DRAM MEMORY MODULE RANK CALCULATION

Whitepaper

Document #AN0033 – DRAM Memory Module Rank Calculation Whitepaper | Rev. A

viking TECHNOLOGY

A RF, Optical, Microelectronics and Memory Company

Abstract

Viking Technology manufactures DRAM modules for OEMs in Enterprise, Telecommunications and Industrial markets. It offers full DRAM technology portfolio from DDR4 to legacy DDR1. Viking's modules follow JEDEC standard and range from standard form factors to the most comprehensive small form-factor and specialty custom modules. Each memory module has rank based on how DRAM chips are organized. A memory rank is a set of DRAM chips connected to the same chip select, and which are therefore accessed simultaneously. In practice they also share all of the other command and control signals, and only the data pins for each DRAM are separate (but the data pins are shared across ranks).

Table of Contents

Table of Tables

Table of Figures

Module Rank Calculation

1 Memory Rank

A memory rank is a set of DRAM chips connected to the same chip select, which are therefore accessed simultaneously. In practice they also share all of the other command and control signals, and only the chip select pins for each rank are separate (the data pins are shared across ranks).
The term Rank was created by JEDEC, the memory industry's standards group, to distinguish between the number of memory banks on a module as opposed to the number of memory banks on a component, or memory chip. The concept of memory rank applies to all memory module form factors, though in general it tends to matter primarily on server platforms, due to the larger amounts of memory they manage.

A memory rank is, simply put, a block or area of data that is created using some, or all, of the memory chips on a module [Figure-1].

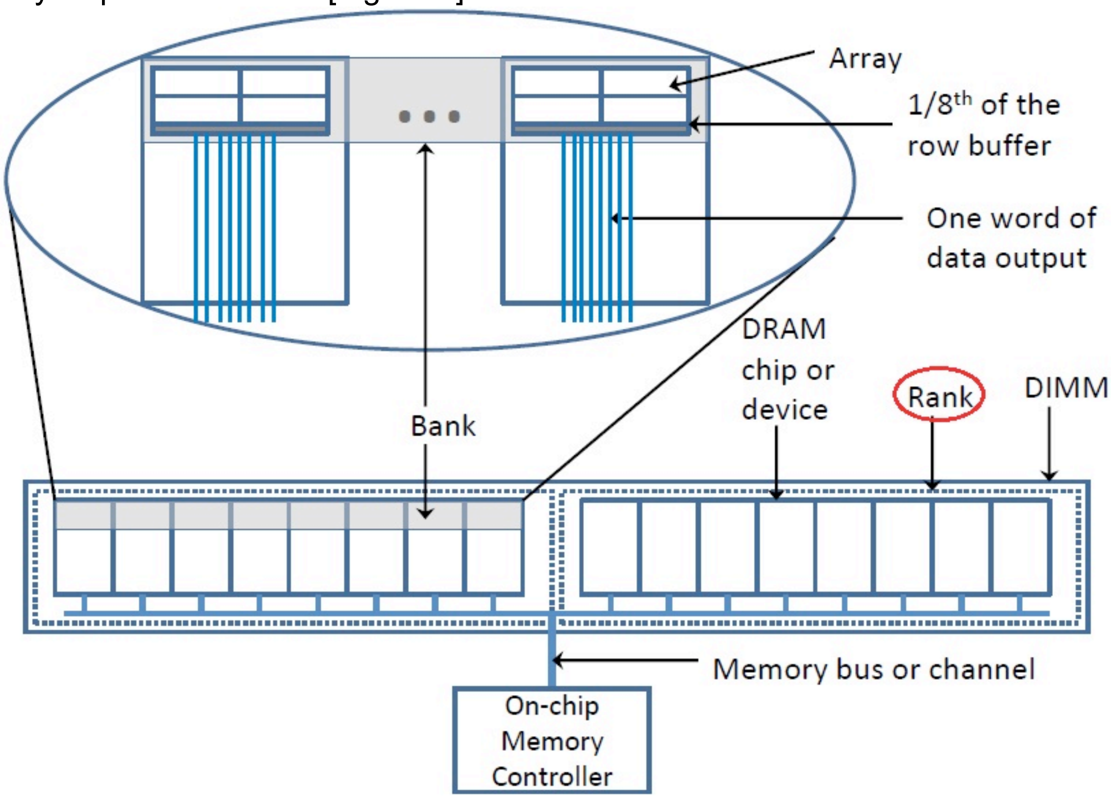

Figure-1: Module architecture

On a memory module, a rank is a data block that is 64 bits wide. On systems that support Error Correction Code (ECC) an additional 8 bits are added, which makes the data block 72 bits wide. Depending on how a memory module is engineered, it may have one, two, or four blocks of 64-bit wide data areas (or 72-bit wide in the case of ECC modules.) The number of physical DRAMs depends on their individual widths. Multiple ranks can coexist on a single DIMM, and modern DIMMs can consist of one rank (single rank), two ranks (dual rank), four ranks (quad rank), or eight ranks (octal rank). Viking denotes this on the module label as 1Rx8, 1Rx4, or 2Rx4, 2Rx8, or similar [Figure-2].

