Selection of Appropriate Heatsink For IBM 5x86C Microprocessors

Application Note

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Introduction

The main objective of this application note is to provide anyone using the IBM manufactured 5x86C microprocessor with 100 or 120 MHz[1] internal clock frequency, how to select a proper thermal solution. This application note will show you how to determine whether an external heatsink is needed for a specific package and customer application environment. If an external heatsink is required, this application note will show you how to select an optimized heatsink.

In order to operate an electronic device, power is supplied from an external source. The supplied power in the electronic device generates heat. If the generated heat is not removed properly, the temperature of the device could rise above the maximum operating limit. (Note that all the temperatures in thermal management are measure in degrees Celsius (° C).)

Some manufacturers define this limit by specifying the maximum allowable case temperature measured at the center of the top surface of the device package. However, the main objective is to keep the junction temperature of the device within a specified limit. Since it is not easy to measure the junction temperature of the device, some manufacturers specify the case temperature limit based on the package chosen for the device. The case temperature limit is the translation of the junction temperature of the device using internal thermal resistance of the package. Two different carrier packages such as ceramic PGA and plastic QFP may have different case temperature limits for the same device.

Other manufacturers, however, specify the maximum allowable junction temperature of the device. This is the temperature at the transistor junction internal to the device. In any event, if the temperature of the case or junction temperature of the device exceeds the maximum allowable limit specified by a manufacturer, the device may experience malfunctions, reduced performance or reduced lifespan.

1 The 5x86C microprocessor is currently available in 100 MHz speed only. Information on 120MHz operation is provided for planning purposes only.

Fixed Thermal Parameters

There are several factors that influence the thermal performance of an electronic device. Major parameters to be considered in the thermal solution of the IBM 5x86C microprocessor are discussed below.

Case and Junction Temperatures

Most device manufacturers provide information on the maximum case temperature limit of the package. When a manufacturer supplies a junction temperature limit for a device, an internal thermal resistance, which is also known as junction-to-case thermal resistance of the package, is also provided by the supplier. The internal thermal resistance or the junction-to-case thermal resistance of the package is defined as the ratio of temperature difference between junction and case and power generated in the device. For instance, the maximum case temperature for the 5x86C microprocessor is 85° C for both the 168 pin 44 mm^2 ceramic pin grid array (PGA) and the 208 pin 28 mm^2 metalized heatsink (MHS) plastic quad flat pak (PQFP).

Power

The most influential factor in the thermal performance of the device is the power generated in the device. This generated power is simply the product of the supply voltage in volts and the current in amps. Although most electronic devices come with specified voltage and current supply requirements for proper operation, actual power supplied to the microprocessor is slightly altered at system level due to inherent system variations. A slight variation in the power supply would affect the junction temperature of the device significantly. Tables 1 and 2 show two different power measurements and internal clock frequencies for 5x86C microprocessors in 168 pin PGA and 208 pin PQFP packages respectively. As you can see from Tables 1 and 2, for a given voltage, as internal clock frequency increases, the demand for supply current increases and thereby power is increased.

Variable Thermal Parameters

Air Flow

Another very influential factor in the thermal equation of the device is the air flow over the microprocessor package. The airflow can be measured in feet per minute using an anemometer. Heat can be removed from the device in three different ways. The first is conduction from the device to the package surface, the second is convection and the third is radiation off the package surface area. The internal thermal resistance characterizes the conduction effects. The radiation heat removal is very negligible compared with conduction and convection and therefore it is not considered in the thermal analysis. The surface area and air flow influence the amount of convective heat transfer.

The system designer determines whether a fan or blower is required for the machine in order to remove the heat generated in the system. The system designer also determines the number of the air vents and the location of the air vents in the machine. The amount of air flow over the microprocessor is dependent on the size and location of the system fan or blower with respect to the microprocessor, the number and location of the air vents and the location of the high system components or the baffles installed. Some systems may not have a fan or blower installed due to some other restraints. Tables 1 and 2 show various air flows and associated maximum allowable system temperatures for 100 and 120 MHz internal clock frequency 5x86C microprocessors in 168 pin PGA and 208 pin PQFP packages respectively. Tables 1 and 2 are the basic tools used to determine whether an external heatsink is required.

