MR16R1624(8/G)EG0
MR18R1624(8/G)EG0

Change History

Version 0.1 (December 2003) - *Preliminary*
** First copy.* ** Based on the 1.0 ver. (July 2002) 256/288Mbit D-die RIMM® Module Datasheet*

Version 1.0 (May 2004)
** Eliminate "Preliminary"*

Exhibit
EX2100

SAMSUNG ELECTRONICS

Version 1.0 May 2004

Netlist EX2002
Samsung v Netlist
IPR2023-00454

MR16R1624(8/G)EG0
MR18R1624(8/G)EG0

(16Mx16)*4(8/16)pcs RIMM® Module based on 256Mb E-die, 32s banks,16K/32ms Ref, 2.5V
(16Mx18)*4(8/16)pcs RIMM® Module based on 288Mb E-die, 32s banks,16K/32ms Ref, 2.5V

Overview

The RIMM® module is a general purpose high- performance memory module suitable for use in a broad range of applications including computer memory, personal computers, workstations and other applications where high bandwidth and low latency are required.

The RIMM module consists of 256/288Mb RDRAM® devices. These are extremely high-speed CMOS DRAMs organized as 16M words by 16 or 18 bits. The use of Rambus Signaling Level (RSL) technology permits up to 1066 MHz transfer rates while using conventional system and board design technologies. RDRAM® devices are capable of sustained data transfers at 0.94 ns per two bytes (7.5ns per 16 bytes).

The RDRAM architecture enables the highest sustained bandwidth for multiple, simultaneous, randomly addressed, memory transactions. The separate control and data buses with independent row and column control yield over 95% bus efficiency. The RDRAM device's 32-bank architecture supports up to four simultaneous transactions per device.

Features

- ♦ High speed up to 1066 MHz RDRAM storage
- ♦ 184 edge connector pads with 1mm pad spacing
- ♦ Module PCB size : 133.35mm x 31.75mm x 1.27mm (5.25" x 1.25" x 0.05") - 256Mb and 288Mb base PC800 RIMM Module
- ♦ Module PCB size : 133.35mm x 34.93mm x 1.27mm (5.25" x 1.375" x 0.05") - 256Mb and 288Mb base PC1066 RIMM Module
- ♦ Each RDRAM device has 32 banks, for a total of 512, 256, 128 banks on each 512/576MB, 256/288MB, 128/144MB module respectively
- ♦ Gold plated edge connector pad contacts
- ♦ Serial Presence Detect(SPD) support
- ♦ Operates from a 2.5 volt supply (±5%)
- ♦ Powerdown self refresh modes
- ♦ Separate Row and Column buses for higher efficiency
- ♦ WBGA lead free package (92/84 balls)

Key Timing Parameters/Part Numbers

The following table lists the frequency and latency bins available for RIMM modules.

Table 1: Part Number by Freq. & Latency

Organization	Speed			Part Number
	Bin	I/O Freq. (MHz)	t_{RAC} (Row Access Time) ns	
64M x 16/18	-CT9	1066	32P	MR16/18R1624EG0-CT9
	-CM8	800	40	MR16/18R1624EG0-CM8
	-CK8	800	45	MR16/18R1624EG0-CK8
128M x 16/18	-CT9	1066	32P	MR16/18R1628EG0-CT9
	-CM8	800	40	MR16/18R1628EG0-CM8
	-CK8	800	45	MR16/18R1628EG0-CK8
256M x 16/18	-CT9	1066	32P	MR16/18R162GEG0-CT9
	-CM8	800	40	MR16/18R162GEG0-CM8
	-CK8	800	45	MR16/18R162GEG0-CK8

Form Factor

The RIMM modules are offered in 184-pad 1mm edge connector pad pitch suitable for 184 contact RIMM connectors. Figure 1 below, shows a sixteen device RIMM module.

Note: On double sided modules, RDRAM devices are also installed on bottom side of PCB.

Figure 1: RIMM Module shown with heat spreader removed

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Table 2: Module Pad Numbers and Signal Names

Pin	Pin Name	Pin	Pin Name
A1	Gnd	B1	Gnd
A2	LDQA8	B2	LDQA7
A3	Gnd	B3	Gnd
A4	LDQA6	B4	LDQA5
A5	Gnd	B5	Gnd
A6	LDQA4	B6	LDQA3
A7	Gnd	B7	Gnd
A8	LDQA2	B8	LDQA1
A9	Gnd	B9	Gnd
A10	LDQA0	B10	LCFM
A11	Gnd	B11	Gnd
A12	LCTMN	B12	LCFMN
A13	Gnd	B13	Gnd
A14	LCTM	B14	NC
A15	Gnd	B15	Gnd
A16	NC	B16	LROW2
A17	Gnd	B17	Gnd
A18	LROW1	B18	LROW0
A19	Gnd	B19	Gnd
A20	LCOL4	B20	LCOL3
A21	Gnd	B21	Gnd
A22	LCOL2	B22	LCOL1
A23	Gnd	B23	Gnd
A24	LCOL0	B24	LDQB0
A25	Gnd	B25	Gnd
A26	LDQB1	B26	LDQB2
A27	Gnd	B27	Gnd
A28	LDQB3	B28	LDQB4
A29	Gnd	B29	Gnd
A30	LDQB5	B30	LDQB6
A31	Gnd	B31	Gnd
A32	LDQB7	B32	LDQB8
A33	Gnd	B33	Gnd
A34	LSCK	B34	LCMD
A35	Vcmos	B35	Vcmos
A36	SOUT	B36	SIN
A37	Vcmos	B37	Vcmos
A38	NC	B38	NC
A39	Gnd	B39	Gnd
A40	NC	B40	NC
A41	Vdd	B41	Vdd
A42	Vdd	B42	Vdd
A43	NC	B43	NC
A44	NC	B44	NC
A45	NC	B45	NC
A46	NC	B46	NC

