

Thermal Considerations

In order to avoid malfunctioning of the CC5-RAVE, take care of appropriate cooling of the processor and system, e.g. by a cooling fan suitable to the maximum power consumption of the CPU chip actually in use. Please note, that the processors temperature is steadily measured by a special controller (MAX1617), attached to the onboard SMBus® (System Management Bus). The processor core (die) temperature is signalled by the forward voltage of a CPU integrated diode. A second diode internal to the MAX1617 allows for acquisition of the boards surface temperature. The programmable overtemperature alarm allows to trigger the SMBus alert line in order to avoid overheating. A suitable software to display both, the die temperature, as well as the board temperature, is MBM (Motherboard Monitor), which can be downloaded from the web. After installation, both temperatures can be observed permanently from the Windows taskbar.

By default, the CC5-RAVE is equipped with a passive heatsink, covering not only the processor chip itself but also major areas on the board, for an optimum thermal conduction. In addition, a forced vertical air flow trough the system enclosure (e.g. bottom mount fan unit) is strongly recommended. Be sure to thoroughly discuss your actual cooling needs with EKF. Generally, the faster the CPU speed the higher is its power consumption.

The maximum power consumption and operating temperature of a particular processor can be derived from the tables below. Fortunately, the power consumption is by far lower when executing typical Windows or Linux tasks. The heat dissipation increases especially when rendering software is executed, e.g. the Acrobat Distiller. EKF tests the CC5-RAVE by running 'kpower.exe', a proprietary Intel tool for generating the maximum stress to the processor.



Celeron® Processors Maximum Power Consumption and Die Temperature

Processor	Speed	Host Bus	CPU ID	maximum Power	max. Die Temperature
Celeron 1.1G	1.1GHz	100MHz	068Ah	33.0W	77°C
Celeron 1G	1GHz	100MHz	068Ah	29.0W	75°C
Celeron 950	950MHz	100MHz	068Ah	28.0W	79°C
Celeron 900	900MHz	100MHz	068Ah	26.7W	77°C
Celeron 850	850MHz	100MHz	068Ah	25.7W	80°C
Celeron 850	850MHz	100MHz	0686h	22.5W	80°C
Celeron 800	800MHz	100MHz	068Ah	24.5W	80°C
Celeron 800	800MHz	100MHz	0686h	20.8W	80°C
Celeron 766	766MHz	66MHz	068Ah	23.6W	80°C
Celeron 766	766MHz	66MHz	0686h	20.0W	80°C
Celeron 733	733MHz	66MHz	068Ah	22.8W	80°C
Celeron 733	733MHz	66MHz	0686h	19.1W	80°C
Celeron 700	700MHz	66MHz	0686h	21.9W	80°C
Celeron 700	700MHz	66MHz	0683h	18.3W	80°C
Celeron 667	667MHz	66MHz	0686h	21.1W	82°C
Celeron 667	667MHz	66MHz	0683h	17.5W	82°C
Celeron 633	633MHz	66MHz	0686h	20.2W	82°C
Celeron 633	633MHz	66MHz	0683h	16.5W	82°C
Celeron 600	600MHz	66MHz	0686h	19.6W	90°C
Celeron 600	600MHz	66MHz	0683h	15.8W	90°C
Celeron 566	566MHz	66MHz	068Ah	19.2W	90°C
Celeron 566	566MHz	66MHz	0686h	14.9W	90°C
Celeron 533A	533MHz	66MHz	0683h	14.0W	90°C
Celeron 533	533MHz	66MHz	0665h	28.3W	T_case 70°C
Celeron 500	500MHz	66MHz	0665h	27.0W	T_case 70°C
Celeron 466	466MHz	66MHz	0665h	25.6W	T_case 70°C
Celeron 433	433MHz	66MHz	0665h	24.1W	T_case 85°C
Celeron 400	400MHz	66MHz	0665h	23.7W	T_case 85°C
Celeron 366	366MHz	66MHz	0665h	21.7W	T_case 85°C
Celeron 333	333MHz	66MHz	0665h	19.7W	T_case 85°C

Pentium-III® Processors Maximum Power Consumption and Die Temperature

Processor	Speed	Host Bus	CPU ID	maximum Power	max. Die Temperature
Pentium-III 1.13G	1.13GHz	133MHz	068Ah		
Pentium-III 1.1G	1.1GHz	100MHz	068Ah		
Pentium-III 1BG	1GHz	133MHz	068Ah	29.0W	75°
Pentium-III 1BG	1GHz	133MHz	0686h	26.1W	70°
Pentium-III 1G	1GHz	100MHz	068Ah	29.0W	75°
Pentium-III 933	933MHz	133MHz	068Ah	27.5W	77°
Pentium-III 933	933MHz	133MHz	0686h	24.5W	77°
Pentium-III 900	900MHz	100MHz	068Ah	26.7W	77°
Pentium-III 900	900MHz	100MHz	0686h	23.2W	77°
Pentium-III 866	866MHz	133MHz	068Ah	26.1W	80°
Pentium-III 866	866MHz	133MHz	0686h	22.9W	80°
Pentium-III 850	850MHz	100MHz	068Ah	25.7W	80°
Pentium-III 850	850MHz	100MHz	0686h	22.5W	80°
Pentium-III 800EB	800MHz	133MHz	068Ah	24.5W	80°
Pentium-III 800EB	800MHz	133MHz	0686h	20.8W	80°
Pentium-III 800	800MHz	100MHz	068Ah	24.5W	80°
Pentium-III 800	800MHz	100MHz	0686h	20.8W	80°
Pentium-III 750	750MHz	100MHz	068Ah	23.2W	80°
Pentium-III 750	750MHz	100MHz	0686h	19.5W	80°
Pentium-III 733	733MHz	133MHz	068Ah	22.8W	80°
Pentium-III 733	733MHz	133MHz	0686h	19.1W	80°
Pentium-III 700	700MHz	100MHz	068Ah	21.9W	80°
Pentium-III 700	700MHz	100MHz	0686h	18.3W	80°
Pentium-III 667	667MHz	133MHz	0686h	17.5W	82°
Pentium-III 650	650MHz	100MHz	0686h	17.0W	82°
Pentium-III 600EB	600MHz	133MHz	0686h	15.8W	82°
Pentium-III 600E	600MHz	100MHz	0686h	15.8W	82°
Pentium-III 550E	550MHz	100MHz	0683h	14.5W	85°
Pentium-III 533EB	533MHz	133MHz	0683h	14.0W	85°
Pentium-III 500E	500MHz	100MHz	0683h	13.2W	85°