System Temperature

The system temperature, which is usually measured at about 12" above the microprocessor, may be different from the room temperature in which the device is to be operated. Since the other components of the Printed Circuit Board (PCB), such as the voltage regulator, also generate heat, the system temperature is usually 5° to 10° C higher than the room temperature. The system temperature rise can be minimized by providing air vents in the machine, selecting the proper size and location of the fan, and properly distributing heat generating components on the PCB.

Room Temperature

The environment also influences the thermal performance of the device. The environment usually is specified by maximum room temperature and altitude at which the device operates. A Class B environment represents a maximum room temperature of 32.2° C (90° F) and 2250 meters (7000 feet) in altitude. While a Class C environment represents a maximum room temperature of 40.6° C (105° F) and 2250 meters (7000 feet) in altitude.

You may, by now, notice that some of the parameters discussed above are fixed by the manufacturer, while others can be changed by the customer application. The fixed parameters for a selected microprocessor and package are supply voltage, current, case temperature or junction temperature, and internal thermal resistance. These parameters are specified by the manufacturer. For a given microprocessor, a customer can choose the operating room temperature limit, vary the air flow over the microprocessor and configure the system design in various ways. These parameters are obviously variable and are very influential in the selection of a heatsink.

Heatsink vs. No Heatsink Determination

This section provides a methodology for determining if a heatsink is required. If an external heatsink is required, the selection of an optimized heatsink is shown later in this application note.

CPU Internal Clock Frequency		100MHz	120MHz
Maximum V_{CC} in Volts		3.60	3.60
Maximum I_{CC} in Amps		1.2	1.4
Maximum Power in Watts		4.32	5.04
Air Flow over CPU in Feet/Minute (FPM)	0	14.8°	3.1°
	50	17.0°	5.6°
	100	19.1°	8.1°
	200	23.4°	13.2°
	400	36.5°	28.3°
	600	45.0°	38.4°
	800	-	43.4°

Table 1. Maximum Allowable SystemTemperature in Degrees C to Meet T_C = 85° C for 168 Pin 44 mm^2 Ceramic PGA 5x86C microprocessor without Heatsink

For a given 168 pin 44 mm ceramic pin grid array package 5x86C microprocessor and using the values from Table 1 above:

1. Find out the internal clock frequency in MHz and associated system supply voltage for a selected microprocessor. Let us say the chosen microprocessor has 100 MHz internal clock frequency and 3.60 V supply voltage. From Table 1 we determine that the maximum current drawn will be 1.2 A and the maximum power generated will be 4.32 watts.

2. Next determine how much air is flowing over the selected microprocessor in the system. Let us say for a chosen microprocessor, no air is flowing over the microprocessor.

3. For the selected internal clock frequency, supply voltage and air flow, obtain the maximum allowable system temperature from Table 1. For our example the maximum allowable system temperature is 14.8° C.

4. Since the system temperature rise is usually 5 - 10° C, subtract 10° C from the obtained maximum allowable system temperature in step 3. This would be the maximum allowable room temperature for a selected microprocessor and given air flow. For our example, the maximum allowable room temperature would 4.8° C.

5. As mentioned earlier each system is designed to operate in a certain environment such as Class B or C. The customer specifies the operating environment for the system. If the operating environment maximum room temperature exceeds the maximum allowable room temperature estimated in step 4, an external heatsink is required. If the maximum allowable room temperature exceeds the operating environment maximum room temperature, no heatsink is required. Let us say, for our example, the Class B operating environment has been selected by the customer. The Class B operating environment maximum room temperature of 32.2° C is higher than the maximum allowable room temperature of 4.8° C. Hence, an external heatsink is required for a selected 5x86C microprocessor package in the operating environment Class B with no air flow over the microprocessor.

Here is a second example in which no external heatsink is required. For a microprocessor with 100 MHz internal clock frequency at 3.60 V supply voltage in a 168 pin ceramic PGA package a customer chooses an operating environment of Class B with 600 ft per min. air flow over the microprocessor. Table 1 shows that the maximum allowable system temperature for this application is 45° C. Hence, for a 10° C system rise, maximum allowable room temperature would be 35° C.

Since the maximum allowable room temperature (35° C) is higher than the maximum operating environment temperature of 32.2° C, no external heatsink is required. You may have noticed in both examples that they had the same thermal parameters except air flow. In the second example, by allowing air flow of 600 ft per min. over the microprocessor, a customer eliminates the need for an external heatsink.