Pin	Pin Name	Pin	Pin Name
A47	NC	B47	NC
A48	NC	B48	NC
A49	NC	B49	NC
A50	NC	B50	NC
A51	Vref	B51	Vref
A52	Gnd	B52	Gnd
A53	SCL	B53	SA0
A54	Vdd	B54	Vdd
A55	SDA	B55	SA1
A56	SVdd	B56	SVdd
A57	SWP	B57	SA2
A58	Vdd	B58	Vdd
A59	RSCK	B59	RCMD
A60	Gnd	B60	Gnd
A61	RDQB7	B61	RDQB8
A62	Gnd	B62	Gnd
A63	RDQB5	B63	RDQB6
A64	Gnd	B64	Gnd
A65	RDQB3	B65	RDQB4
A66	Gnd	B66	Gnd
A67	RDQB1	B67	RDQB2
A68	Gnd	B68	Gnd
A69	RCOL0	B69	RDQB0
A70	Gnd	B70	Gnd
A71	RCOL2	B71	RCOL1
A72	Gnd	B72	Gnd
A73	RCOL4	B73	RCOL3
A74	Gnd	B74	Gnd
A75	RROW1	B75	RROW0
A76	Gnd	B76	Gnd
A77	NC	B77	RROW2
A78	Gnd	B78	Gnd
A79	RCTM	B79	NC
A80	Gnd	B80	Gnd
A81	RCTMN	B81	RCFMN
A82	Gnd	B82	Gnd
A83	RDQA0	B83	RCFM
A84	Gnd	B84	Gnd
A85	RDQA2	B85	RDQA1
A86	Gnd	B86	Gnd
A87	RDQA4	B87	RDQA3
A88	Gnd	B88	Gnd
A89	RDQA6	B89	RDQA5
A90	Gnd	B90	Gnd
A91	RDQA8	B91	RDQA7
A92	Gnd	B92	Gnd

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Table 3: Module Connector Pad Description

Signal	Pins	I/O	Type	Description
Gnd	A1, A3, A5, A7, A9, A11, A13, A15, A17, A19, A21, A23, A25, A27, A29, A31, A33, A39, A52, A60, A62, A64, A66, A68, A70, A72, A74, A76, A78, A80, A82, A84, A86, A88, A90, A92, B1, B3, B5, B7, B9, B11, B13, B15, B17, B19, B21, B23, B25, B27, B29, B31, B33, B39, B52, B60, B62, B64, B66, B68, B70, B72, B74, B76, B78, B80, B82, B84, B86, B88, B90, B92			Ground reference for RDRAM core and interface. 72 PCB connector pads.
LCFM	B10	**I**	**RSL**	Clock from master. Interface clock used for receiving RSL signals from the Channel. Positive polarity.
LCFMN	B12	**I**	**RSL**	Clock from master. Interface clock used for receiving RSL signals from the Channel. Negative polarity.
LCMD	B34	**I**	V_{CMOS}	Serial Command used to read from and write to the control registers. Also used for power management.
LCOL4.. LCOL0	A20, B20, A22, B22, A24	**I**	**RSL**	Column bus. 5-bit bus containing control and address information for column accesses.
LCTM	A14	**I**	**RSL**	Clock to master. Interface clock used for transmitting RSL signals to the Channel. Positive polarity.
LCTMN	A12	**I**	**RSL**	Clock to master. Interface clock used for transmitting RSL signals to the Channel. Negative polarity.
LDQA8.. LDQA0	A2, B2, A4, B4, A6, B6, A8, B8, A10	**I/O**	**RSL**	Data bus A. A 9-bit bus carrying a byte of read or write data between the Channel and the RDRAM device. LDQA8 is non-functional on modules with x16 RDRAM devices
LDQB8.. LDQB0	B32, A32, B30, A30, B28, A28, B26, A26, B24	**I/O**	**RSL**	Data bus B. A 9-bit bus carrying a byte of read or write data between the Channel and the RDRAM device. LDQB8 is non-functional on modules with x16 RDRAM devices.
LROW2.. LROW0	B16, A18, B18	**I**	**RSL**	Row bus. 3-bit bus containing control and address information for row accesses.
LSCK	A34	**I**	V_{CMOS}	Serial Clock input. Clock source used to read from and write to the RDRAM control registers.
NC	A16, B14, A38, B38, A40, B40, A43, B43, A44, B44, A45, B45, A46, B46, A47, B47, A48, B48, A49, B49, A50, B50, A77, B79			These pads are not connected. These 24 connector pads are reserved for future use.
RCFM	B83	**I**	**RSL**	Clock from master. Interface clock used for receiving RSL signals from the Channel. Positive polarity.
RCFMN	B81	**I**	**RSL**	Clock from master. Interface clock used for receiving RSL signals from the Channel. Negative polarity.
RCMD	B59	**I**	V_{CMOS}	Serial Command Input. Pin used to read from and write to the control registers. Also used for power management.

