

# Principle and Architecture of Ultra Low Power SRAM Device

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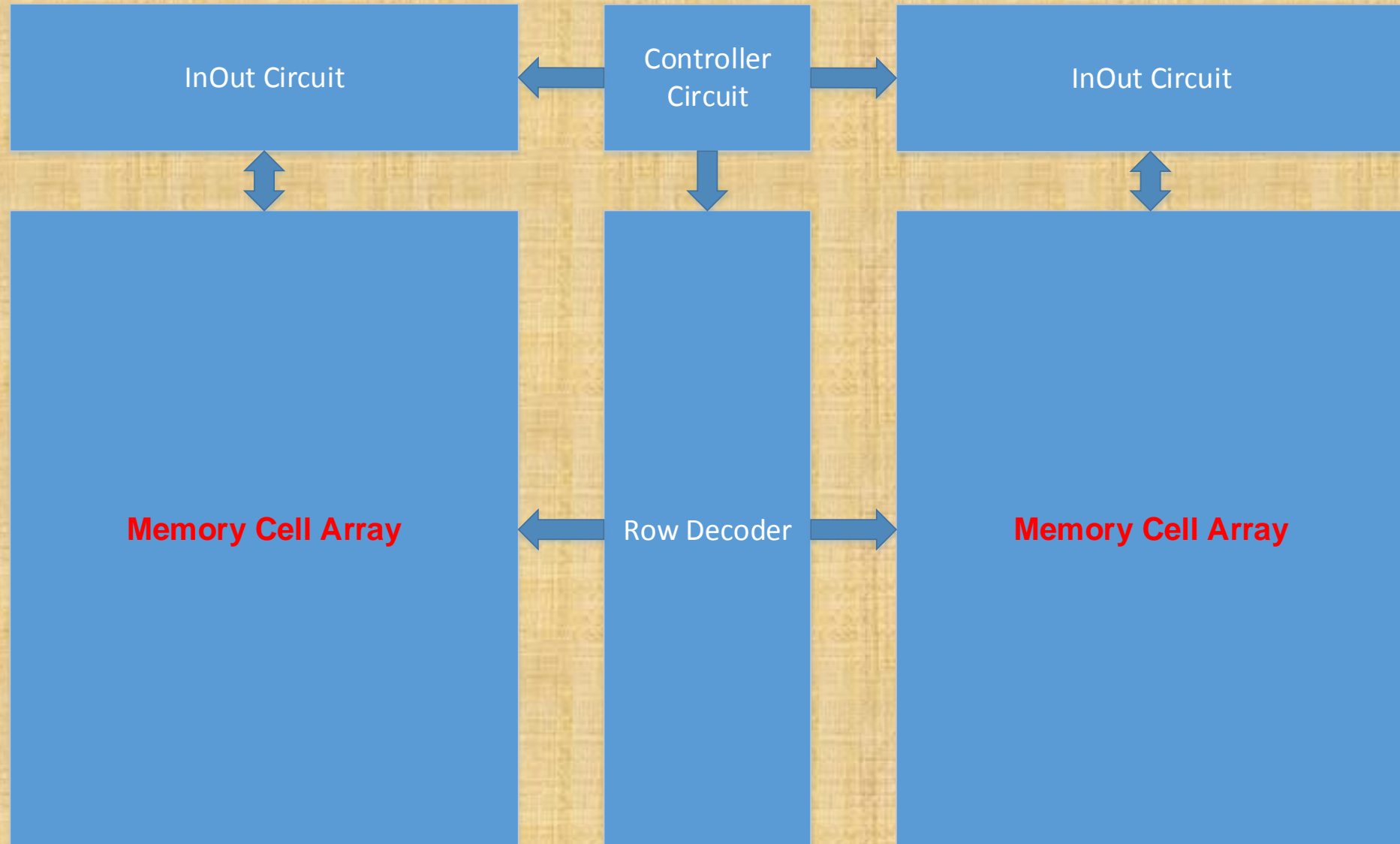
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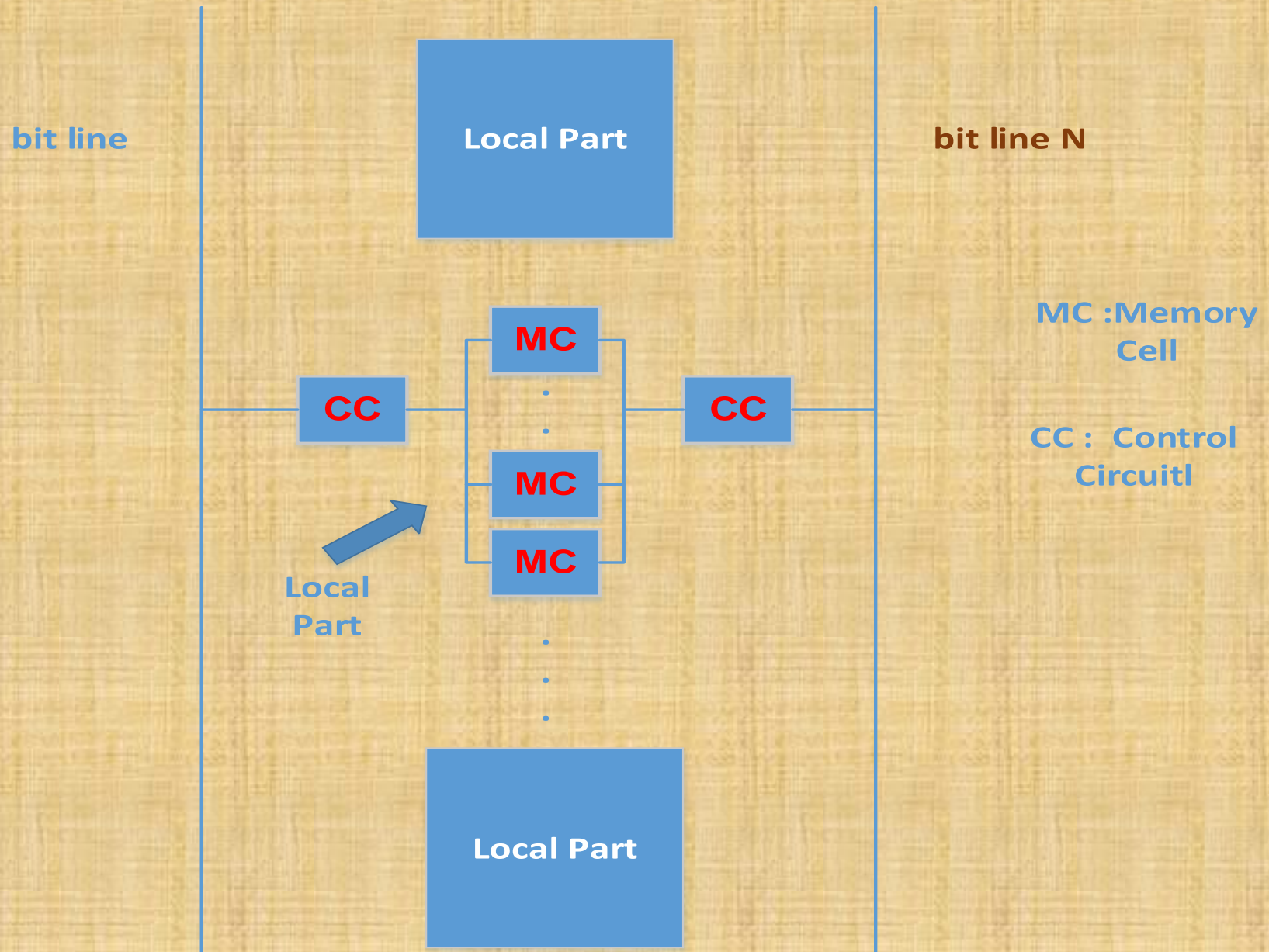
# Features 1