Table 2 below shows corresponding allowable system temperatures to meet a case temperature (T_C) of 85° C in a 208 pin 28 mm^2 PQFP package.

CPU Internal Clock Frequency		100MHz	120MHz
Maximum V_{CC} in Volts		3.60	3.60
Maximum I_{CC} in Amps		1.2	1.4
Maximum Power in Watts		4.32	5.04
Air Flow over CPU in Feet/Minute (FPM)	0	10.3° C	–2.2° C
	50	21.9° C	11.4° C
	100	26.2° C	16.5° C
	200	32.7° C	24.0° C
	400	40.5° C	33.1° C
	600	–	–
	800	–	–

Table 2. Maximum Allowable SystemTemperature in Degrees C to Meet T_C = 85° C for 208 Pin 28 mm^2 MHS_PQFP 5x86C microprocessor without external heatsink.

Selecting an Optimized Heatsink

Once it is determined that an external heatsink is needed for a specific microprocessor package and application, choosing an optimized heatsink is the next step. In thermal management, a heatsink is usually characterized by sink-to-ambient thermal resistance. This is defined as the ratio calculated by subtracting the system temperature from the temperature of the bottom of the heatsink where it makes contact with the microprocessor package and dividing the resultant differance by the generated power in the device.

Most of the heatsink suppliers specify the sink-to-ambient thermal resistance for the heatsinks listed in their catalogs. Since 5x86C 100 and 120 MHz microprocessors in 168 pin PGA and 208 pin PQFP packages are used in the desktop and mobile personal computers, most customers may have two distinct operating environments -- namely Class B and C which were discussed earlier.

Table 3 below lists the minimum required sink-to-ambient thermal resistance of heatsinks for 168 pin PGA and 208 pin PQFP packages, 100 and 120 MHz internal clock frequencies and Class B and C environments. A 10° C system temperature rise was assumed to derive the sink-to-ambient thermal resistance. 0.4° C/W interface thermal resistance (known as case-to-sink thermal resistance) was estimated based on the interface material's bond thickness of 0.006", 100% coverage of the bonding area of 28 mm^2 and 0.5 watt per meter-degree K thermal conductivity of the bonding material.

Type of Package	Internal Clock Frequency in MHz	Operating Environment Class B (32.2° C) or Class C (40.6° C)	System Temperature in Degrees C	Thermal Resistance in Degrees C per Watt
168 PIN PGA	100	32.2° C	42.2° C	9.75° C/W
168 PIN PGA	100	40.6° C	50.6° C	7.8° C/W
168 PIN PGA	120	32.2° C	42.2° C	8.33° C/W
168 PIN PGA	120	40.6° C	50.6° C	6.66° C/W
208 PIN PQFP	100	32.2° C	42.2° C	9.5° C/W
208 PIN PQFP	100	40.6° C	50.6° C	7.56° C/W
208 PIN PQFP	120	32.2° C	42.2° C	8.09° C/W
208 PIN PQFP	120	40.6° C	50.6° C	6.42° C/W

Table 3. Sink to Ambient Thermal Resistance in Degrees C per Watt

For a selected 5x86C microprocessor with an internal clock frequency in a given package and a chosen operating environment, the required sink-to-ambient thermal resistance of a heatsink can be obtained from Table 3. For instance, for a 168 pin PGA package 5x86C microprocessor at 100 MHz and Class B operating environment, the sink-to-ambient thermal resistance of the heatsink is 9.75° C per watt. Now, for a chosen air flow in the customer application, an appropriate heatsink can be selected from the heatsink catalog provided by the supplier.[2]

Refer to Appendix A where examples of heatsinks for 168 pin PGA and 208 pin PQFP packages, 100 and 120 MHz internal clock frequencies and Class B and C operating environments with various air flows ranging from 0 to 1000 ft per min. are provided for design guidelines. Note that the suggested heatsinks are only some of the possible solutions. One suggested heatsink solution may be ideal for one application but not for another due to physical constraints in the system.

