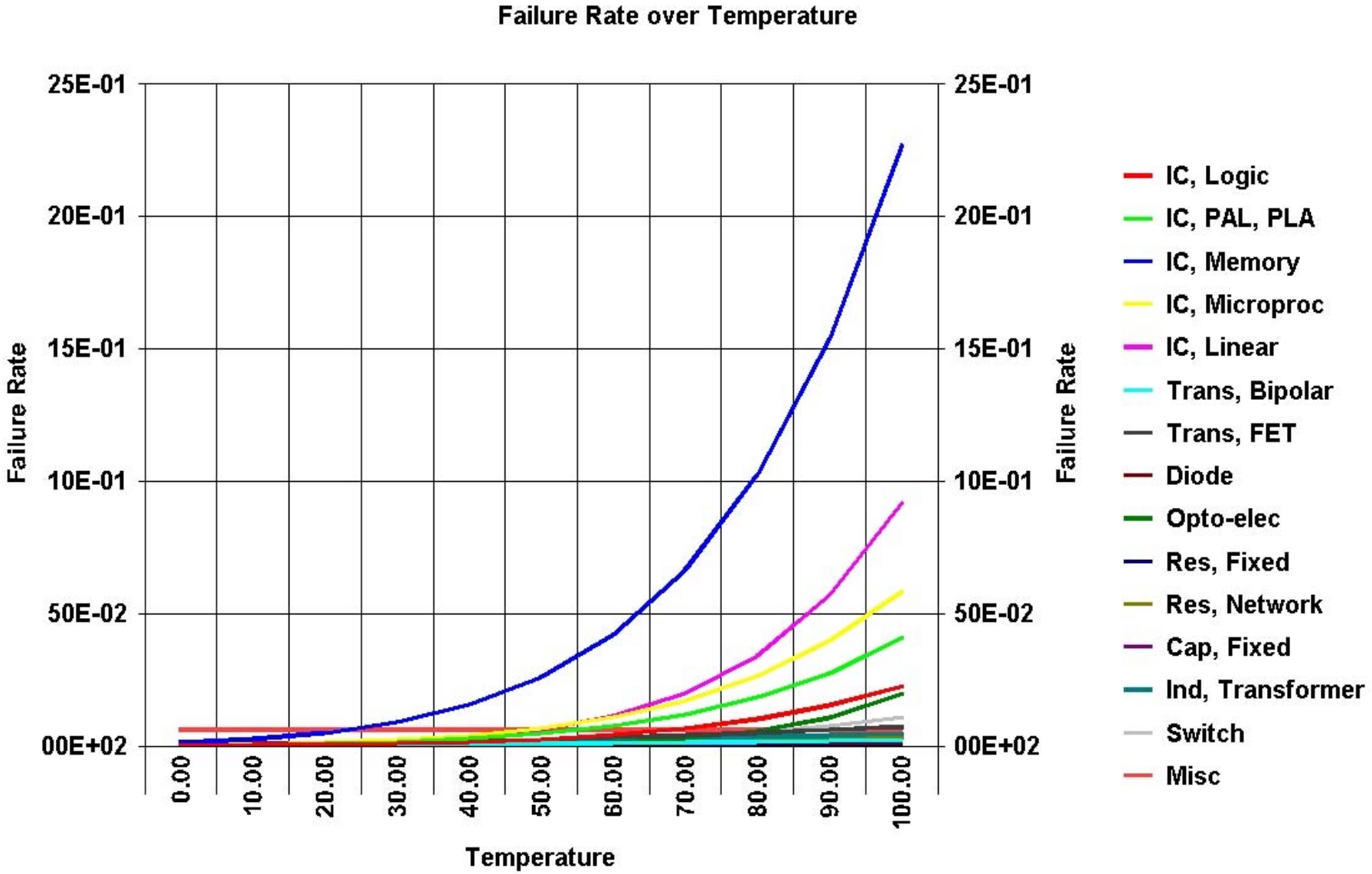
Failure Rate over Temperature
25E-01
20E-01
15E-01
10E-01
50E-02
00E+02
Failure Rate
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Temperature
IC, Logic
IC, PAL, PLA
IC, Memory
IC, Microproc
IC, Linear
Trans, Bipolar
Trans, FET
Diode
Opto-elec
Res, Fixed
Res, Network
Cap, Fixed
Ind, Transformer
Switch
Misc