Figure-2 Viking Module example

There is little difference between a dual rank UDIMM and two single rank UDIMMs in the same memory channel, other than that the DRAMs reside on different PCBs. The electrical connections between the memory controller and the DRAMs are almost identical (with the possible exception of which chip selects go to which ranks). Increasing the number of ranks per DIMM is mainly intended to increase the memory density per channel. Too many ranks in the channel can cause excessive loading and decrease the speed of the channel. Also some memory controllers have a maximum supported number of ranks. DRAM load on the CA (Command/Address) bus can be reduced by using registered memory.

Predating the term “rank”, sometimes also called “row” is the use of single-sided and double-sided modules, especially with SIMMs (Single In-line Memory Module**)**. Single sided or Double-sided [Figure-3] is a physical term describing the arrangement of chips on one side or two sides of the memory module.

Double-Sided Memory refers to how the module is physically built with the individual memory chips. In this instance, they are placed on both sides of the PCB.

Single-sided memory modules are newer and the chips are denser, enabling more capacity. Earlier 16 chips were used to make a 256M module, now it takes eight chips. Older motherboards may not recognize single sided memory. While most often the number of sides used to carry RAM chips corresponded to the number of ranks, sometimes they didn't. This could lead to confusion and technical issues. The x4 and x8 refer to the number of banks on the memory component or chip. It is this number, not the number of individual memory chips on a PCB, which determines the Rank of the finished module. In other words, if a module has chips on both sides of the PCB, which makes it dual-sided, it can still be Single Ranked, Dual Ranked, or Quad Ranked, depending on how those chips are engineered.

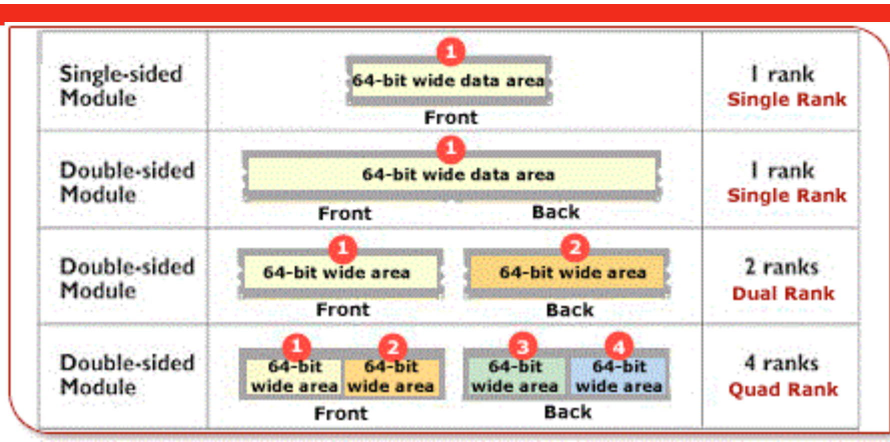

Figure-3 Description of Ranks

Single-sided modules are always single-rank. Doubled-sided un-buffered DIMMs and SO DIMMs are always dual-rank.

2 Single-rank, dual-rank, and quad-rank DIMMs

To understand and configure memory protection modes properly, an understanding of single-rank (1R), dual-rank (2R), and quad-rank (4R) DIMMs is helpful. Some DIMM configuration requirements are based on these classifications.

A single-rank DIMM has one set of memory chips that is accessed while writing to or reading from the memory. A dual-rank DIMM is similar to having two single-rank DIMMs on the same module, with only one rank accessible at a time. A quad-rank DIMM is, effectively, two dual-rank DIMMs on the same module. Only one rank is accessible at a time. The server memory control subsystem selects the proper rank within the DIMM when writing to or reading from the DIMM.