By now, you may have concluded that the less the thermal resistance of the heatsink, the better heat dissipation can be achieved. It may also be noted that more surface area on the heatsink provides less thermal resistance. More air flow over the heatsink also lowers the thermal resistance of the heatsink. If the physical constraint in the system does not allow any possible heatsink solutions, an alternate fan/heatsink, thermoelectric cooling or heatpipe solution may be adopted.

[2] See Appendix B for a partial list of heatsink suppliers. IBM did not qualify any of these vendors for any of the suggested heatsinks nor does IBM endorse any of these vendors or their products.

Heatsink Attachment

The selected heatsink can be attached to the 5x86C microprocessor in several ways. Thermal epoxies, thermally conductive adhesive, and mechanical fastening systems such as clip and screws are three methods commonly used. Each method has its own advantages and disadvantages. If the x-y size of the heatsink is less than or equal to the microprocessor x-y size, thermally conductive adhesive such as Thermattach T405 from Chomerics would be the most effective solution. The thermally conductive adhesive attach process is simple and reworkable. The attach process can be done manually. No special tool or curing oven is required.

Note that although the thermally conductive adhesive attach process is the suggested solution, other attach processes such as mechanical fastening and thermal epoxies can also be employed. However, due care must be taken to ensure that the equivalent interface thermal resistance of 0.4° C/W has been maintained. If the interface thermal resistance exceeds 0.4° C/W, the sink-to-ambient thermal resistance of the heatsink must be adjusted accordingly.

Summary

The intent of this application note has been to familiarize you with the thermal management of the IBM 5x86C microprocessor. This application note provides a step by step process to help you understand the thermal management of IBM 5x86C microprocessors. It also provides you with recommended heatsink solutions which you may use as guidelines. Although most of the major thermal parameters are considered in the process, it is advisable to carry out thermal performance experiments in an actual system for verification.

Appendix A

168 I/O PGA Ceramic Package 5x86C Microprocessor - 100 MHz

Examples of Heatsinks for Class B Environment[3]

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in ° C/W	Heatsink	
			Vendor	Part Number
0	43.18 X 44 X 16.51	9	THERMALLOY	18564
0	48.51 X 48.51 X 9.02	9.48	IERC	BDN19-3CB/A01
50	31.37 X 34.49 X 16.51	9.5	THERMALLOY	2329
50	43.43 X 43.43 X 14.10	9.5	IERC	BDN17-5CB/A01
50	44.45 X 44 X 6.35	9.12	AAVID	65060
50	45.97 X 45.97 X 9.02	9.75	IERC	BDN18-3CB/A01
50	53.30 X 53.30 X 10.20	9.75	WAKEFIELD	698-40
100	31.37 X 33.02 X 12.45	9.35	THERMALLOY	2338
100	35.81 X 35.81 X 15.37	9.71	IERC	BDN14-6CB/A01
100	42.16 X 44 X 9.91	9.16	AAVID	67620
100	44.45 X 43.18 X 10.16	9.69	WAKEFIELD	629-40
200	28.19 X 28.19 X 15.37	9.55	IERC	BDN11-6CB/A01
200	33.27 X 33.27 X 9.02	9.23	IERC	BDN13-3CB/A01
200	24 X 44 X 10.29	8.79	AAVID	67600
200	32.89 X 44 X 6.6	9.29	AAVID	63475
1000	17.40 X 10.16 X 10.16	9.46	THERMALLOY	2341

[3] Dimension and part number data in this and the remaining tables has been taken from the respective vendor catalogs. Thermal Resistance data has been calculated by our engineer based on observations made in our laboratory and using industry accepted algorithms.

