CAMM2连接器标准与技术挑战

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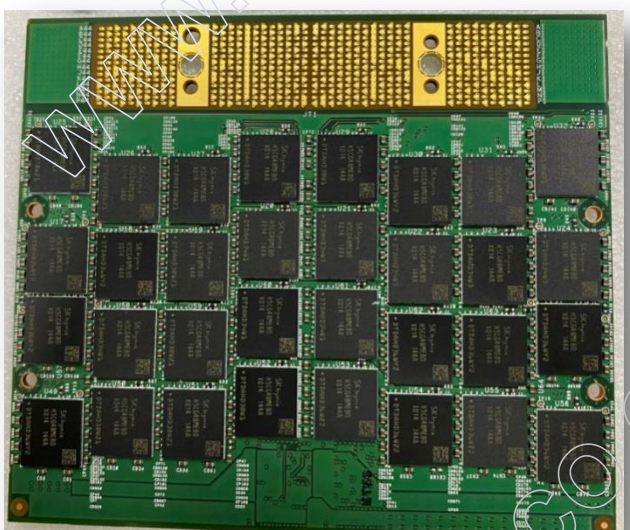
CAMM的由来

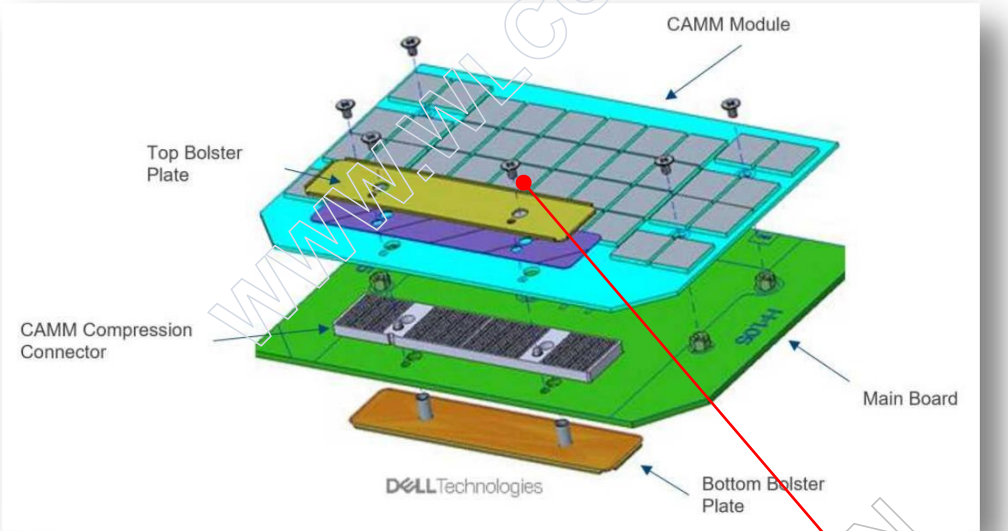
2022年4月，戴尔发布 Precision 7770 移动工作站，搭载 12 代酷睿 55W 处理器和 RTX A5500 显卡。此外，这款移动工作站**首发了戴尔 CAMM 笔记本 DDR5 内存**。



CAMM 内存模组（Compression Attached Memory Module）

https://www.ithome.com/0/615/543.htm

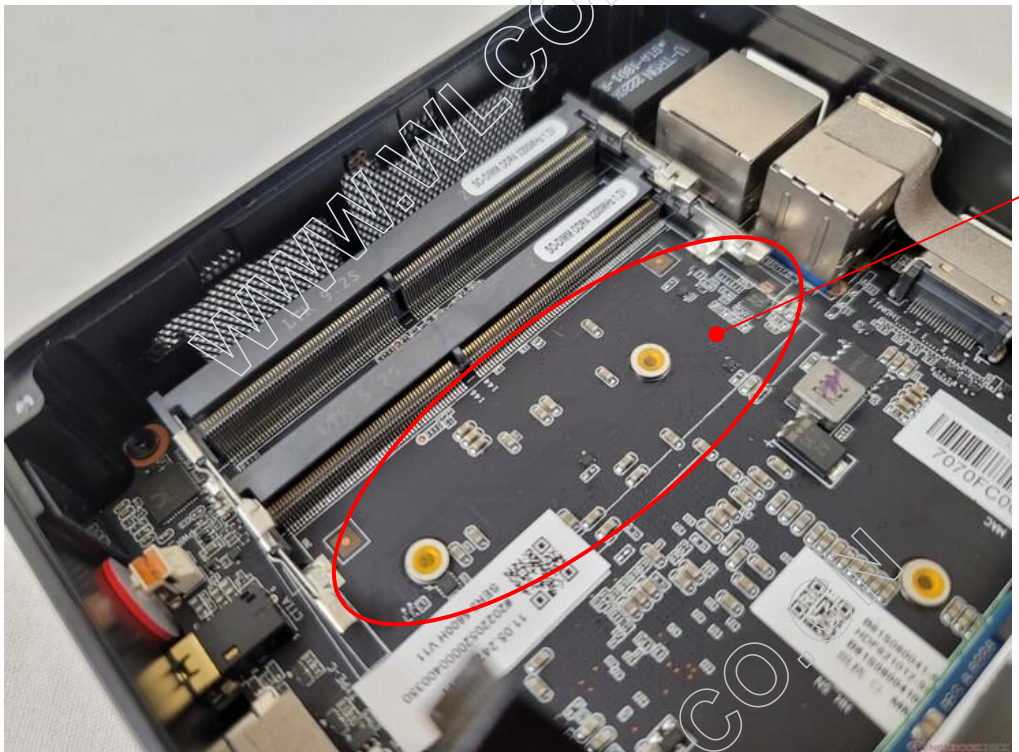
CAMM连接器结构



内存模块通过螺丝，直接锁紧在主板上。

https://www.pcworld.com/article/693366/dell-defends-its-controversial-new-laptop-memory.html
https://www.notebookcheck.net/CAMM-memory-preview-The-Dell-SODIMM-revolution.658666.0.html