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Signal	Pins	I/O	Type	Description
RCOL4.. RCOL0	A73, B73, A71, B71, A69	**I**	**RSL**	Column bus. 5-bit bus containing control and address information for column accesses.
RCTM	A79	**I**	**RSL**	Clock to master. Interface clock used for transmitting RSL signals to the Channel. Positive polarity.
RCTMN	A81	**I**	**RSL**	Clock to master. Interface clock used for transmitting RSL signals to the Channel. Negative polarity.
RDQA8.. RDQA0	A91, B91, A89, B89, A87, B87, A85, B85, A83	**I/O**	**RSL**	Data bus A. A 9-bit bus carrying a byte of read or write data between the Channel and the RDRAM device. RDQA8 is non-functional on modules x16 RDRAM devices.
RDQB8.. RDQB0	B61, A61, B63, A63, B65, A65, B67, A67, B69	**I/O**	**RSL**	Data bus B. A 9-bit bus carrying a byte of read or write data between the Channel and the RDRAM device. RDQB8 is non-functional on modules x16 RDRAM devices.
RROW2.. RROW0	B77, A75, B75	**I**	**RSL**	Row bus. 3-bit bus containing control and address information for row accesses.
RSCK	A59	**I**	V_{CMOS}	Serial Clock input. Clock source used to read from and write to the RDRAM control registers.
SA0	B53	**I**	SV_{DD}	Serial Presence Detect Address 0.
SA1	B55	**I**	SV_{DD}	Serial Presence Detect Address 1.
SA2	B57	**I**	SV_{DD}	Serial Presence Detect Address 2.
SCL	A53	**I**	SV_{DD}	Serial Presence Detect Clock.
SDA	A55	**I/O**	SV_{DD}	Serial Presence Detect Data (Open Collector I/O).
SIN	B36	**I/O**	V_{CMOS}	Serial I/O for reading from and writing to the control registers. Attaches to SIO0 of the first RDRAM device on the module.
SOUT	A36	**I/O**	V_{CMOS}	Serial I/O for reading from and writing to the control registers. Attaches to SIO1 of the last RDRAM device on the module.
SV_{DD}	A56, B56			SPD Voltage. Used for signals SCL, SDA, SWE, SA0, SA1 and SA2.
SWP	A57	**I**	SV_{DD}	Serial Presence Detect Write Protect (active high). When low, the SPD can be written as well as read.
V_{CMOS}	A35, B35, A37, B37			CMOS I/O Voltage. Used for signals CMD, SCK, SIN, SOUT.
Vdd	A41, A42, A54, A58, B41, B42, B54, B58			Supply voltage for the RDRAM core and interface logic.
Vref	A51, B51			Logic threshold reference voltage for RSL signals.

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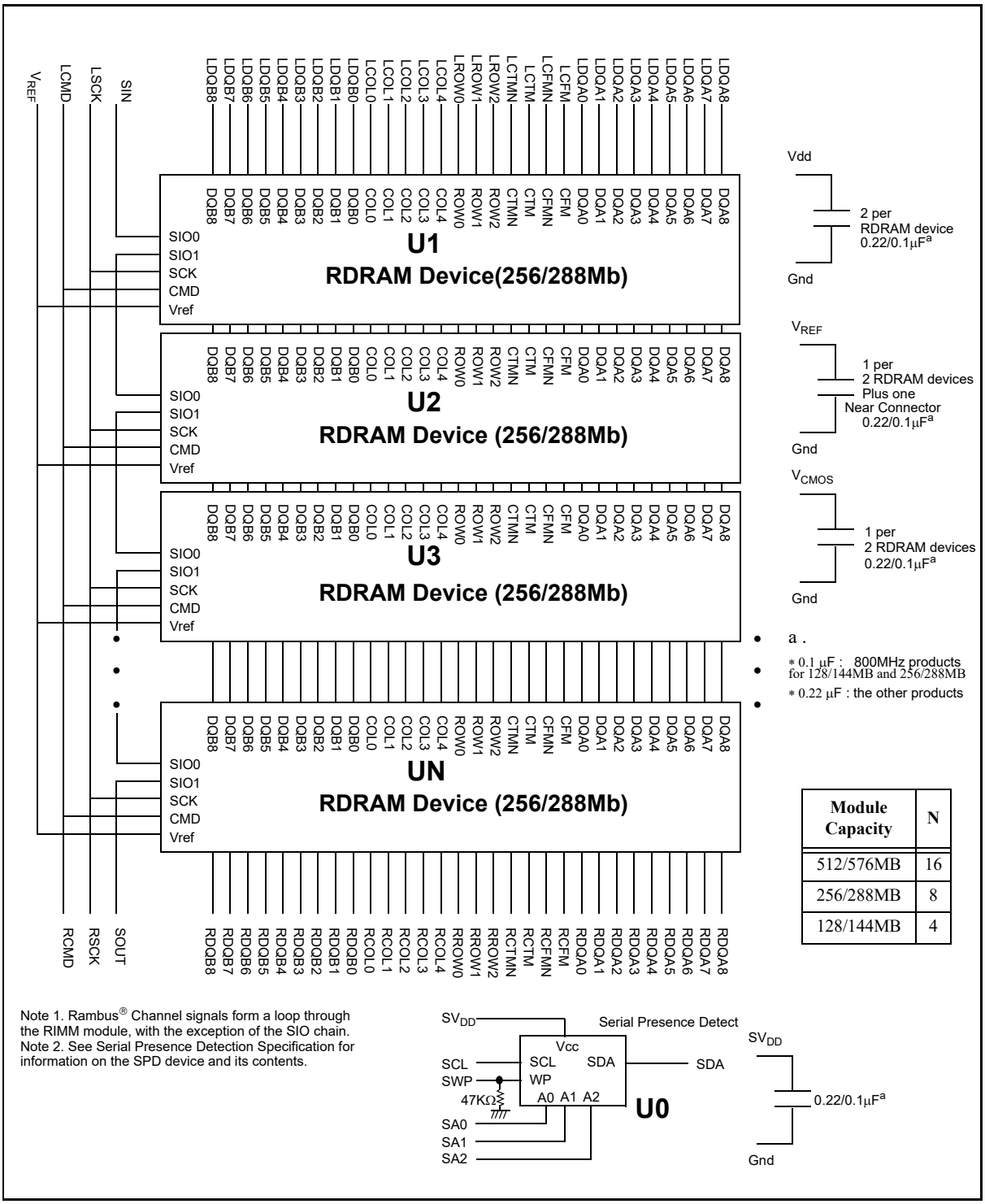