168 I/O PGA Ceramic Package 5x86C Microprocessor - 100 MHz

Examples of Heatsinks for Class C Environment

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in ° C/W	Heatsink	
			Vendor	Part Number
0	41.28 X 43.18 X 16.51	7.24	THERMALLOY	2332
0	44.7 X 44 X 14.73	7.63	AAVID	67240
0	53.59 X 53.59 X 15.37	7.48	IERC	BDN21-6CB/A01
50	37.97 X 38.10 X 16.51	7.56	THERMALLOY	2330
50	43.18 X 44 X 16.51	7.17	THERMALLOY	18564
50	45.97 X 45.97 X 15.37	7.8	IERC	BDN18-5CB/A01
50	48.51 X 48.51 X 14.1	7.8	IERC	BDN19-5CB/A01
50	51.05 X 51.05 X 14.10	7.56	IERC	BDN20-5CB/A01
50	53.59 X 53.59 X 9.02	7.8	IERC	BDN21-3CB/A01
100	43.43 X 43.43 X 14.1	7.44	IERC	BDN17-5CB/A01
100	43.18 X 44 X 8.89	7.8	THERMALLOY	18051
100	45.97 X 45.97 X 9.02	7.66	IERC	BDN18-3CB/A01
200	28.07 X 30.48 X 16.51	7.58	THERMALLOY	2337
200	33.27 X 33.27 X 14.1	7.54	IERC	BDN13-5CB/A01
200	37.97 X 38.1 X 10.16	7.51	THERMALLOY	2319
200	41.28 X 43.18 X 8.89	7.12	THERMALLOY	2321
200	27.94 X 44 X 9.52	7.25	THERMALLOY	19034
300	28.19 X 28.19 X 15.37	7.82	IERC	BDN11-6CB/A01
300	33.27 X 33.27 X 9.02	7.55	IERC	BDN13-3CB/A01
400	25.65 X 25.65 X 14.1	7.71	IERC	BDN10-5CB/A01
400	28.19 X 28.19 X 9.02	7.62	IERC	BDN11-3CB/A01
400	30.73 X 30.73 X 9.02	7.73	IERC	BDN12-3CB/A01
400	44.45 X 43.18 X 6.35	7.81	WAKEFIELD	629-25

168 I/O PGA Ceramic Package 5x86C Microprocessor - 120 MHz

Examples of Heatsinks for Class B Environment

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in° C/W	Heatsink	
			Vendor	Part Number
0	44.45 X 43.18 X 16.51	7.97	WAKEFIELD	629-65
0	44.7 X 44 X 14.73	7.63	AAVID	67240
0	45.97 X 45.97 X 15.37	8.36	IERC	BDN18-5CB/A01
0	53.59 X 53.59 X 9.02	8.24	IERC	BDN21-3CB/A01
50	37.97 X 38.10 X 16.51	7.8	THERMALLOY	2330
50	43.18 X 44 X 12.7	8.06	THERMALLOY	19701
50	48.51 X 48.51 X 14.1	7.8	IERC	BDN19-5CB/A01
50	51.05 X 51.05 X 9.02	8.09	IERC	BDN20-3CB/A01
100	31.37 X 34.49 X 16.51	8.07	THERMALLOY	2329
100	40.89 X 40.89 X 15.37	8.16	IERC	BDN16-6CB/A01
100	43.43 X 43.43 X 9.02	8.26	IERC	BDN17-3CB/A01
100	43.18 X 44 X 8.89	7.86	THERMALLOY	18051
100	53.3 X 53.3 X 10.2	8.17	WAKEFIELD	698-40
200	28.07 X 27.94 X 15.24	8.25	THERMALLOY	2327
200	38.35 X 38.35 X 9.02	7.86	IERC	BDN15-3CB/A01
200	43.18 X 44 X 4.5	8.27	THERMALLOY	18739
300	28.19 X 28.19 X 15.37	7.82	IERC	BDN11-6CB/A01
400	44.45 X 43.18 X 6.35	7.81	WAKEFIELD	629-25
600	23.11 X 23.11 X 9.02	8.18	IERC	BDN09-3CB/A01

168 I/O PGA Ceramic Package 5x86C Microprocessor - 120 MHz

Examples of Heatsinks for Class C Environment

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in C/W	Heatsink	
			Vendor	Part Number
0	44.7 X 44 X 30.48	5.55	THERMALLOY	18614
0	53.3 X 53.3 X 16.5	6.42	WAKEFIELD	698-65
0	58.93 X 44 X 14.75	6.33	THERMALLOY	18410
50	44.7 X 44 X 14.73	6.2	AAVID	67240
50	44.58 X 45.72 X 16.51	6.33	THERMALLOY	2333
100	37.97 X 38.1 X 16.51	6.5	THERMALLOY	2330
100	44.45 X 44 X 6.35	6.44	AAVID	65060
100	45.97 X 45.97 X 15.37	6.25	IERC	BDN18-5CB/A01
100	48.51 X 48.51 X 14.1	6.37	IERC	BDN19-5CB/A01
100	51.05 X 51.05 X 9.02	6.6	IERC	BDN20-3CB/A01
200	38.35 X 38.35 X 14.1	6.28	IERC	BDN15-5CB/A01
200	42.95 X 44 X 8.38	6.15	AAVID	68240
300	38.35 X 38.35 X 9.02	6.42	IERC	BDN15-3CB/A01
400	24.76 X 27.94 X 15.24	6.43	THERMALLOY	2328
400	33.27 X 33.27 X 9.02	6.54	IERC	BDN13-3CB/A01
600	25.65 X 25.65 X 14.1	6.32	IERC	BDN10-5CB/A01
600	30.73 X 30.73 X 9.02	6.33	IERC	BDN12-3CB/A01
1000	23.11 X 23.11 X 9.02	6.36	IERC	BDN09-3CB/A01