传统SODIMM的缺点



1. SODIMM 在PCB主板上的布线，占用了太多PCB主板的空间。

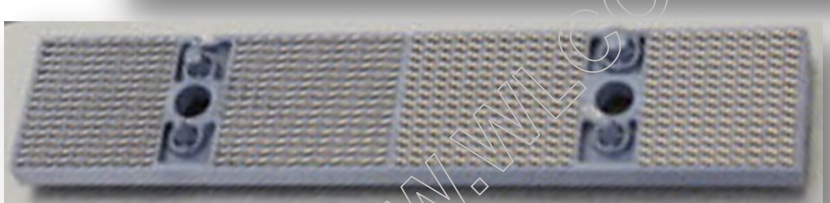
2. 另外，有20多年的SODIMM标准，连接器的物理结构决定传输速度已经很难突破6400 MT/s。

https://www.notebookcheck.net/CAMM-memory-preview-The-Dell-SODIMM-revolution.658666.0.html

CAMM与SODIMM外形的比较

SODIMM 内存模组
4*32G

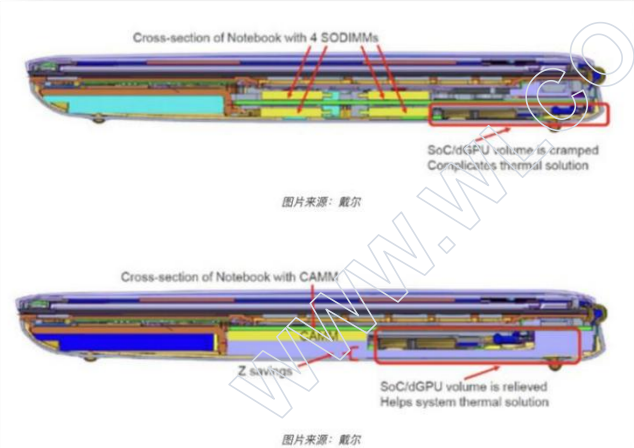
CAMM 内存模组
128G

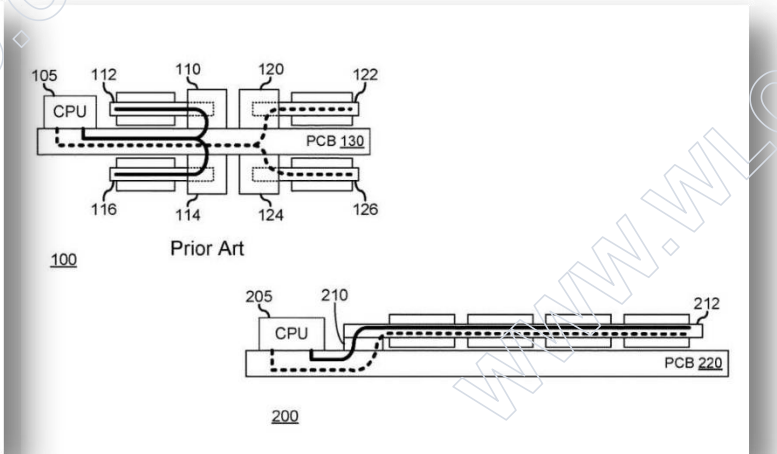


CAMM CONNECTOR

SODIMM CONNECTOR

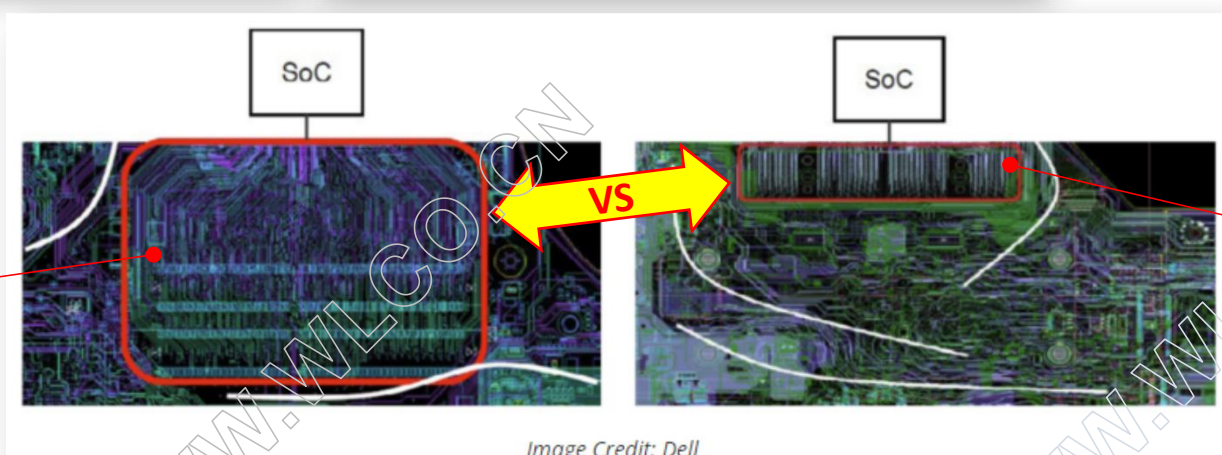
CAMM的优点





- 内存与CPU之间的走线简单---内存性能提升；
- 腾出更多的走线空间---空间可用于优化其他元件，整体提升；
- CAMM 连接器成本的增加，却带来主板成本的降低。