A special method to reduce power consumption is to force the processor into the 'Throttle Mode'. This is achieved by actuating the 'Stop Clock' input of the CPU, and can be activated through the BIOS settings. A Throttle Mode of 50% e.g. means a duty cycle of 50% on the stop clock input. However, while saving considerable power consumption, the data throughput of the processor is also reduced. The table below shows the effect of several throttle mode settings on the processor temperature in a given system equipped with the CC5-RAVE. The CPU is a 850MHz Pentium-III processor, the airflow around the CC5 cards slot is about 16m³/h, which is typical for EKF systems. While the testing procedure, the CPU is stressed to its maximum by running kpower.exe.

Ambient Temperature °C Climate Chamber	Throttle Mode (PIII-850) °C							
	0% (100% duty)		25%		50%		87.5%	
	Board	Die	Board	Die	Board	Die	Board	Die
40	52	74	50	68	48	60	42	48
45	59	82	58	75	54	66	50	54
50	64	87	64	82	60	72	55	58
55	71	93	69	86	66	77	61	63
60	76	98	74	91	71	82	65	67
65	81	104	79	96	76	87	71	72
70	87	110	84	102	81	92	76	78
75	92	115	89	107	87	98	80	81
80	97	119	95	112	92	103	85	86
85	1)	1)	100	117	97	108	90	92
90			1)	1)	102	113	95	97
95					108	119	101	102
100					1)	1)	106	107

1) System not operational anymore

From the table on the previous page the maximum allowed die temperature of the PIII-850 can be derived as 80°C. If a small amount of overtemperature would be tolerated, the test system can be operated up to 45°C ambient temperature at 0% throttle mode, and up to 75°C at 87.5% throttle mode. However, the processor under test did remain fully functional up to ~120°C die temperature. Under typical conditions (not executing kpower.exe), the heat dissipation of the CPU would be remarkable lower, thus increasing the maximum ambient temperature of the CC5-RAVE.

The table below shows the effect of several throttle mode settings on the processor temperature in a given system equipped with the CC5-RAVE, now provided with a 566MHz Celeron processor. Again, the airflow around the CC5 cards slot is about 16m³/h, which is typical for EKF systems, and as before, while the testing procedure, the CPU is stressed to its maximum by running kpower.exe.

Ambient Temperature °C Climate Chamber	Throttle Mode (Celeron-566) °C							
	0% (100% duty)		25%		50%		87.5%	
	Board	Die	Board	Die	Board	Die	Board	Die
40	48	66	48	62	46	56	42	43
45	56	74	54	69	51	61	48	49
50	61	80	59	74	57	67	52	53
55	66	85	64	78	62	72	58	59
60	71	90	69	83	67	77	63	64
65	76	97	74	88	72	82	68	69
70	82	104	81	97	77	87	72	74
75	88	109	86	101	82	92	78	80
80	94	117	92	109	87	98	84	85
85	98	121	96	115	93	104	88	90
90	1)	1)	103	121	98	110	94	95
95			1)	1)	103	115	99	99
100					108	121	104	106

1) System not operational anymore

The maximum allowed die temperature of the Celeron-566 can be derived as 90°C. The test system can be operated up to 60°C ambient temperature at 0% throttle mode (which is 100% duty cycle), and up to 85°C at 87.5% throttle mode. However, the processor under test did remain fully functional up to ~120°C die temperature. Under typical conditions (not executing kpower.exe), the heat dissipation of the CPU would be remarkable lower, thus increasing the maximum ambient temperature of the CC5-RAVE.

The measuring results in the table above are based on a forced vertical airflow of 16m³/h around each card slot in a fully equipped 19-inch system rack, achieved by three Papst 4312M fans operated at 12V. Under these conditions, the CC5 heatsink delivers a thermal resistance of about 1K/W.

What can be recommended as an optimum airflow? The table below shows the effect on the maximum allowable ambient temperature of our PIII-850 system at the specified maximum processor die temperature of 80°C. Again, the processor is stressed to its maximum power dissipation by running kpower.exe.

Fan Type Pabst x 3	Vertical Airflow around each Card Slot	Maximum Ambient Temp. @Throttle Mode			
		0%	25%	50%	87.5%
4312GL/6V	4m ³ /h	20°C	35°C	44°C	69°C
4312GL/12V	10m ³ /h	31°C	43°C	55°C	73°C
4312M/12V	16m ³ /h	42°C	48°C	57°C	74°C
4312-179/13.2V	27m ³ /h	43°C	50°C	60°C	75°C

As easily can be seen, increasing the airflow above 16m³/h has no significant effect on the maximum allowable ambient temperature. So ~16m³/h would be the optimum airflow for most industrial systems.

Conclusion

Take care of sufficient heat exchange in your system. If appropriate, setup the Throttle Mode feature. Both Celeron and Pentium-III processors can be reliably operated over a wide temperature range in a suitable environment.