Module Capacity	N
512/576MB	16
256/288MB	8
128/144MB	4

Note 1. Rambus® Channel signals form a loop through the RIMM module, with the exception of the SIO chain.
Note 2. See Serial Presence Detection Specification for information on the SPD device and its contents.

Figure 2: RIMM Module Functional Diagram

Absolute Maximum Ratings

Table 4: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
$V_{I,ABS}$	Voltage applied to any RSL or CMOS signal pad with respect to Gnd	- 0.3	V_{DD} + 0.3	V
$V_{DD,ABS}$	Voltage on VDD with respect to Gnd	- 0.5	V_{DD} + 1.0	V
T_{STORE}	Storage temperature	- 50	100	°C
T_{PLATE}	Plate temperature	-	92	°C

DC Recommended Electrical Conditions

Table 5: DC Recommended Electrical Conditions

Symbol	Parameter and Conditions	Min	Max	Unit
V_{DD}	Supply voltage	2.50 - 0.13	2.50 + 0.13	V
V_{CMOS}	CMOS I/O power supply at pad for 2.5V controllers: CMOS I/O power supply at pad for 1.8V controllers:	V_{DD} 1.8 - 0.1	V_{DD} 1.8 + 0.2	V V
V_{REF}	Reference voltage	1.4 - 0.2	1.4 + 0.2	V
V_{SPD}	Serial Presence Detector- Positive power supply	2.2	3.6	V

Table 6: RIMM Module Capacity and Number of RDRAM device

RIMM Module Capacity:	512/576MB	256/288MB	128/144MB
Number of 256/288Mb RDRAM devices	16	8	4

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RIMM Module Current Profile

Table 7: RIMM Module Current Profile

I_{DD}	RIMM Module Capacity		512/576MB	256/288MB	128/144MB	Unit
	Number of 256/288Mb RDRAM devices		16	8	4	
	RIMM Module power conditions [a]	Freq	Max	Max	Max	
I_{DD1}	One RDRAM device in Read[b], balance in NAP mode	-1066	760/810[c]	728/778	712/762	mA
		-800	620/660	588/628	572/612	
I_{DD2}	One RDRAM device in Read[b], balance in Standby mode	-1066	2275/2325	1435/1485	1015/1065	mA
		-800	1985/2025	1225/1265	845/885	
I_{DD3}	One RDRAM device in Read[b], balance in Active mode	-1066	3100/3150	1820/1870	1180/1230	mA
		-800	2585/2625	1505/1545	965/1005	
I_{DD4}	One RDRAM device in Write, balance in NAP mode	-1066	750/800	718/768	702/752	mA
		-800	605/640	573/608	557/592	
I_{DD5}	One RDRAM device in Write, balance in Standby mode	-1066	2265/2315	1425/1475	1005/1055	mA
		-800	1970/2005	1210/1245	830/865	
I_{DD6}	One RDRAM device in Write, balance in Active mode	-1066	3090/3140	1810/1860	1170/1220	mA
		-800	2570/2605	1490/1525	950/985	

a. Actual power will depend on memory controller and usage patterns. Power does not include Refresh Current.
b. I/O current is a function of the % of 1's, to add I/O power for 50% 1's for a X16 need to add 257mA or 290mA for X18 ECC module for the following: V_{DD} = 2.5V, V_{TERM} = 1.8V, V_{REF} = 1.4V and V_{DIL} = V_{REF} - 0.5V.
c. Current values represent X16(Non-Ecc) / X18(Ecc)

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AC Electrical Specifications

Table 8: AC Electrical Specifications

Symbol	Parameter and Conditions	Min	Typ	Max	Unit
Z_L	Module Impedance of RSL Signals	25.2	28	30.8	Ω
$Z_{UL\text{-}CMOS}$	Module Impedance of SCK and CMOS signals	23.8	28	32.2	Ω
T_{PD}	Propagation Delay variation of RSL signals. Average clock delay from finger to finger of all RSL clock nets (CTM, CTMN, CFM, and CFMN)	-		See Table10[a,b]	ns
ΔT_{PD}	Propagation delay variation of RSL signals with respect to T_{PD} [b,c] for 4 and 8 device modules	-21		21	ps
	Propagation delay variation of RSL signals with respect to T_{PD} [b,c] for 16 device modules	-24		24	ps
$\Delta T_{PD\text{-}CMOS}$	Propagation delay variation of SCK signals with respect to an average clock delay	-250		250	ps
$\Delta T_{PD\text{-}SCK,CMD}$	Propagation delay variation of CMD signals with respect to SCK signal	-200		200	ps
V_α/V_{IN}	Attenuation Limit			See Table10[a]	%
V_{XF}/V_{IN}	Forward crosstalk coefficient (300ps input rise time @ 20%-80%)			See Table10[a]	%
V_{XB}/V_{IN}	Backward crosstalk coefficient (300ps input rise time @ 20%-80%)			See Table10[a]	%

a. Table 10 lists parameters and specifications for different storage capacity RIMM Modules that use 256Mb or 288Mb RDRAM devices.
b. T_{PD} or Average clock delay is defined as the delay from finger to finger of RSL signal.
c. If the RIMM module meets the following specification, then it is compliant to the specification. If the RIMM module does not meet these specifica tions, then the specification can be adjusted by the "Adjusted ΔT_{PD} Specification" table 9 below.

