AN1094

Thermally Enhanced Quad Flat Packages

Ruth Waterman- Massey
Motorola, Chandler AZ

Introduction

Within recent years the Quad Flat Package (QFP) has found wide acceptance as a cost effective surface mount in the ASIC and semiconductor industry for pin counts from 64 - 208.

Now with the increasing density and higher performance found in the sub-micron CMOS technologies a thermally enhanced version is needed to support applications with power dissipation needs in excess of the approximately 1 W limit imposed by Plastic QFP's.

Motorola is developing thermally enhanced QFP packages for use with the HDC larger arrays (HDC064 and HDC105) and the new family of sub-micron H4C arrays. A parallel evaluation and development program of two possible solutions is currently being conducted by the ASIC division in Chandler, Arizona.

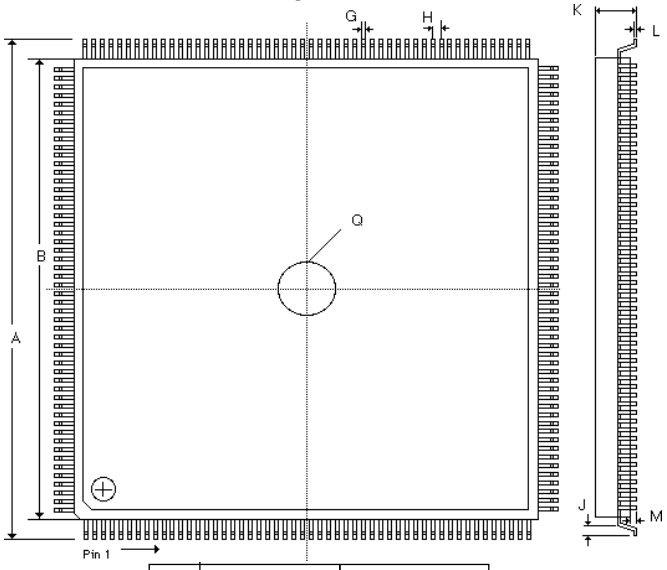
Objective of this note

This application note is written to support customers in designing with these packages during the development, evaluation and qualification stages which will continue through 1992.

Mechanical Dimensions

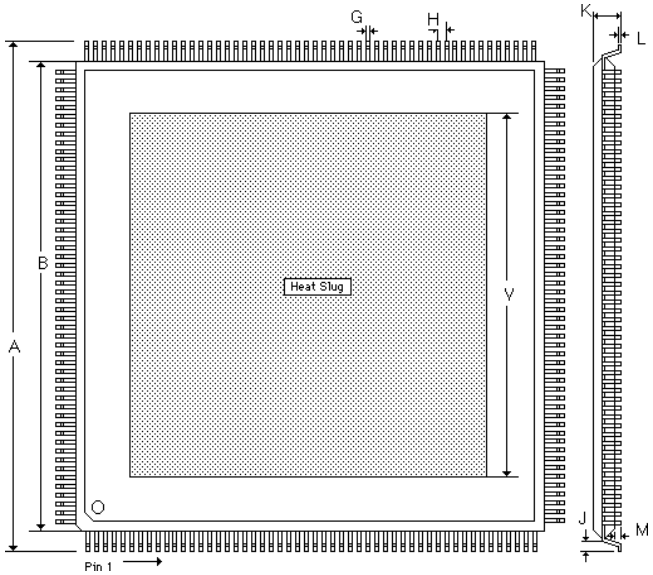
Figure 1 shows the mechanical dimensions for both the 160 pin MQuad and MicroCool packages. Both packages support the same PCB footprint and pinout although as can be seen through close inspection there are other minor dimensional differences which may affect assembly equipment such as pick and place machine settings. Table 1 shows the mechanical differences between these two packages.

MQUAD



Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	31.00	31.40	1.220	1.236
B	27.56	27.72	1.085	1.091
G	0.30 (160X)		0.012 (160X)	
H	0.650 BSC		0.0256 BSC	
J	0.67	0.93	0.026	0.036
K	3.50	4.04	0.136	0.152
L	0.13	0.18	0.005	0.007
M	0.25	0.51	0.010	0.020
Q	3.17		0.125	

MicroCool



Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	31.10	31.37	1.224	1.235
B	27.90	28.10	1.098	1.106
G	0.30 (160X)		0.012 (160X)	
H	0.650 BSC		0.0256 BSC	
J	0.75	0.92	0.030	0.036
K	3.45	3.85	0.136	0.152
L	0.13	0.18	0.005	0.007
M	0.25	0.35	0.010	0.012
V	16.8 SQ		0.661 SQ	

FIGURE 1 Mechanical Dimensions of 160 MQuad & MicroCool Packages

Also the MQuad during the development stage will not be manufactured using the Molded Carrier Ring (MCR) and guaranteed limits will be 6 mils. The MicroCool, however will use the MCR and coplanarity will be 4 mils.