SODIMM 在主板上的走线布局

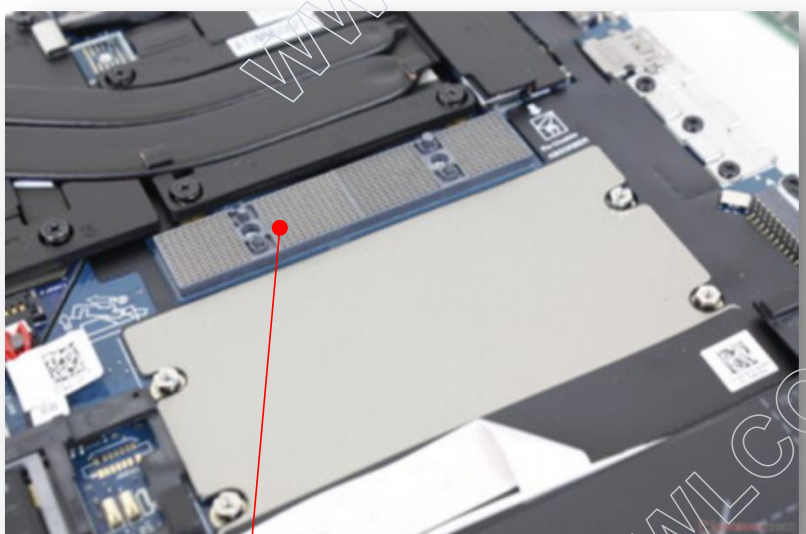


CAMM 在主板上的走线布局

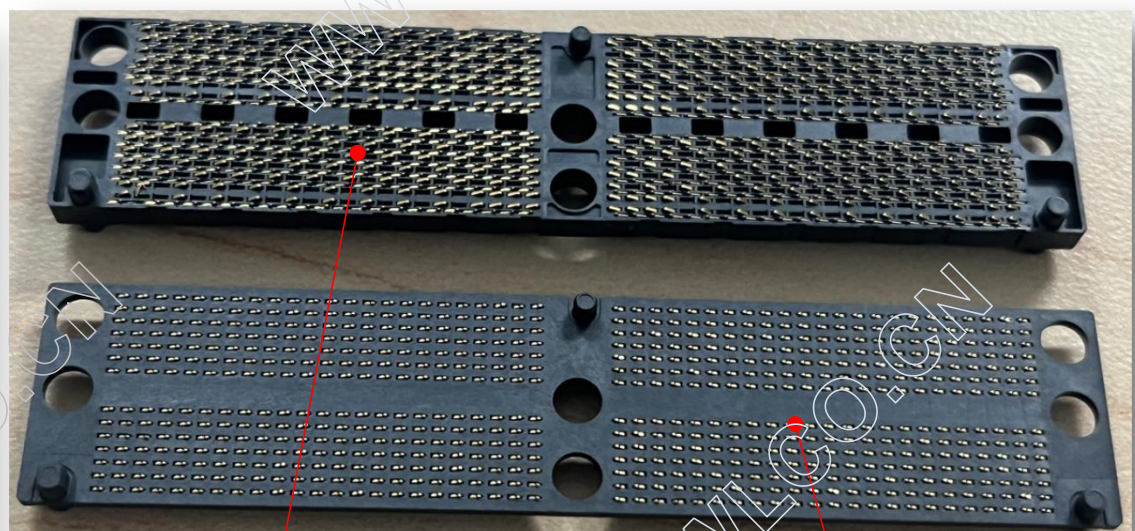
https://www.pcworld.com/article/693366/dell-defends-its-controversial-new-laptop-memory.html
https://www.storagereview.com/review/dell-camm-dram-the-new-laptop-standard

CAMM2 CONNECTOR 的由来

- 2022年9月，DELL把CAMM技术推向JEDEC协会，希望籍此借助JEDEC协会把CAMM推广成行业标准，以扩大应用生态链、降低制造成本。
- 为与DELL的CAMM区分，JEDEC把名称CAMM更改为CAMM2。
- CAMM2 连接器又分支持 DDR5 和 LPDDR5两种。