- 1. The **power** of the new SRAM device is **15%~20%** compare to current technology.
- 2. The area of the new SRAM device is **around the same** compare to current technology.
- 3. The **implementation** of new SRAM device is **simple** and **easy**.
- 4. The **circuit interface** of new SRAM device is **the same** as current technology.
- 5. The **operation voltage** is the **same** as digital voltage.(1.0 V at 28nm process)  
=> This invention is not base on voltage scaled down.
- 6. The new SRAM device requires **4** metal layers.
- 7. The new SRAM device is **mainly applied to the L1/L2 cache** of the **CPU/GPU** in the SOC chip.
- 8. Running over 3 GHz at 14/16 nm process; over 2 GHz at 28 nm process.

# Circuits : Memory Overview

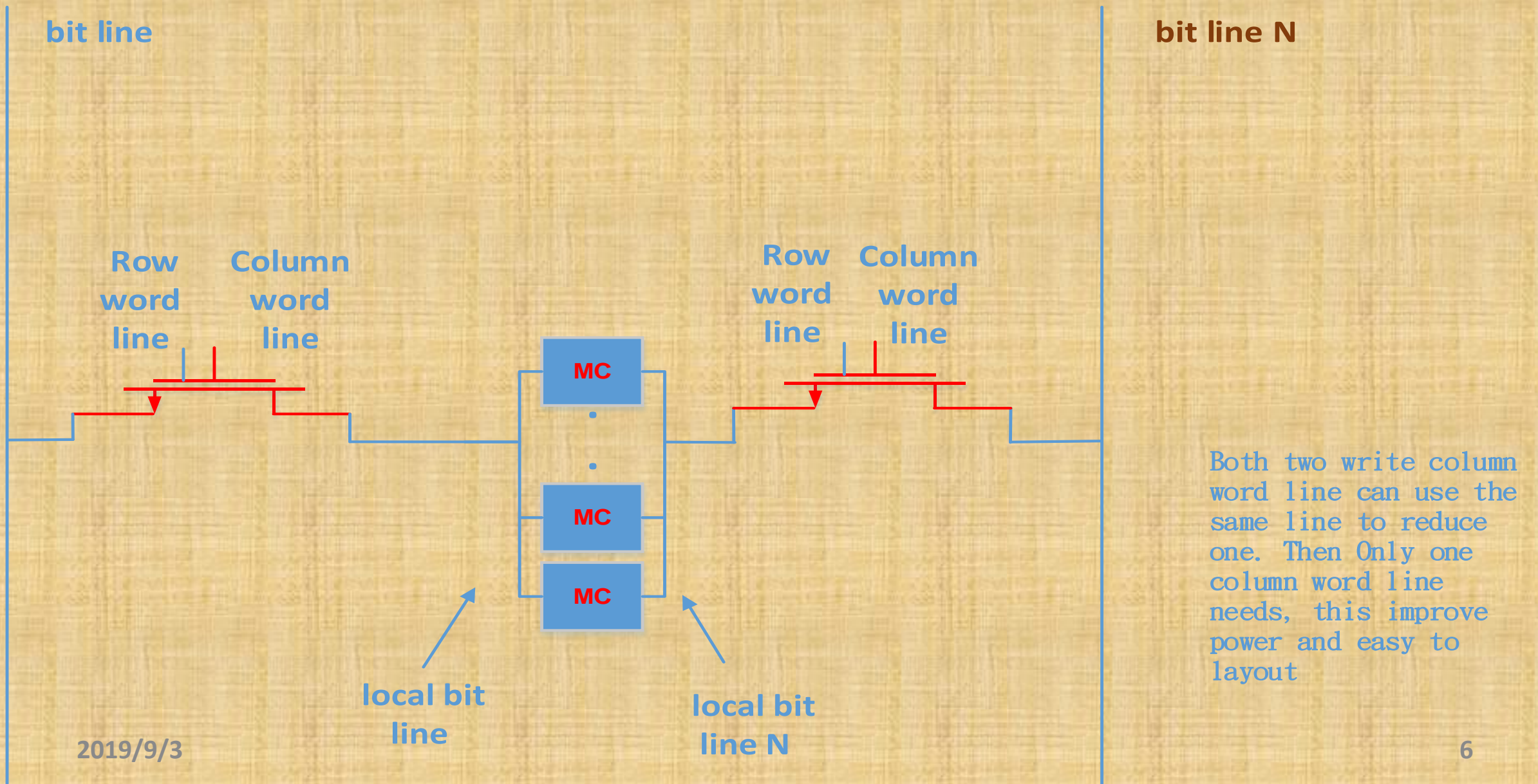


# Circuits : Memory unit

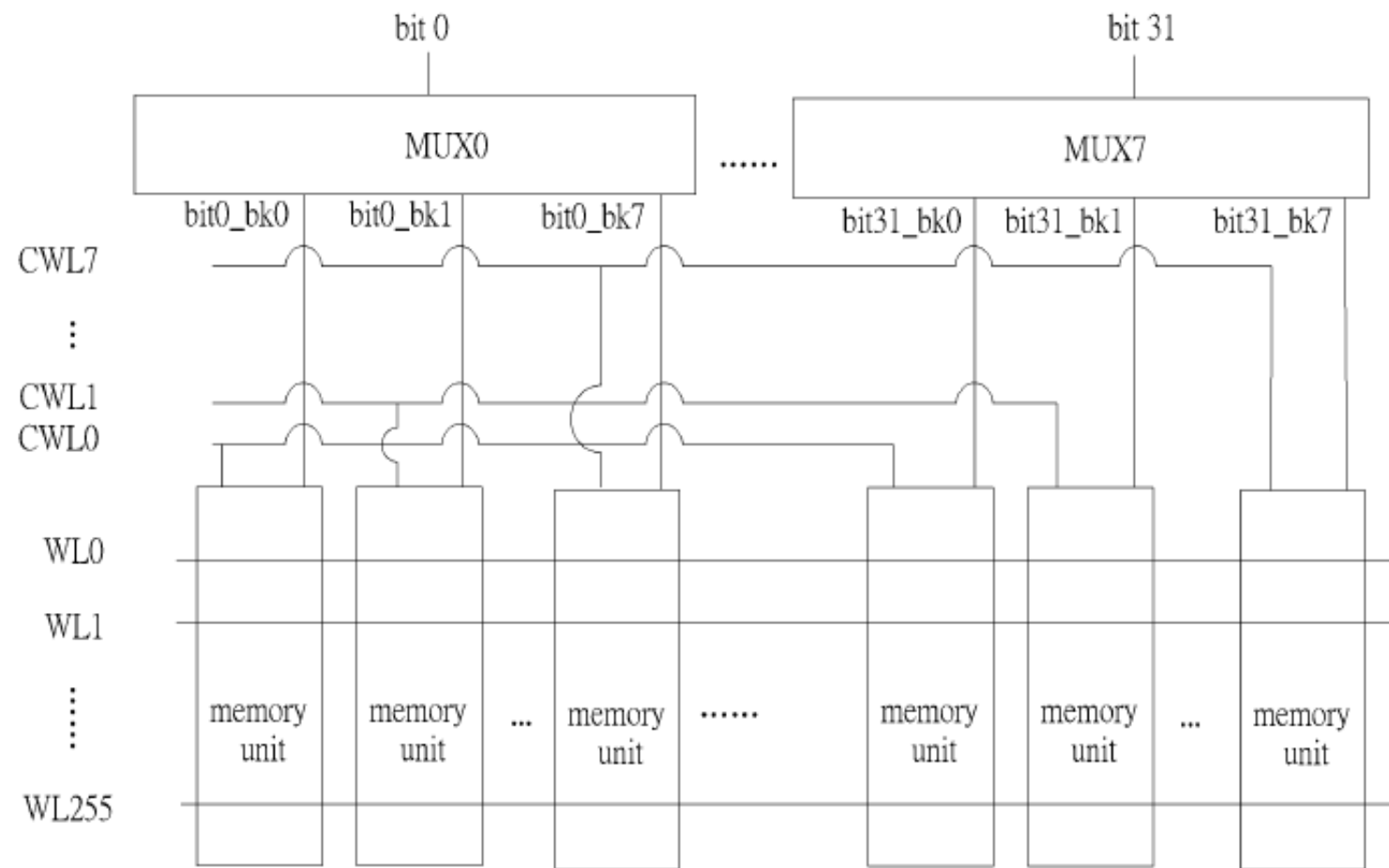




## Circuits : Memory unit/Local Part



# Circuits : Memory Array



# Circuits : Memory Array Explanation 1

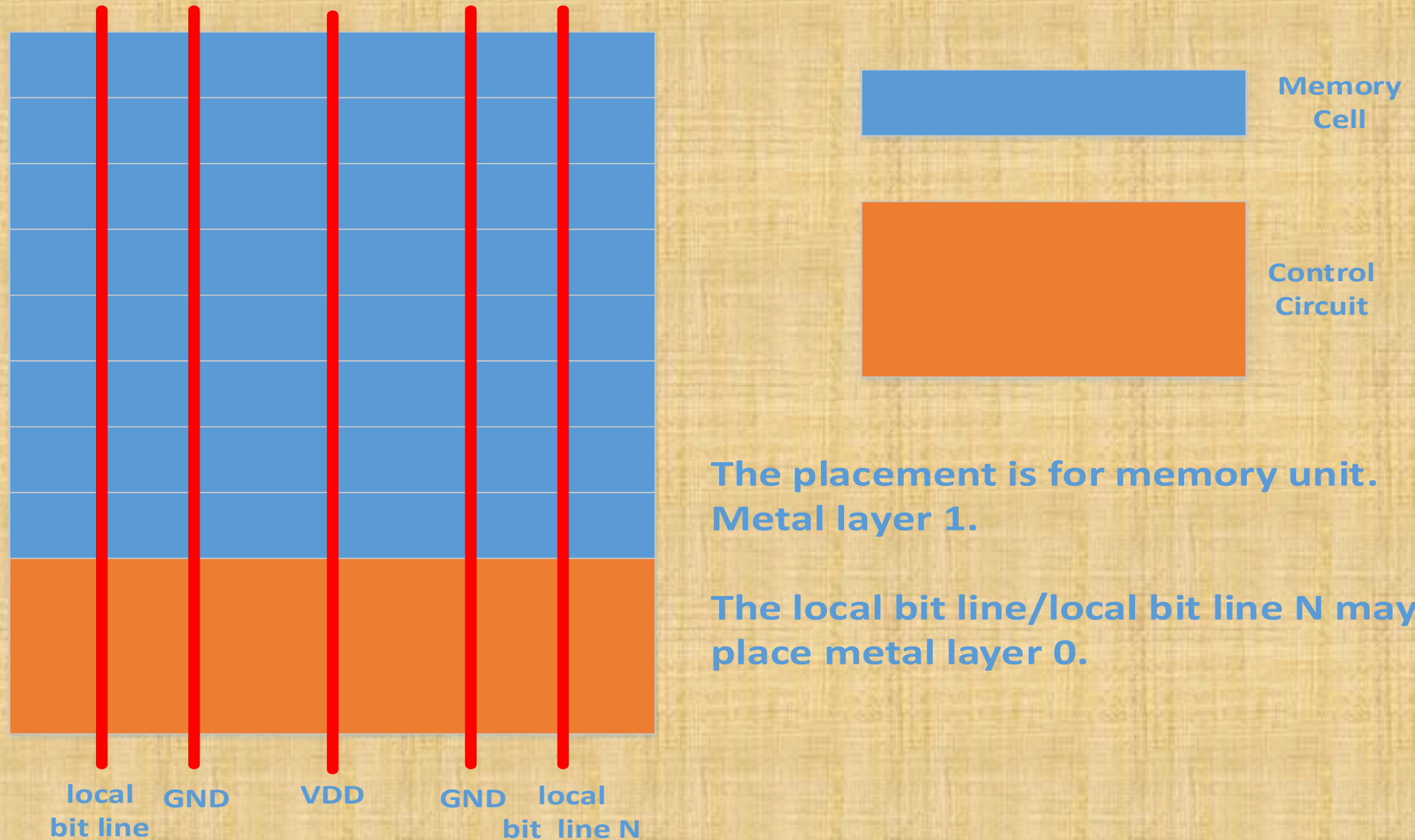
- There has 8 blocks, one block has 32 bit line set. One bit line set has bit line and bit line N(not shown).
- The CWLX (CWL0 ~CWL7) is for turn on the double gate switch of corresponding blocks.
- There has row word lines(RWL)(not shown)(Please reference patent list later). The selected row word line will also for turn on the double gate switch. For example WL0 – WL7 are with RWL0, WL248 – WL255 are with RWL31. So when SRAM cell is selected by WL0 – WL7, RWL0 will active, etc.
- Both CWLX and corresponding row word line are active, the double gate switch will turn on.