Adjusted ΔT_{PD} Specification

Table 9: Adjusted ΔT_{PD} Specification

Symbol	Parameter and Conditions	Adjusted Min/Max	Absolute Min / Max		Unit
ΔT_{PD}	Propagation delay variation of RSL signals with respect to T_{PD} for 4 and 8 device modules	+/-[20+(18*N*ΔZ0)][a]	-30	30	ps
	Propagation delay variation of RSL signals with respect to T_{PD} for 16 device modules	+/-[24+(18*N*ΔZ0)][a]	-50	50	ps

a. Where: N = Number of RDRAM devices installed on the RIMM module
ΔZ0 = delta Z0% = (max Z0 - min Z0)/(min Z0)
(max Z0 and min Z0 are obtained from the loaded (high impedance) impedance coupons of all RSL layers on the modules)

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AC Electrical Specifications for RIMM Modules

Table 10: AC Electrical Specifications for RIMM Modules

Symbol	RIMM Module Capacity		512/576MB	256/288MB	128/144MB	Unit
	Number of 256/288Mb RDRAM devices		16	8	4	
	Parameter and Condition for RIMM Modules	Freq.	Max	Max	Max	
T_{PD}	Propagation Delay, all RSL signals	-1066	2.11	1.56	1.56	ns
		-800	2.11	1.56	1.56	
V_{α}/V_{IN}	Attenuation Limit	-1066	27.0	17.0	17.0	%
		-800	25.0	16.0	16.0	
V_{XF}/V_{IN}	Forward crosstalk coefficient (300ps input rise time @ 20%-80%)	-1066	8.0	4.0	4.0	%
		-800	8.0	4.0	4.0	
V_{XB}/V_{IN}	Backward crosstalk coefficient (300ps input rise time @ 20%-80%)	-1066	2.5	2.0	2.0	%
		-800	2.5	2.0	2.0	
R_{DC}	DC Resistance Limit	-1066	1.2	0.8	0.6	Ω
		-800	1.2	0.8	0.6	

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Physical Dimensions -1 *(For PCB)*

The following defines the RIMM module dimensions. All units are in millimeters with inches in brackets[ ], where appropriate. The dimensions without tolerance specification use the default tolerance of ±0.127[±0.005].