CAMM CONNECTOR

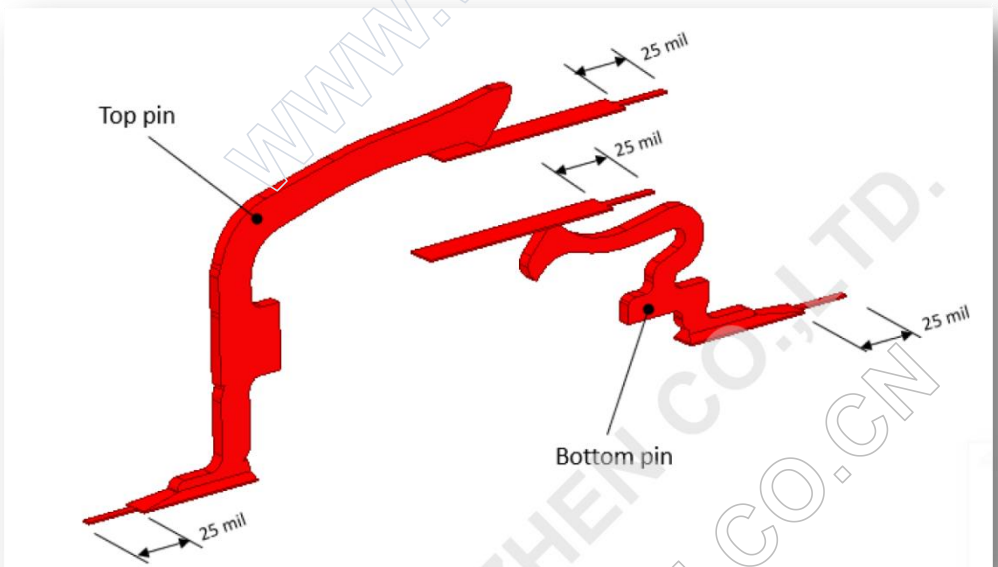


DDR5 CAMM2 CONNECTOR

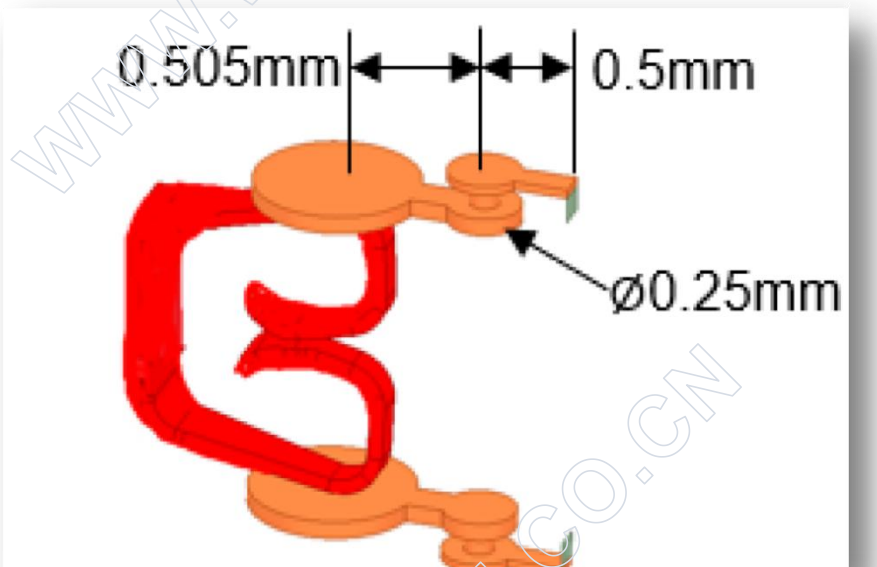
LPDDR5 CAMM2 CONNECTOR

CAMM2 VS SDDIMM CONNECTOR SI

传统SODIMM 连接器端子分上层端子、下层端子。由于上层端子比较大、长，其SI性能比下层端子差，SI标准也是单独分开定义的。



SODIMM 上下端子结构不一样

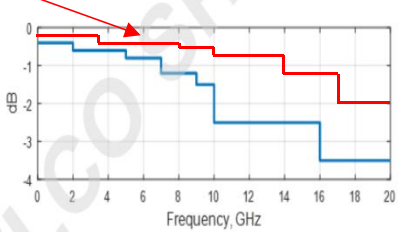


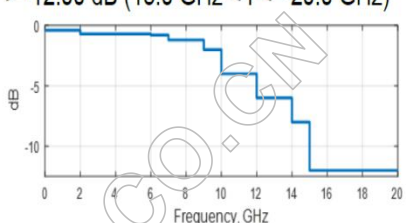
CAMM2连接器端子结构都一样。

CAMM2 VS SODIMM CONNECTOR SI ---IL

S-Parameter	Target Value (top pin)	Target Value (bottom pin)
Insertion Loss **Note:** Signals with 1:1 S/G	> -0.40 dB (f <= 2.0 GHz) > -0.60 dB (2.0 GHz < f <= 5.0 GHz) > -0.80 dB (5.0 GHz < f <= 7.0 GHz) > -1.20 dB (7.0 GHz < f <= 9.0 GHz) > -1.50 dB (9.0 GHz < f <= 10.0 GHz) > -2.50 dB (10.0 GHz < f <= 16.0 GHz) > -3.50 dB (16.0 GHz < f <= 20.0 GHz)	> -0.40 dB (f <= 2.0 GHz) > -0.70 dB (2.0 GHz < f <= 6.0 GHz) > -0.80 dB (6.0 GHz < f <= 7.0 GHz) > -1.20 dB (7.0 GHz < f <= 9.0 GHz) > -2.0 dB (9.0 GHz < f <= 10.0 GHz) > -4.00 dB (10.0 GHz < f <= 12.0 GHz) > -6.00 dB (12.0 GHz < f <= 14.0 GHz) > -8.00 dB (14.0 GHz < f <= 15.0 GHz) > -12.00 dB (15.0 GHz < f <= 20.0 GHz)