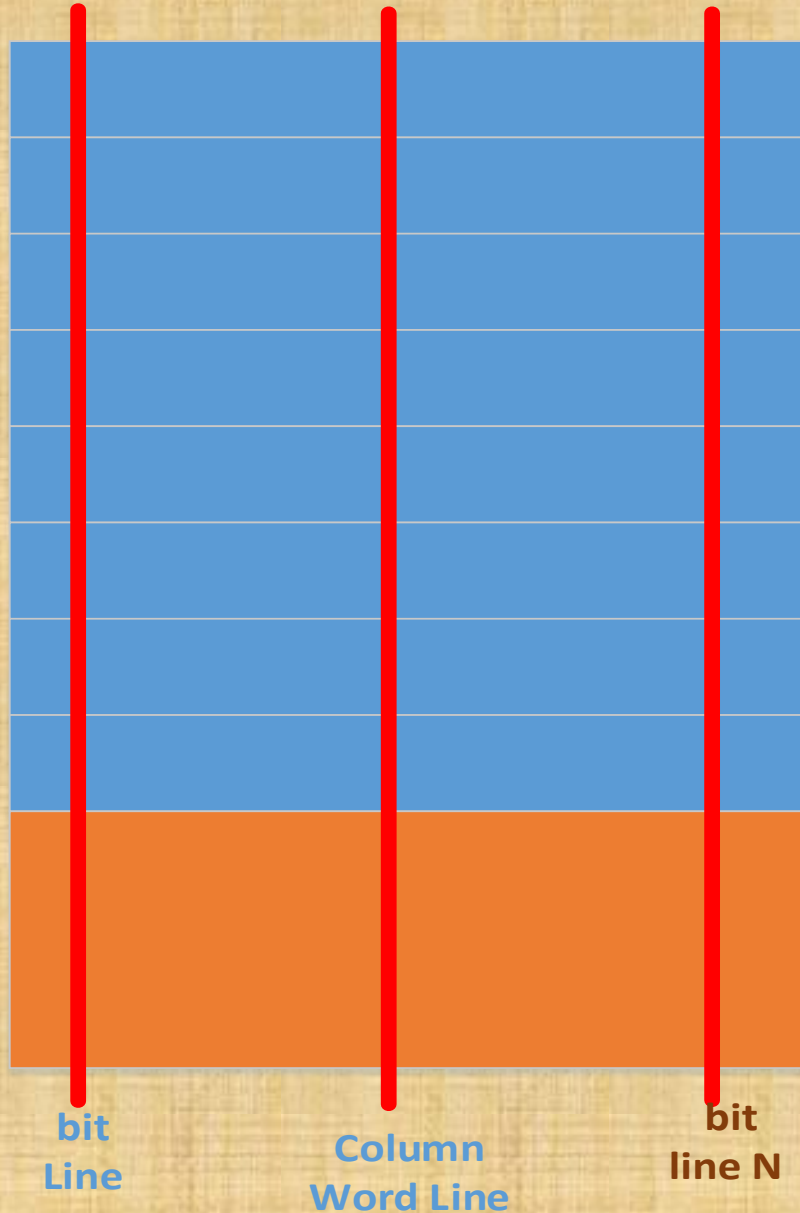
## Circuits : Memory Array Explanation 2

- Thus only the bit lines of selected block will charge or discharge when read or write.
- And the un-select blocks will only charge or discharge the local bit lines. And the local bit line is very short, the connected SRAM cell is very few, so the this power is almost can ignore.
- Due to only the bit lines of selected block will charge/discharge, the pre-charge can only active in read cycle.