208 I/O PQFP Plastic MHS Package 5x86C Microprocessor - 100 MHz

Examples of Heatsinks for Class B Environment

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in° C/W	Heatsink	
			Vendor	Part Number
0	43.18 X 44 X 16.51	9	THERMALLOY	18564
0	48.51 X 48.51 X 9.02	9.48	IERC	BDN19-3CB/A01
50	31.37 X 34.49 X 16.51	9.5	THERMALLOY	2329
50	43.43 X 43.43 X 14.10	9.5	IERC	BDN17-5CB/A01
50	44.45 X 44 X 6.35	9.12	AAVID	65060
100	31.37 X 33.02 X 12.45	9.35	THERMALLOY	2338
100	42.16 X 44 X 9.91	9.16	AAVID	67620
200	33.27 X 33.27 X 9.02	9.23	IERC	BDN13-3CB/A01
200	24 X 44 X 10.29	8.79	AAVID	67600
200	32.89 X 44 X 6.6	9.29	AAVID	63475
300	44.45 X 43.18 X 6.35	9.02	WAKEFIELD	629-25
1000	17.40 X 10.16 X 10.16	9.46	THERMALLOY	2341

208 I/O PQFP Plastic MHS Package 5x86C Microprocessor - 100 MHz

Examples of Heatsinks for Class C Environment

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in° C/W	Heatsink	
			Vendor	Part Number
0	41.28 X 43.18 X 16.51	7.24	THERMALLOY	2332
0	53.34 X 44 X 13.72	7.46	AAVID	66435
0	53.59 X 53.59 X 15.37	7.48	IERC	BDN21-6CB/A01
50	37.97 X 38.10 X 16.51	7.56	THERMALLOY	2330
50	43.18 X 44 X 16.51	7.17	THERMALLOY	18564
50	51.05 X 51.05 X 14.10	7.56	IERC	BDN20-5CB/A01
100	43.43 X 43.43 X 14.1	7.44	IERC	BDN17-5CB/A01
100	43.18 X 44 X 7.62	7.49	AAVID	63570
100	54.48 X 43.18 X 8.89	7.27	THERMALLOY	2358
200	28.07 X 30.48 X 16.51	7.58	THERMALLOY	2337
200	33.27 X 33.27 X 14.1	7.54	IERC	BDN13-5CB/A01
200	37.97 X 38.1 X 10.16	7.51	THERMALLOY	2319
200	27.94 X 44 X 9.52	7.25	THERMALLOY	19034
300	24.76 X 27.94 X 15.24	7.4	THERMALLOY	2328
300	33.27 X 33.27 X 9.02	7.55	IERC	BDN13-3CB/A01
600	23.11 X 23.11 X 15.37	7.16	IERC	BDN09-6CB/A01
600	25.65 X 25.65 X 9.02	7.12	IERC	BDN10-3CB/A01