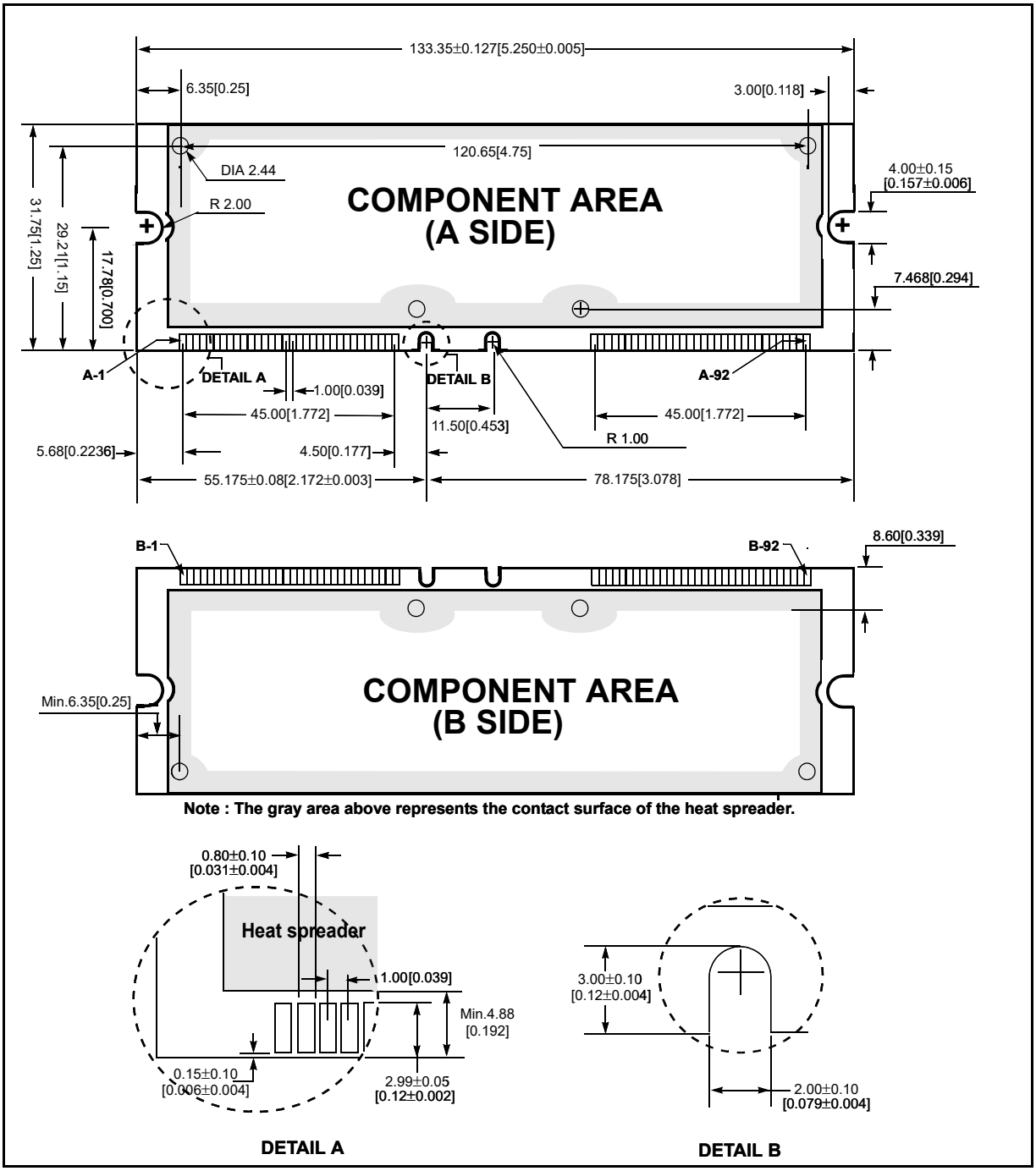

Figure 3: 256Mb/288Mb base RIMM Module PCB Physical Dimensions

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Physical Dimensions -2 *(For PCB)*

The following defines the RIMM module dimensions. All units are in millimeters with inches in brackets[ ], where appropriate. The dimensions without tolerance specification use the default tolerance of ±0.127[±0.005].

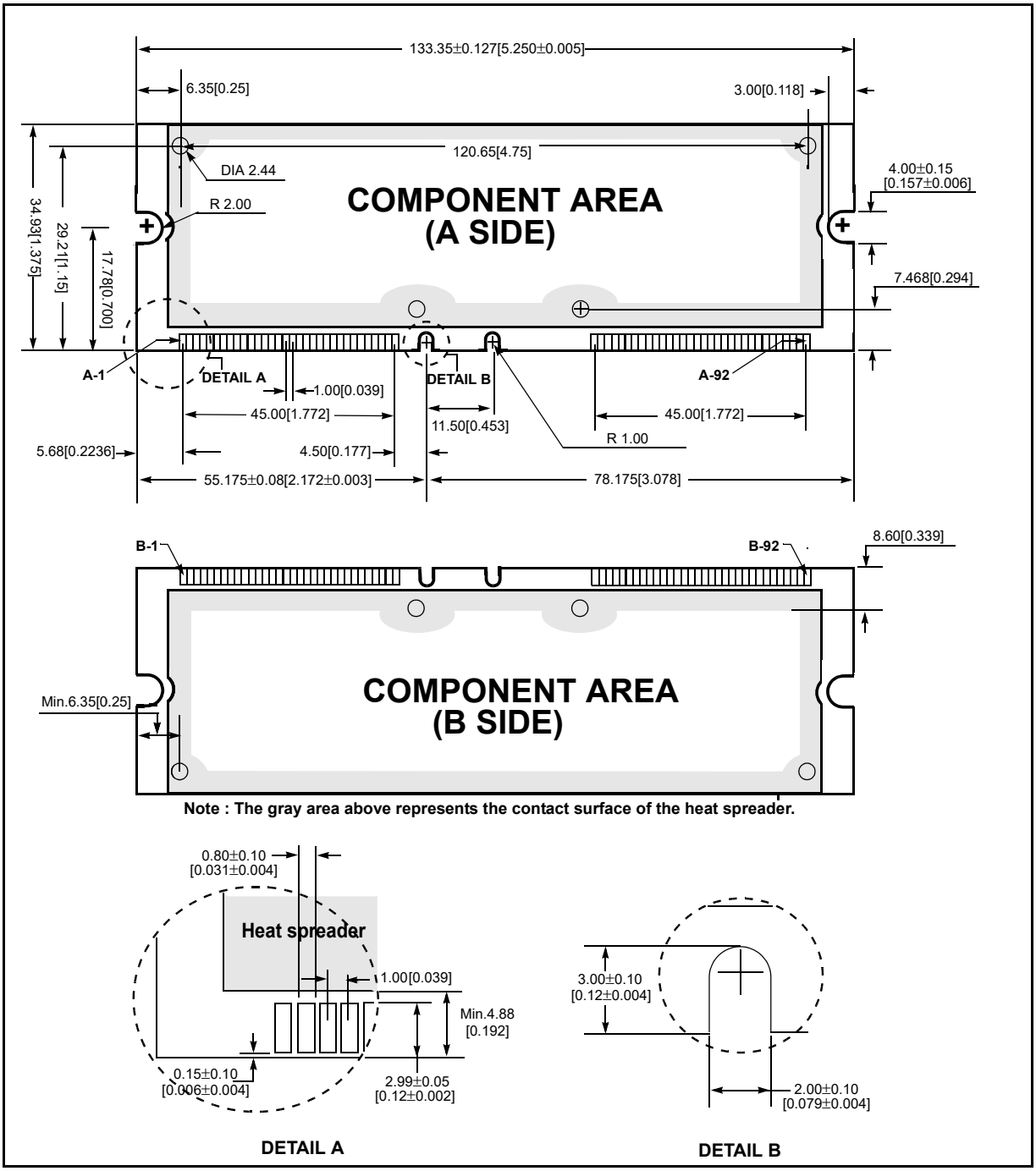

Figure 4: 256Mb/288Mb base RIMM Module PCB Physical Dimensions

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Physical Dimensions -3 *(For Heat Spreader)*

The following defines the RIMM module dimensions. All units are in millimeters with inches in brackets[ ], where appropriate.
The dimensions without tolerance specification use the default tolerance of ±0.127[±0.005].