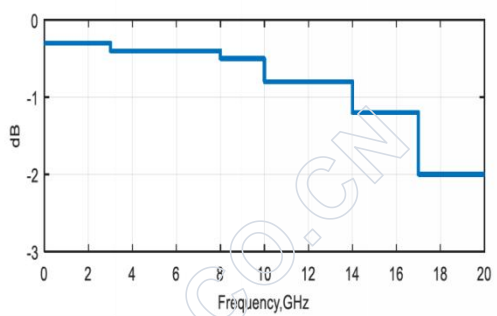
CAMM2 IL





SODDR5 IL

S-Parameter	Target Value
Insertion Loss (IL) **Note:** • Measure from both the baseboard side and module side	> -0.30 dB (f <= 3.0 GHz) > -0.40 dB (3.0 GHz < f <= 8.0 GHz) > -0.50 dB (8.0 GHz < f <= 10.0 GHz) > -0.80 dB (10.0 GHz < f <= 14.0 GHz) > -1.20dB (14.0 GHz < f <= 17.0 GHz) > -2.00 dB (17.0 GHz < f <= 20.0 GHz)

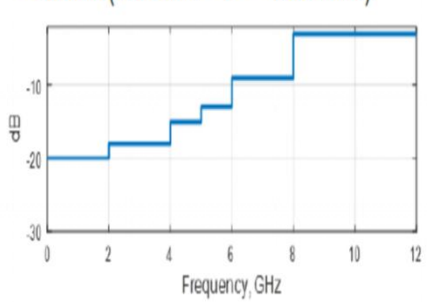


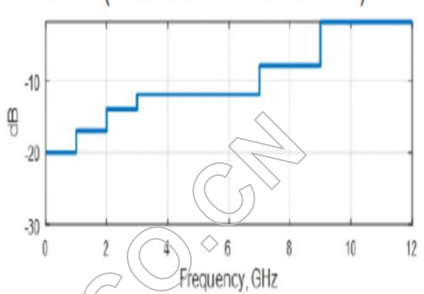
CAMM2 IL

CAMM2 VS SODIMM CONNECTOR SI---RL

SODDR TOP PIN　　SODDR BOTTOM PIN

Return Loss **Note:** Signals with 1:1 S/G	< -20.0 dB (f <= 2.0 GHZ) < -18.0 dB (2.0 GHz < f <= 4.0 GHz) < -15.0 dB (4.0 GHz < f <= 5.0 GHz) < -13.0 dB (5.0 GHz < f <= 6.0 GHz) < -9.0 dB (6.0 GHz < f <= 8.0 GHz) < -3.0 dB (8.0 GHz < f <= 12.0 GHz)	< -20.0 dB (f <= 1.0 GHZ) < -17.0 dB (1.0 GHz < f <= 2.0 GHz) < -14.0 dB (2.0 GHz < f <= 3.0 GHz) < -12.0 dB (3.0 GHz < f <= 7.0 GHz) < -8.0 dB (7.0 GHz < f <= 9.0 GHz) < -2.0 dB (9.0 GHz < f <= 12.0 GHz)





SODDR5 RL

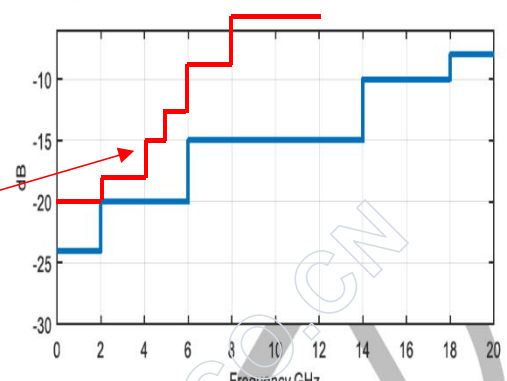
Return Loss (RL)

Note:

- Signals with 1:1 S/G
- Measure from both the baseboard side and module side

< -24.0 dB (f <= 2.0 GHz)
< -20.0 dB (12.0 GHz < f <= 6.0 GHz)
< -15.0 dB (6.0 GHz < f <= 14.0 GHz)
< -10.0 dB (14.0 GHz < f <= 18.0 GHz)
< -8.0 dB (18.0 GHz < f <= 20.0 GHz)

SODDR TOP PIN RL

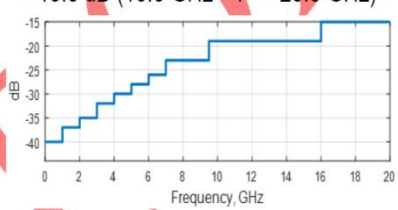


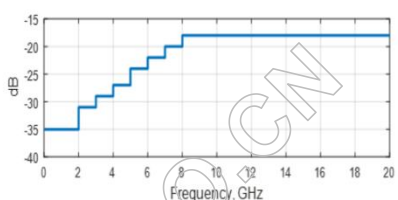
CAMM2 RL

CAMM2 VS SODIMM CONNECTOR SI---FEXT

SODDR TOP PIN SODDR BOTTOM PIN

	SODDR TOP PIN	SODDR BOTTOM PIN
1:1 S/G Same Side FEXT **Note:** Both the victim and the aggressor are located at the same side	< -40.0 dB (f <= 1.0 GHZ) < -37.0 dB (1.0 GHz < f <= 2.0 GHz) < -35.0 dB (2.0 GHz < f <= 3.0 GHz) < -32.0 dB (3.0 GHz < f <= 4.0 GHz) < -30.0 dB (4.0 GHz < f <= 5.0 GHz) < -28.0 dB (5.0 GHz < f <= 6.0 GHz) < -26.0 dB (6.0 GHz < f <= 7.0 GHz) < -23.0 dB (7.0 GHz < f <= 9.5 GHz) < -19.0 dB (9.5 GHz < f <= 16.0 GHz) < -15.0 dB (16.0 GHz < f <= 20.0 GHz)	< -35.0 dB (f <= 2.0 GHZ) < -31.0 dB (2.0 GHz < f <= 3.0 GHz) < -29.0 dB (3.0 GHz < f <= 4.0 GHz) < -27.0 dB (4.0 GHz < f <= 5.0 GHz) < -24.0 dB (5.0 GHz < f <= 6.0 GHz) < -22.0 dB (6.0 GHz < f <= 7.0 GHz) < -20.0 dB (7.0 GHz < f <= 8.0 GHz) < -18.0 dB (8.0 GHz < f <= 20.0 GHz