Dual-rank and quad-rank DIMMs provide the greatest capacity with the existing memory technology. For example, if current DRAM technology supports 8-GB single-rank DIMMs, a dual-rank DIMM would be 16 GB, and a quad-rank DIMM would be 32 GB.

LRDIMMs are labeled as quad-rank DIMMs; however, they function more like dual-rank DIMMs. There are four ranks of DRAM on the DIMM, but the LRDIMM buffer creates an abstraction that allows the DIMM to appear as a dual-rank DIMM to the system. The LRDIMM buffer also isolates the electrical loading of the DRAM from the system to allow for faster operation. These two changes allow the system to support up to three LRDIMMs per memory channel, providing for up to 50% greater memory capacity and higher memory operating speed compared to quad-rank RDIMMs.

3 Rank Calculations

As mentioned above, the number of physical DRAMs depends on their individual widths. For example, a rank of x8 (8 bit wide) DRAMs would consist of eight physical chips (nine if ECC is supported), but a rank of x4 (4 bit wide) DRAMs would consist of 16 physical chips (18 if ECC is supported). Since a Rank is 64 or 72 bits, an ECC module made from x4 chips will need eighteen chips for one Single Rank (18 x 4 = 72). An ECC module made from x8 chips needs only nine of them for a Rank (9 x 8 = 72). A module made from eighteen x8 chips would be Dual Ranked (18 x 8 = 144, 144/72 = 2). An ECC module that has twice as many x8 chips becomes Quad Ranked (36 x 8 = 288, 288/72 = 4).

1 RANK = 64bit width (or 72bit with ECC)

Single Rank = 64bit

Double Rank = 64bit + 64 bit

Quad Rank = 64bit + 64 bit + 64bit + 64 bit

As mentioned before, ranks are for interleaving to make a system run faster. This is where one device or part of a device is being accessed for data whilst another device or part of a device is getting ready to deliver data.

On some server upgrades there will be a maximum number of ranks a server will address or certain ranked modules may need to be fitted to certain sockets. For example, if a server can address 8 ranks. It may take a variation of 1GB, 2GB, 4GB and 16GB module to achieve this.

For 2GB modules the server may take:
4 x 2GB 2-Rank modules = 8 Ranks with 8GB or
8 x 2GB 1-Rank modules = 8 Ranks with 16GB

Or alternatively using 16GB modules,
2 x 16GB 4-Rank modules = 8 Ranks with 32GB

Some planning is required when completing some server upgrades that need ranking, as installing the incorrect amount or type of ranks may lead to problems, or memory may need to be removed and replaced in the future to achieve the maximum density of memory if all sockets are used. More examples are in the following table [Table-1].

Having a dual or quad Ranked module is like having two or four DRAM modules combined onto one module. For example, you can instantly go from four single rank 4GB RDIMM to a single quad Rank 16GB RDIMM (assuming of course the system is compatible with 16GB RDIMMs).

Table-1: Examples of rank calculation

No. of Components on the Module	Multiply (x)	DRAM chip configuration	Total	Divide by module rank (x64 or x72)	Module Rank
18	x	4	72	72	1
36	x	8	288	72	4
32	x	8	256	64	4
8	x	16	128	64	2
18	x	8	144	72	2

Table-1

4 Disadvantages of multiple rank modules

1. There is a small performance reduction for multi-rank systems as they require some pipeline stalls between accessing different ranks. For two ranks on a single DIMM it might not even be required, but this parameter is often programmed independently of the rank location in the system (if on the same DIMM or different DIMMs). Nevertheless, this pipeline stall is negligible compared to the aforementioned effects.
2. Another drawback with higher ranked modules is that servers sometimes have a limit on how many Ranks they can address. For example, a server with four memory slots may be limited to a total of eight Ranks. This means you can install four single ranked modules or four dual ranked modules but only two quad ranked modules, as installing more would exceed the amount of ranks that can be addressed.

Global Locations				
US Headquarters	Canada Office	Texas Office	India Office	Singapore Office
2950 Red Hill Ave. Costa Mesa, CA 92626 Main: +1 714 913 2200 Fax: +1 714 913 2202	500 March Road Ottawa, ON K2K 0J9 Canada	1201 W. Crosby Road Carrollton, TX 75006 USA	A 3, Phase II, MEPZ- Special Economic Zone NH 45, Tambaram, Chennai-600045 India	No 2 Chai Chee Drive Singapore, 109840
For all of our global locations, visit our website under global locations. For sales information, email us at sales@vikingtechnology.com				

viking TECHNOLOGY

A RF, Optical, Microelectronics and Memory Company