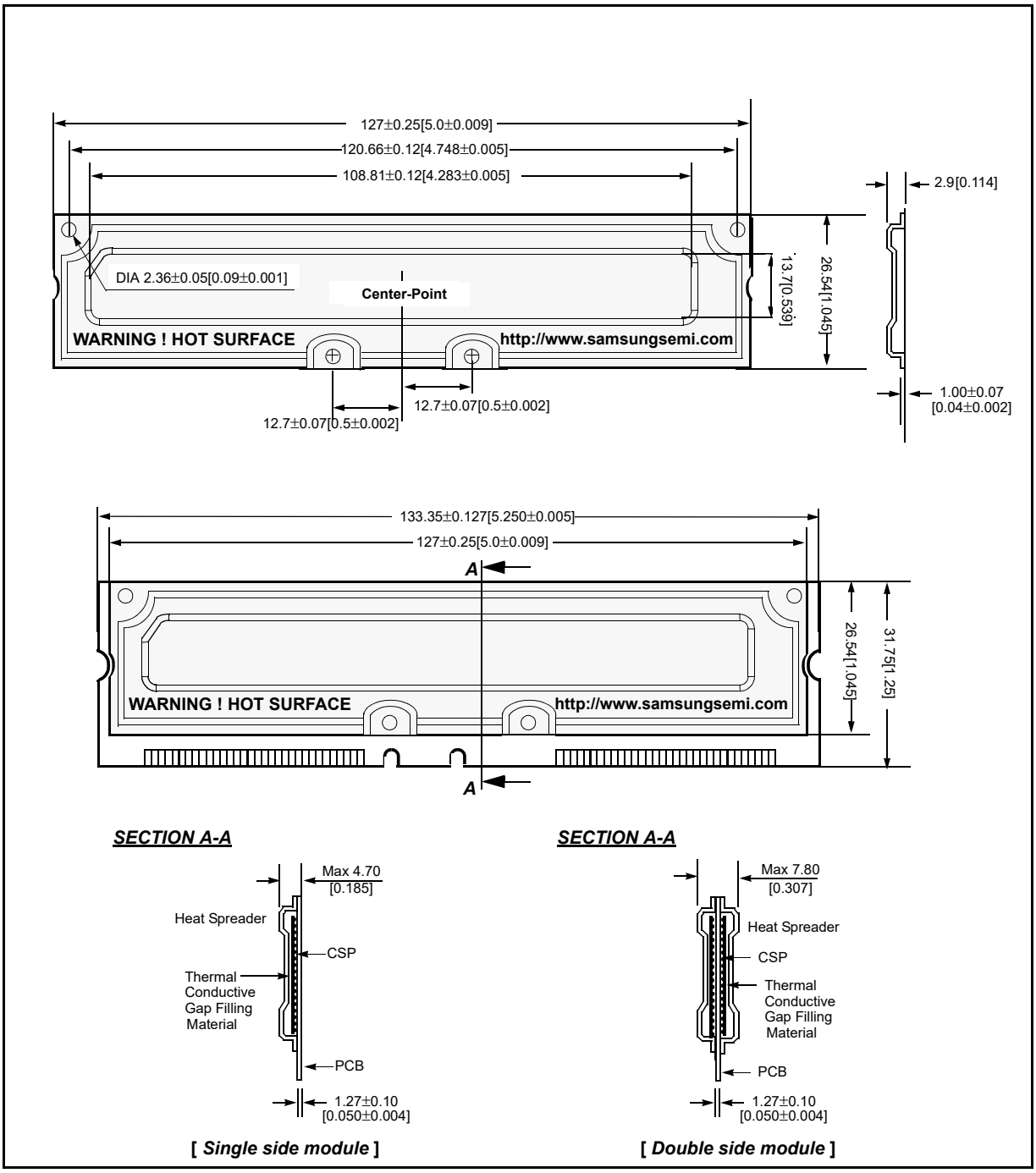

Figure 5: Heat Spreader Physical Dimensions

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Physical Dimensions -4 *(For Heat Spreader)*

The following defines the RIMM module dimensions. All units are in millimeters with inches in brackets[ ], where appropriate.
The dimensions without tolerance specification use the default tolerance of ±0.127[±0.005].