SODDR5 FEXT

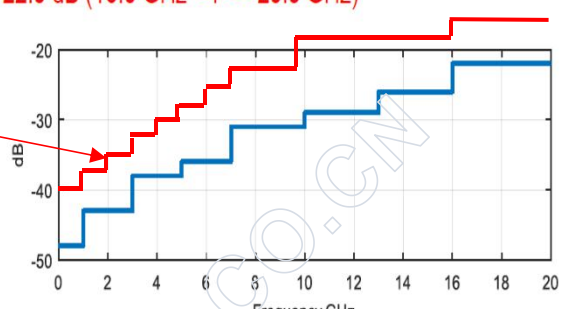
Far End Crosstalk (FEXT)

Note:

- Both the victim and the aggressor are located at the same side
- Measure from the module side

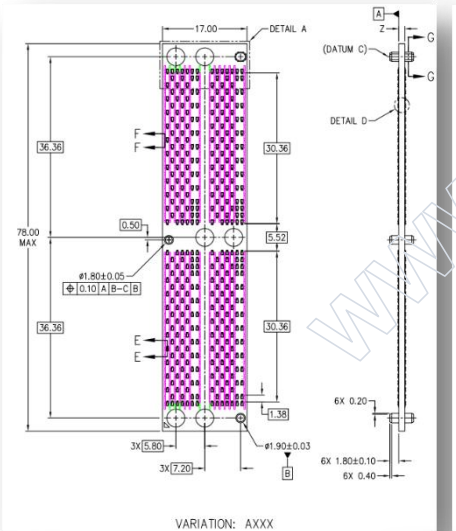
SODDR TOP PIN FEXT

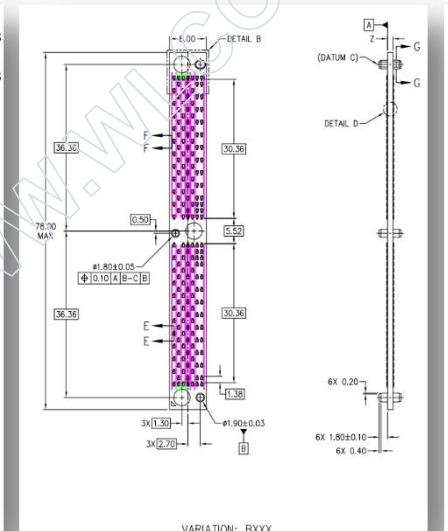
< -48.0 dB (f <= 1.0 GHz)
< -43.0 dB (1.0 GHz < f <= 3.0 GHz)
< -38.0 dB (3.0 GHz < f <= 5.0 GHz)
< -36.0 dB (5.0 GHz < f <= 7.0 GHz)
< -31.0 dB (7.0 GHz < f <= 10.0 GHz)
< -29.0 dB (10.0 GHz < f <= 13.0 GHz)
< -26.0 dB (13.0 GHz < f <= 16.0 GHz)
< -22.0 dB (16.0 GHz < f <= 20.0 GHz)