# Place and Louting : Memory Unit Metal Layer 1



# Place and Louting : Memory Unit Metal Layer 2

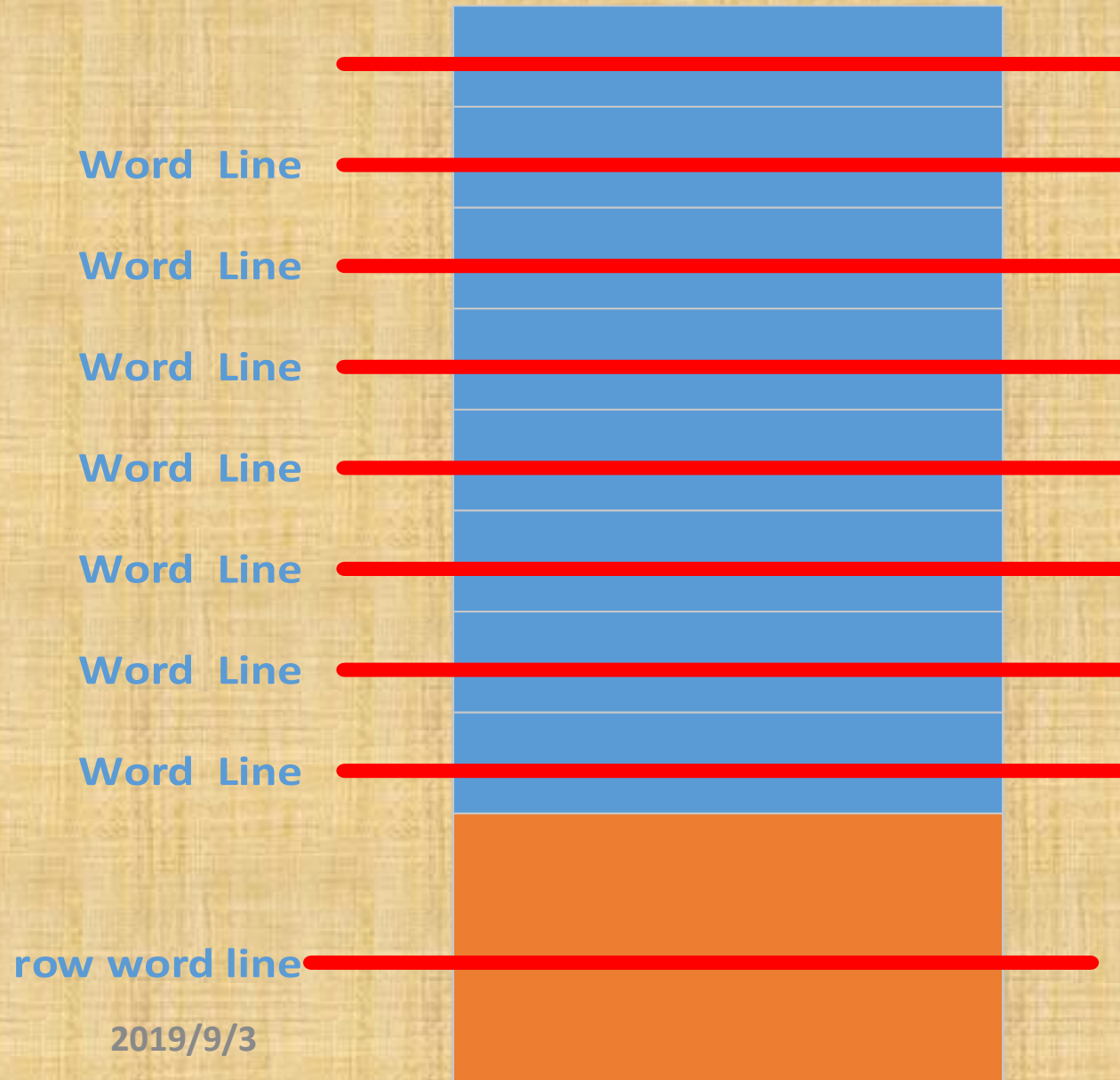


The placement is for memory unit.  
Metal layer 2.