For details on Coplanarity measurement and the MCR please refer to Pages 6-2 in the Packaging Manual for ASIC Arrays. (BR916/D Rev 1)

Table 1: Mquad/MicroCool Mechanical Differences

	MQUAD	MicroCool
Body Size	27.64 +/-.08mm	28 +/-.1 mm
Body Material	Aluminum	Mold Compound with Copper Heatslug
Leadframe	Copper	Copper with PCB
Weight w/o MCR With MCR	5.5g NA	8.5g 13.5g
Coplanarity	6 mils no MCR	4 mils MCR

Thermal Performance

Table 2 shows the thermal resistance comparisons at different power dissipations and cooling conditions. The actual operating conditions of the device contribute to the amount of power that can be dissipated. The relationship is:

$$T_a = T_j + P_d * \Theta_{ja}$$

Example:

In a given environment -

T_a(Ambient Temperature) is 40 C and
T_j (Junction Temperature) is100 C
Θ_{ja}(Thermal Resistance) =15 C/W at 500lfm
Power dissipation (P_d) is 4W.

Table 2: Thermal Resistance Comparison

Package	Power	0 lfm	100 lfm	200 lfm	500 lfm	
208 MQUAD						
	2W	20.9	12.9	11.1	8.9	C/W
	3W	19.9	11.9	10.1	7.9	C/W
208 MicroCool						
	2W	27.6	18.3	16.2	13.7	C/W
	3W	26.7	17.2	15.1	12.6	C/W

Inductance of Packaging

The inductance of a package, which contributes to the inductive loading of the output, affects the performance, noise spikes and ground bounce of a design. This in turn directly impacts the number of power and ground pins required to support the simultaneously switching outputs of the design.

Table 3: Inductance of MQUAD/MicroCool

Package	Max Value (Corner)	Min Value (Center)
208 MQUAD	8.3nH	6.2nH
208 MicroCool	14.4nH	11.0nH

Graph 1 shows noise voltage spikes (in Volts) generated by varying numbers of simultaneously switching 4mA drivers on Motorola's H4C product series.The package inductance assumed in this example is 10nH.

Graph 1

No of Simultaneously Switching Output's

Summary

In summary, the key differences between the two proposed packages for thermally enhanced applications are as follows:

A. Mechanically - The body materials and leadframe constructions are different. The MQuad is also fractionally smaller than the MicroCool. The MicroCool is also heavier than the MQuad. However due to the fact the MicroCool will be made in the MCR and the MQuad without the 4 mils guaranteed coplanarity will only be achievable with the MicroCool.

B. Thermally - The Thermal Resistance of these two packages follow similarly curves with power and air flow but the MQuad shows a better base number.

C. Electrically - The two metal caps of the MQuad package are believed to act like ground planes and greatly reduce the self inductance at the expense of higher package loading capacitance

During the parallel development stage Motorola recommends the use of the specification below in Table 4 using the worst case conditions will insure working silicon whether it is packaged in either the MQuad or MicroCool package. Table 5 shows the plastic QFP specification for comparison and reference purposes.

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Table 4: Recommended Design Specification for TEQFP

Mechanical				
Footprint	Std JEDEC as exhibited by both packages with 1.6 mm footprint			
Body Size	MicroCool- 28 mm Sq pick & place (may need adjustment)			
Weight	MicroCool- 8.5 g without MCR (13.5g with MCR)			
Electrical	MAX	MIN	Values include bonding wire impedances	
Inductance	14.4nH	11.0nH		
Capacitance	2 pF			
Thermal Resistance C/W				
Power	0 lfm	100 lfm	200 lfm	500 lfm
2 W	27.6	18.3	16.3	13.7
3 W	26.7	17.4	15.3	12.8

Table 5: Specification for Plastic QFP provided for Comparison Purposes

Mechanical				
Footprint	Std JEDEC with 1.6 mm footprint			
Body Size	28mm Square			
Weight	5.0 g without MCR (8.9g with MCR)			
Electrical	MAX	MIN	Values include bonding wire impedances	
Inductance	14.4nH	11.0nH		
Capacitance	1pF			
Thermal Resistance C/W				
	0 lfm	100 lfm	200 lfm	500 lfm
	43.3	32.2	29.8	27.6

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