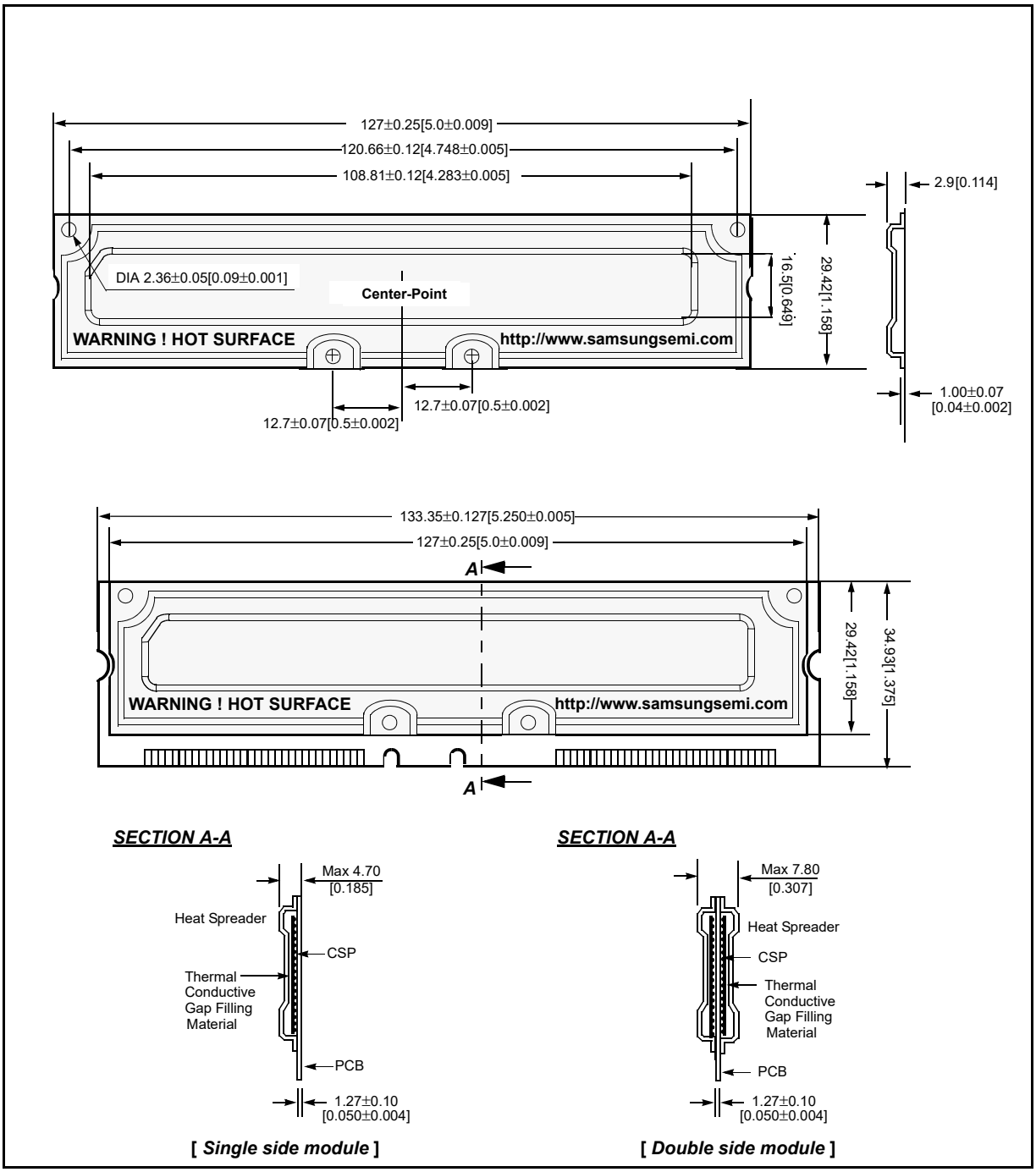

Figure 6: Heat Spreader Physical Dimensions

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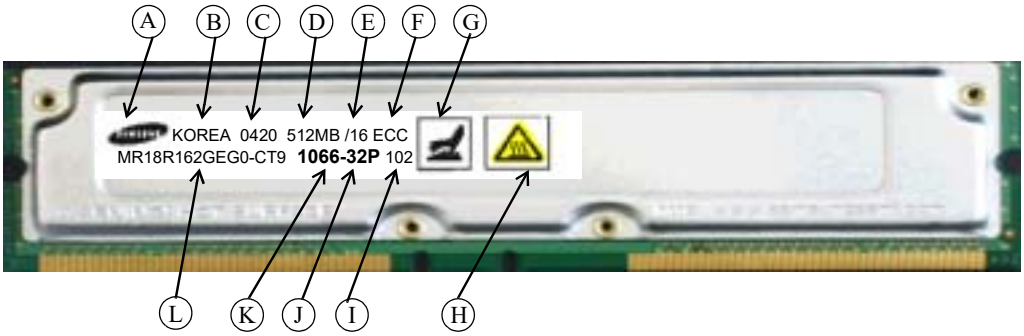
Standard RIMM Module Marking

The RIMM modules available from Samsung are marked like Figure 7 below. This marking also assists users to specify and verify if the correct RIMM modules are installed in their systems. In the diagram, a label is shown attached to the RIMM module's heat spreader. Information contained on the label is specific to the RIMM module and provides RDRAM device information without requiring removal of the RIMM module's heat spreader.



	Label Field	Description	Marked Text	Unit
A	Vendor Logo	RIMM Module Vendor SAMSUNG Logo Area	SAMSUNG	-
B	Country	Country of origin	KOREA	-
C	Year & Week code	Manufactured Year & Week code	yyww	-
D	Module Memory Capacity	Number of 8-bit or 9-bit MBytes of RDRAM storage in RIMM module	128MB, 256MB, 512MB	-
E	Number of RDRAM devices	Number of RDRAM devices contained in the RIMM module	4/8/16	RDRAM devices
F	ECC Support	Indicates whether the RIMM module supports 8 (non ECC) or 9 (ECC) bit Bytes	blank = 8 bit Bytes ECC = 9 bit Bytes	-
G	Notice!	Hot surface caution notice.	-	-
H	Caution Logo	ISO Standard	-	-
I	Gerber & SPD Version	PCB Gerber file & SPD code version used on RIMM Module	Gerber : 10 = 1.0 ver. 01 = 0.1 ver. SPD : 2 = 1.3 ver.	-
J	tRAC	Row Access Time	-32P, -40, -45	ns
K	Memory Speed	Data transfer speed for RDRAM devices	1066, 800	MHz
L	Part No.	SAMSUNG RIMM Module part No.	See Table 1	-

Figure 7: RIMM Module Marking Example

Netlist EX2002-p. 14
Samsung v Netlist
IPR2023-00454

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