The two Column Word Line could be the  
same line for power saving.

**Metal layer 2 can exchange with metal  
layer 3.**

# Place and Louting : Memory Unit Metal Layer 3



The placement is for memory unit.  
Metal layer 3.



## Power of Column Word Line

- Column switch should be parked before the selected block is change. So the column word line doesn't toggle before the selected block is change. This can save power.
- For example , a bit line is connected to 256 SRAM cells, due to the sequence access characteristic of memory, the column word line will require toggle only one cycle of 256 sequence access cycles. In cache memory, this effect will much more, so the column word line will require toggle only one cycle of 512/1024 access cycles. Then the column word line power is divided by 256, 512, 1024.



# Power comparison 1

- Definition : Selected bit line power => **SBLP**  
Unselected Array power => **UAP**  
Decoder power => DP  
Cell read power => CRP  
Cell write power => CWP  
Sense amplifier power => SAP  
Column word line power => **CWLP**  
Row word line power => RWLP  
Word line power => WLP  
Pre-charge Power => PCP

## Power comparison 2

- For example a memory device 256 bits/line X 32 bits/word X 8 blocks. In current design, one word line will enable 32bits X8 blocks = 256 bit cells. That is mean  $256 - 32 = 224$  bit cells waste active powers, because there only need 32 bit cells (**SBLP**) to output. For SRAM cells, one cell active current is around 66 uA, So 224 bit cells will waste  $66 \text{ uA} \times 224 = 14784 \text{ uA}$  (**UAP**). This is the main reason, that my invention makes the SRAM power to such low.

## Power comparison 3

- Current technology read power :

$$\text{SBLP} + \text{DP} + \text{CRP} + \text{RWLP} + \text{WLP} + \text{PCP} + \text{UAP} + \text{SAP}$$

- Current technology write power :

$$\text{SBLP} + \text{DP} + \text{CWP} + \text{RWLP} + \text{WLP} + \text{PCP} + \text{UAP}$$

- New invention read power :

$$\text{SBLP}/2 + \text{DP} + \text{CRP} + \text{RWLP} + \text{WLP} + \text{PCP} + \text{CWLP}/256 + \text{UAP}/32 + \text{SAP}$$

- New invention write power :

$$\text{SBLP}/2 + \text{DP} + \text{CWP} + \text{RWLP} + \text{WLP} + \text{CWLP}/256 + \text{UAP}/32$$

## Power comparison 4

- For 32cells/bit line X 32 bit line X 8 block (1K bytes) to 2048 cells/bit line X 64 bit line X 8 block (128K bytes), the UAP power is around 70% - 90% of SRAM power.  
And the other power is around 50 ~ 70 % of new invention, so the power of new invention is only 10 % ~ 20 % compare to current technology.



# Power Consumption Information

- ✓ 28 nm process.
- ✓ SRAM Device.
- ✓ Speed : Up to 2.5 Ghz.

Bit Line Length X Data Width X Block Numbers	New invention Unit:(uA/MHz)
256 X 32 X 8 Read (8k bytes)	1.77
256 X 32 X 8 Write (8k bytes)	1.54
256 X 64 X 8 Read(16k bytes)	3.25
256 X 64 X 8 Write(16k bytes)	2.78



# United Patent

- **United Patent Number : 10403338.**
- **The patent is impossible to be designed around.**

## **announcement**

- This invention and the US patent are proprietary to me and do not belong to any other company or any individual. Anyone or any company that wants to use the content of this patent on any product must obtain direct license from me.

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