CAMM2 FEXT

CAMM2 CONNECTTOR 规格





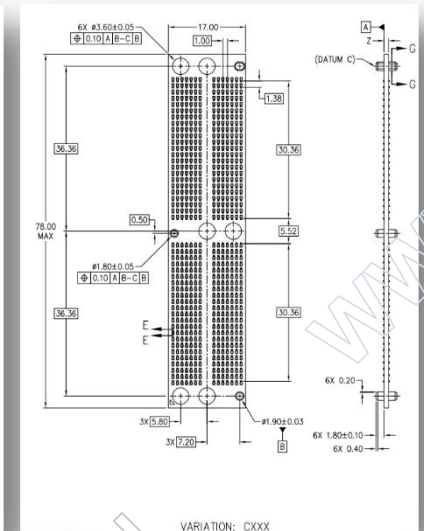
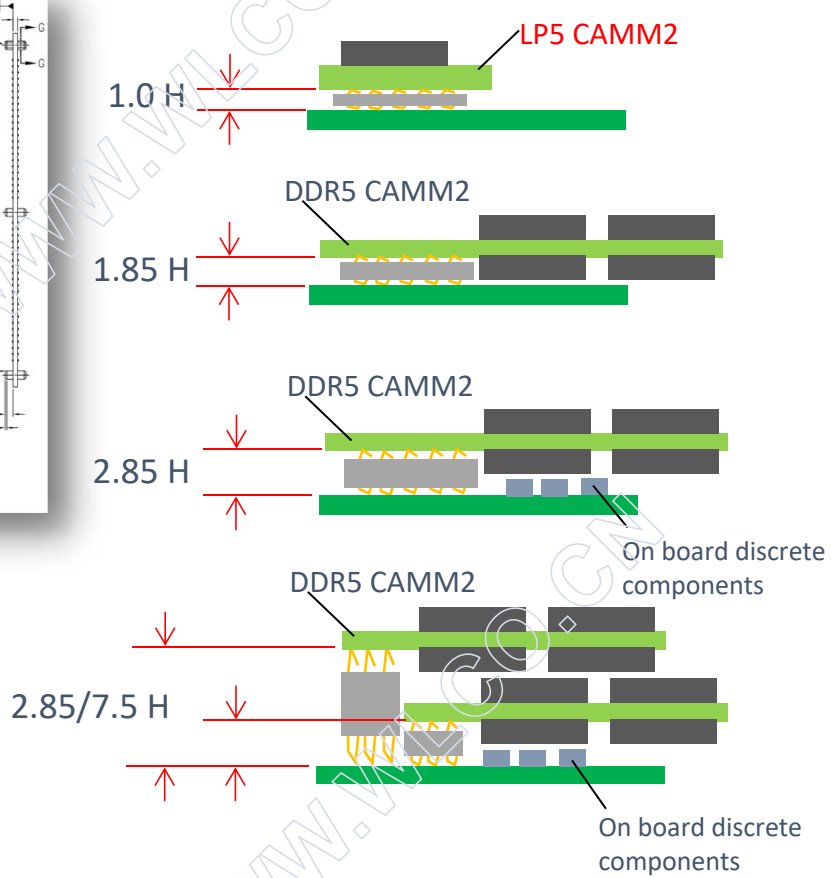
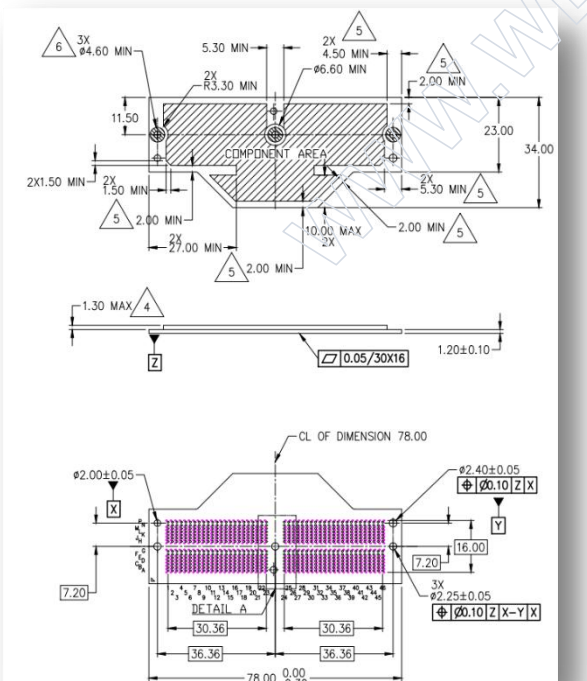


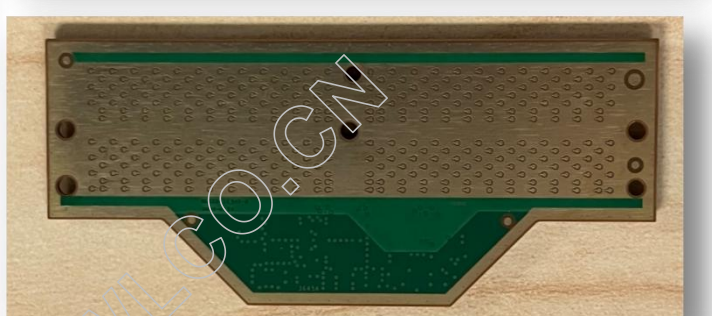
TABLE 1

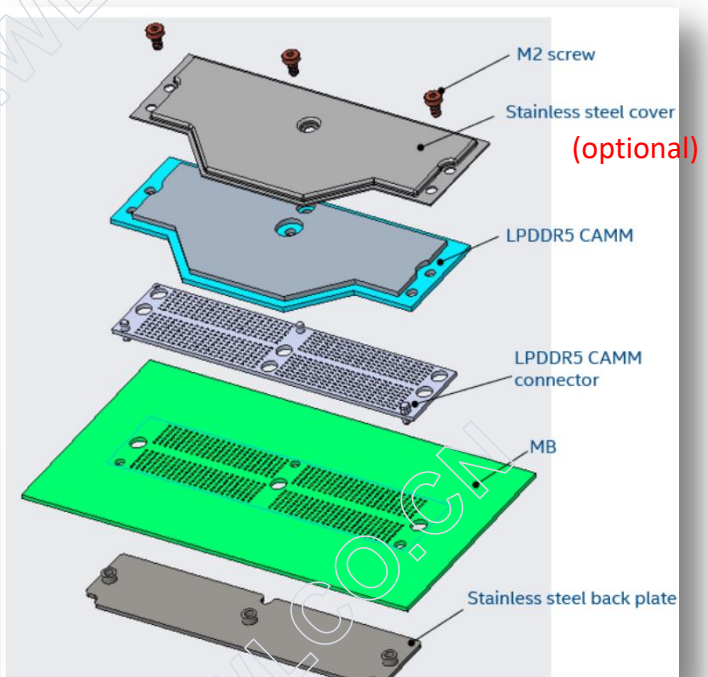
		HEIGHT			
VARIATION ▶		xAxx	xBxx	xCxx	xDxx
SYMBOL ▼					
	MIN	0.95	1.80	2.80	7.45
Z	NOM	1.00	1.85	2.85	7.50
	MAX	1.05	1.90	2.90	7.55
NOTES		–			
REF		14–215			
ISSUE		A			



