# Volatile Memory: Types and Structures and GreenPAK$^{TM}$ Perspective

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## Abstract

This white paper explores various types of memory structures used as volatile memory (VM) and highlights the importance of selecting the appropriate memory type based on the specific requirements of any given application.

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## 1. Introduction

Understanding the various types of memory structures that can be used as volatile memory (VM) and selecting the appropriate type based on each specific application’s needs is crucial. For example, when speed, reliability, and low power consumption are critical, Static Random Access Memory (SRAM) is likely to be the preferred option. For large-scale applications requiring high storage capacity, Dynamic RAM (DRAM) may be more suitable.

## 2. What is SRAM?

SRAM (Static Random Access Memory) - is a type of semiconductor random-access memory (RAM) that uses latching circuitry to store each bit. SRAM is volatile memory; data is lost when power is removed. SRAM is designed to provide fast access times and lower power consumption, making it suitable for applications where speed and reliability are crucial. SRAM is typically used as “cache memory” or main memory in systems that require both high performance and low latency.

## 3. What is DRAM?

DRAM (Dynamic Random Access Memory) - is a type of semiconductor memory in which the data is stored in the form of a charge. Each memory cell in a DRAM module is made of a transistor and a capacitor. The data is stored in the capacitor. DRAM's are volatile devices due to the fact that capacitors lose charge over time because of leakage. To retain the data in memory, the device must be regularly refreshed.

# 4. Differences between DRAM and SRAM

**Structure:** SRAM is built using latches, which are simple circuits that store a single bit of data. On the other hand, DRAM uses capacitors and transistors to store data. This difference in structure means that SRAM is faster and has less power consumption than DRAM.

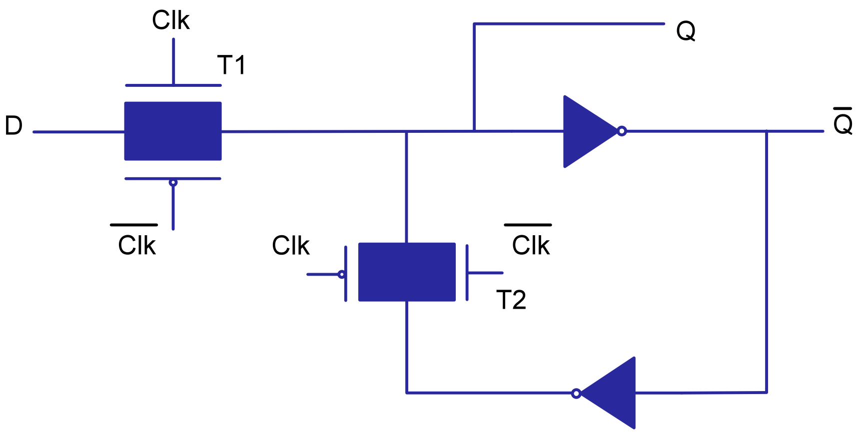


**Figure 1. Positive D latch SRAM structure using transmission gates**

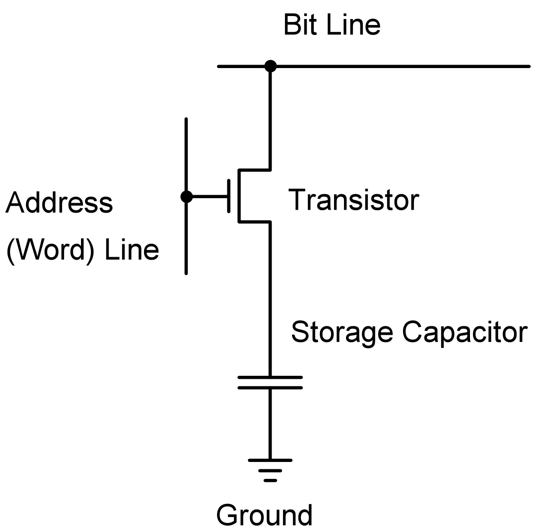


**Figure 2. DRAM single memory cell structure**

**Speed:** SRAM is faster than DRAM because it does not require constant refreshing. Once data is stored in an SRAM cell, it remains there until it is overwritten. DRAM, on the other hand, must be constantly refreshed to keep the data from decaying. This makes SRAM better suited for cache memory, where fast access times are essential.

**Density:** DRAM is denser than SRAM because it uses smaller transistors and capacitors to store data. This makes DRAM more suitable for applications where a large amount of memory is required.

**Power consumption:** SRAM consumes less power than DRAM because it does not require constant refreshing. This makes SRAM more energy efficient, which is important for battery-powered devices.

**Table 1. Differences between Static RAM and Dynamic RAM**

| SRAM | DRAM |
|---|---|
| It stores information as long as power is supplied. | It stores information as long as power is supplied and few milliseconds after the power is switched off |
| Transistors are used to store data in SRAM | Capacitors are used to store data in DRAM |
| Capacitors are not used hence no refreshing is required | To store information for a longer period of time, the contents of the capacitor need to be refreshed periodically |
| SRAM is faster compared to DRAM | DRAM provides slower access speeds |
| Does not need a refreshing unit. | Requires a refreshing unit |
| More expensive | Cheaper |
| SRAMs are low-density devices | DRAMs are high-density devices |
| Bits are stored in voltage form | Bits are stored in the form of electric energy |
| Consumes less power and generates less heat | Uses more power and generates more heat |
| SRAM has lower latency | DRAM has more latency than SRAM |
| SRAM is more resistant to radiation | DRAM is less resistant to radiation |

# 5. GreenPAK Memory

GreenPAK is a family of highly flexible, programmable mixed-signal ICs. The programmability of these devices allows for addressing in many different applications. GreenPAKs use two levels of memory: NVM (Non-Volatile Memory) and registers. During power-on-reset (POR) the contents of the NVM are copied into the registers. After that, the registers are used to configure internal blocks. During normal operation most of the GreenPAKs allow modification register content via I$^2$C or SPI communication interfaces. Most of the GreenPAKs primarily use OTP (one-time programmable) NVM while several ICs are using MTP (multi-time programmable) NVM. For the registers, a positive D latch SRAM structure using transmission gates is utilized. This makes it possible to have reliable and fast register-level memory without the drawbacks of using DRAM (like low speed and needing periodic refreshing). Besides that, the benefits of DRAM memory density diminish due to the relatively small number of registers needed for a GreenPAK device (approximately 2k bits).

# 6. Conclusion

In conclusion, memory plays a crucial role in today's complex systems, and the choice between SRAM and DRAM depends on specific application requirements. By carefully considering the trade-offs between these two types of volatile memory, system designers can make informed decisions about which technology best suits their specific needs and requirements. Whether it is speed, reliability, or power efficiency that takes precedence, a deeper understanding of both SRAM and DRAM's unique characteristics is essential for developing innovative and efficient solutions.

As discussed in this white paper, GreenPAK's use of SRAM with a positive feedback D latch structure offers better performance compared to DRAM. In this context, GreenPAK's programmable mixed-signal ICs offer a promising path for a wide variety of applications, allowing developers to tailor their devices for specific use cases while minimizing power consumption and size, while at the same time maximizing performance.

Visit Renesas GreenPAK website to get more information and view our Application Notes for a variety of ready-made solutions to common designs.

# 7. Revision History

| Revision | Date | Description |
|---|---|---|
| 1.00 | Aug 29, 2024 | Initial release. |

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