208 I/O PQFP Plastic MHS Package 5x86C Microprocessor - 120 MHz

Examples of Heatsinks for Class B Environment

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in° C/W	Heatsink	
			Vendor	Part Number
0	44.7 X 44 X 14.73	7.63	AAVID	67240
0	51.05 X 51.05 X 14.1	7.96	IERC	BDN20-5CB/A01
0	51.18 X 53.34 X 10.16	8.02	THERMALLOY	2325
0	56.87 X 48.26 X 10.16	8.02	THERMALLOY	2359
50	37.97 X 38.10 X 16.51	7.8	THERMALLOY	2330
50	43.18 X 44 X 12.7	8.06	THERMALLOY	19701
50	45.97 X 45.97 X 15.37	7.8	IERC	BDN18-5CB/A01
50	51.05 X 51.05 X 9.02	8.09	IERC	BDN20-3CB/A01
100	31.37 X 34.49 X 16.51	8.07	THERMALLOY	2329
100	43.18 X 44 X 8.89	7.86	THERMALLOY	18051
100	45.97 X 45.97 X 9.02	7.66	IERC	BDN18-3CB/A01
200	30.15 X 44 X 7.11	7.94	AAVID	63455
200	38.35 X 38.35 X 9.02	7.86	IERC	BDN15-3CB/A01
300	28.19 X 28.19 X 15.37	7.82	IERC	BDN11-6CB/A01
400	25.65 X 25.65 X 14.1	7.71	IERC	BDN10-5CB/A01
400	28.19 X 28.19 X 9.02	7.62	IERC	BDN11-3CB/A01
400	30.73 X 30.73 X 9.02	7.73	IERC	BDN12-3CB/A01
400	44.45 X 43.18 X 6.35	7.81	WAKEFIELD	629-25

208 I/O PQFP MHS Plastic Package 5x86C Microprocessor - 120 MHz

Examples of Heatsinks for Class C Environment

Air Flow FPM	Heatsink Overall Dimension in mm	Thermal Resistance Sink to Ambient in° C/W	Heatsink	
			Vendor	Part Number
0	44.7 X 44 X 30.48	5.55	THERMALLOY	18614
0	47.88 X 48.26 X 16.51	6.1	THERMALLOY	2335
0	53.3 X 53.3 X 16.5	6.42	WAKEFIELD	698-65
0	58.93 X 44 X 14.75	6.33	THERMALLOY	18410
50	44.7 X 44 X 14.73	6.2	AAVID	67240
50	44.58 X 45.72 X 16.51	6.33	THERMALLOY	2333
100	44.45 X 44 X 6.35	6.44	AAVID	65060
100	45.97 X 45.97 X 15.37	6.25	IERC	BDN18-5CB/A01
100	48.51 X 48.51 X 14.1	6.37	IERC	BDN19-5CB/A01
200	38.35 X 38.35 X 14.1	6.28	IERC	BDN15-5CB/A01
200	42.95 X 44 X 8.38	6.15	AAVID	68240
300	28.07 X 30.48 X 16.51	6.22	THERMALLOY	2337
300	33.27 X 33.27 X 14.1	6.17	IERC	BDN13-5CB/A01
300	38.35 X 38.35 X 9.02	6.42	IERC	BDN15-3CB/A01
300	44.58 X 45.72 X 6.98	6.24	THERMALLOY	2342
400	24.76 X 27.94 X 15.24	6.43	THERMALLOY	2328
400	30.73 X 30.73 X 14.1	6.15	IERC	BDN12-5CB/A01
600	25.65 X 25.65 X 14.1	6.32	IERC	BDN10-5CB/A01
600	28.19 X 28.19 X 9.02	6.23	IERC	BDN11-3CB/A01
600	30.73 X 30.73 X 9.02	6.33	IERC	BDN12-3CB/A01
600	44.45 X 43.18 X 6.35	6.38	WAKEFIELD	629-25
800	23.11 X 23.11 X 15.37	6.22	IERC	BDN09-5CB/A01
800	25.65 X 25.65 X 9.02	6.18	IERC	BDN10-3CB/A01
1000	23.11 X 23.11 X 9.02	6.36	IERC	BDN09-3CB/A01

APPENDIX B

Heatsink Suppliers

Aavid Thermal Technologies
One Kool Path
P.O. Box 400
Laconia, NH 03247
Tel. (603)528-3400
Fax (603)528-1478

Thermalloy Inc.
2021 W. Valley View
Dallas, TX 75234
Tel. (214)243-4321
Fax (214)241-4656

Wakefield Engineering
60 Audubon Road
Wakefield, MA 01880
Tel. (617)245-5900
Fax (617)246-0874

Web Automation, Ltd.
11411 Plano Road
Dallas, TX 75243
Tel. (214)348-8678
Fax (214)343-8958

IERC
135 W. Magnolia Blvd
Burbank, CA 91502
Tel. (818)842-7277
Fax (818)848-8872