LPDDR5 CAMM2 内存、连接器与配件

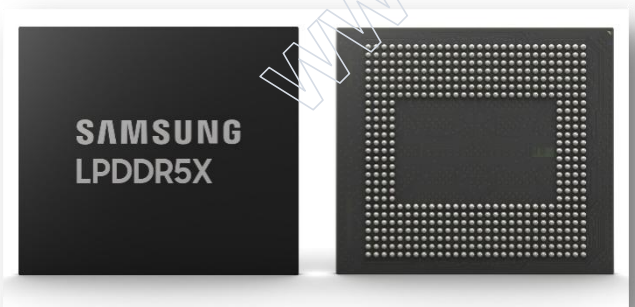




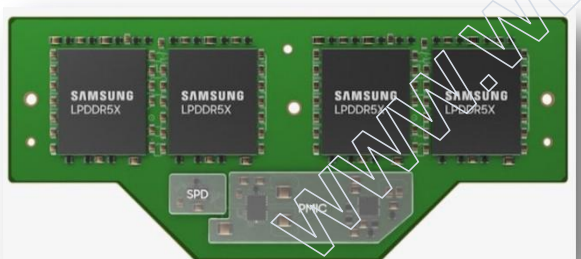


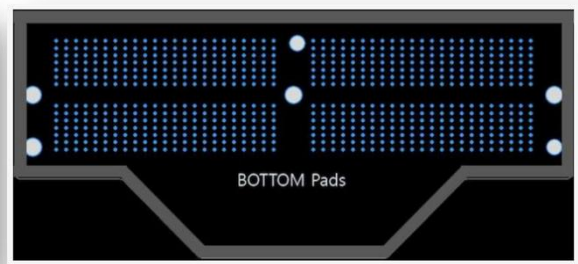
LPDDR5 CAMM2 的优势

CAMM 2出现之前，LPDDR均是直接把芯片焊接在主板上。



CAMM 2的出现，LPDDR5 首次采用Modular LPDDR5的方案。目前Samsung,SK和Micron都有样品测试。





LPDDR5 的数据比较

Laptop Memory Module Standards				
AnandTech	LPCAMM	CAMM	SO-DIMM	Soldered
Memory Type	LPDDR5X	DDR5	DDR5	LPDDR5X
Max Official Data Rate	7500 MT/s	6400 MT/s?	6400 MT/s	8533 MT/s
Current Max Capacity	128GB (Planned)	128GB	192GB (48GB x 4)	32GB (per 64-bit bus)
Bus Width	128-bit	128-bit	64-bit	Variable
Dimensions	78mm x 23mm	?	67.6mm x 30mm	Variable

https://semiconductor.samsung.com/cn/news-events/news/samsung-develops-industrys-first-lpddr5x-dram/
https://www.163.com/dy/article/IFKTP71H0511B8LM.html

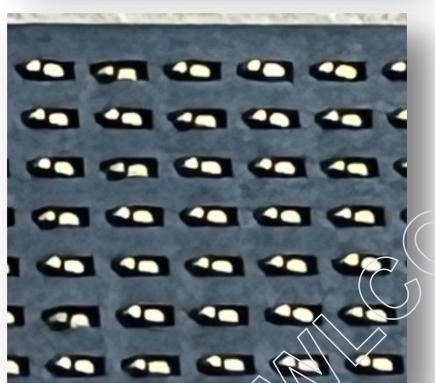
CAMM2 连接器的挑战

特点：
- 连接器不需要焊接，可以随时更换；
- 端子矩形阵列排布，类似CPU SOCKET，实现高密高速；

制造难点：
- 塑胶主体、端子精度要求极高；
- 端子材质需要高强度铜合金材质；
- 端子接触点高度一致性要求高、检测困难。

技术难点：
- 高度较高的规格，需要加入屏蔽片,才能保证SI性能；

DDR5 CAMM2



LP DDR5 CAMM2

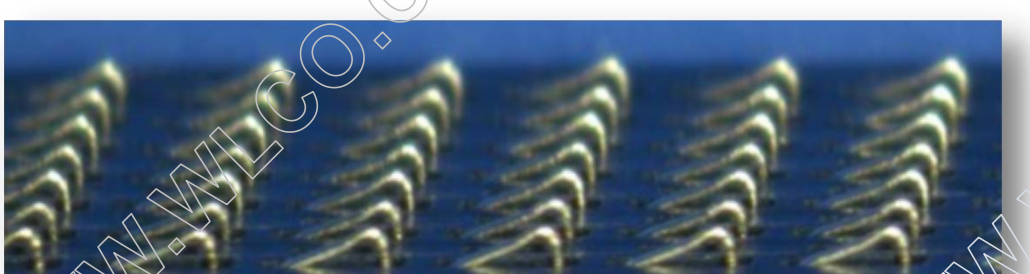
DDR6的发展方向猜想

●各大芯片厂已经在进行DDR6的研究，但还没有明确的方向；

●DDR5、PCIe 5.0等高速连接器均从PTH(Pin Through Hole)向SMT(Surface Mounted Technology)过渡；

●CMT(Compression Mounted Technology)连接器具有很高的密度和优秀的SI性能；

●CAMM2的应用，为CMT(Compression Mounted Technology)连接器打开一扇门，未来可能有越来越多的应用基于CMT连接器开发。



Thanks 谢谢聆听

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