Figure 3

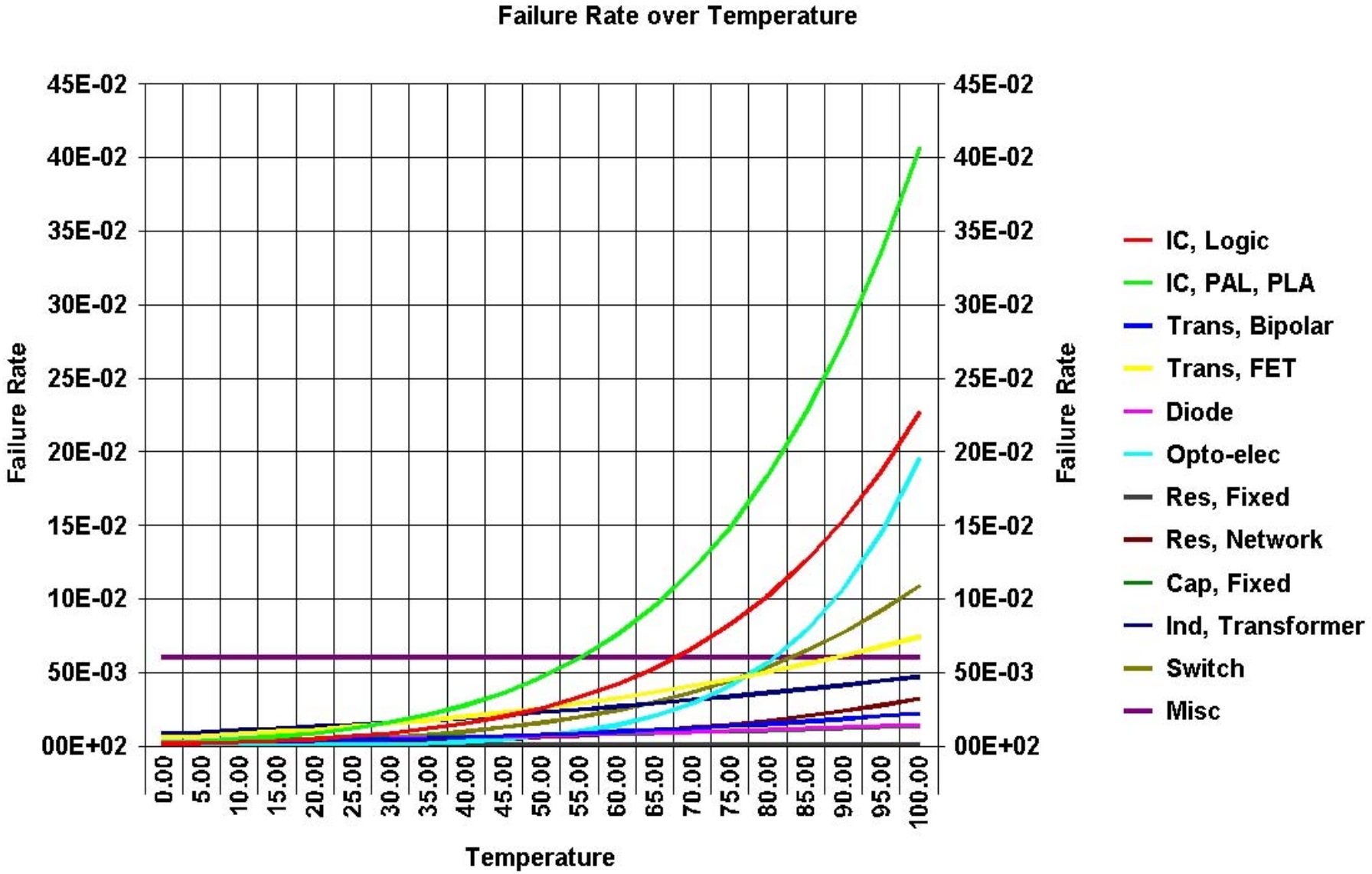
Failure Rate over Temperature
Failure Rate
45E-02
40E-02
35E-02
30E-02
25E-02
20E-02
15E-02
10E-02
50E-03
00E+02
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85.00
90.00
95.00
100.00
Temperature
IC, Logic
IC, PAL, PLA
Trans, Bipolar
Trans, FET
Diode
Opto-elec
Res, Fixed
Res, Network
Cap, Fixed
Ind, Transformer
Switch
Misc

Figure 4