AT25EU Ultra-Low Energy NOR Flash Family

This application note provides an overview and introduction to the Renesas AT25EU family of devices. It discusses current consumption, erase times, and energy consumption.

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1. Overview

Battery powered systems on the edge of the IoT network are quite sensitive to the energy consumption of non-volatile memory devices. Continuous read or write operations, or even occasional over-the-air updates, can consume much energy and help drain the battery, unless the memory device is very energy-efficient.

The AT25EU devices are a new family of NOR Flash products from Renesas Electronics focused on ultra-low energy consumption. They are available in 1-Mbit, 2-Mbit, and 4-Mbit memory sizes. Renesas plans to make higher memory sizes available in the future.

The AT25EU devices achieve its ultra-low energy objective through two main characteristics:

- Very low power consumption for all operations, in most categories much lower power compared to equivalent products in the NOR flash market.
- Very short erase time. Also, the erase time of the AT25EU devices is constant and independent of the size of memory block being erased.

The AT25EU devices provide flexibility by supporting a wide V_{CC} voltage range (1.65 V-3.6 V). They also support the page-erase feature that allows erasing a block as small as 256 bytes. This contrasts with standard flash products, which allow an erase operation on a minimum block size of 4 kBytes. The page-erase feature makes write operations much more efficient.

The command set for the AT25EU devices is standard. The core of its command set is compatible with the industry's mainstream offerings. It supports single-SPI, dual-SPI, and quad-SPI operations. The product is available in multiple package types with standard pinouts.

With ultra-low energy consumption, the AT25EU family extends battery life and is ideal for battery-powered applications and is especially beneficial for coin-cell-operated systems.

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2. Low Current Consumption of Major Operations

The AT25EU consumes much less current during read, erase, and program operations when compared to standard flash devices. To demonstrate that, we looked at the AT25EU0021A, the 2-Mbit flash memory product from the AT25EU family. We compared it to two similar products from major flash vendor:

- Product A is a wide- V_{CC} (1.65 V-3.6 V), 2-Mbit flash memory.
- Product B is a 1.8 V,2-Mbit flash memory.

Below are current consumptions of three major operations.

Category	AT25EU0021A	Product A	Product B	Units	Comments
read current	1	2.2		mA	(at 33 MHz) AT25EU consumes 55% less
	1.1		4	mA	(at 50 MHz) AT25EU consumes 73% less
	1.5			mA	(at 85 MHz) data point n/a for others
program current	1.5	3.5	15	mA	AT25EU consumes 57%/ 90% less
erase current	1.5	3.1	15	mA	AT25EU consumes 52%/ 90% less

3. Erase Time

Erase operations are available on the AT25EU devices in four memory block sizes:

- Page (256 bytes)
- 4 kBytes
- 32 kBytes
- 64 kBytes
- Chip (entire memory array)

Regardless of the erase block size, the typical AT25EU device erase time is constant: typically 8 ms. This is extremely fast compared to standard flash offerings. Below is a comparison of the AT25EU0021A erase time for the same competing products mentioned above.

Category	AT25EU0021A	Product A	Product B	Units	Comments
Page erase time	8	n/a	n/a	ms	
4k Block erase time	8	58	45	ms	AT25EU takes 86%/82% less time.
32 kB lock erase time	8	400	150	ms	AT25EU takes 99%/96% less time.
64 kB lock erase time	8	800	180	ms	AT25EU takes 98%/95% less time.
Chip erase time	8	7500	500	ms	AT25EU takes 99.9%/98% less time.

4. Page Erase

The page erase feature of the AT25EU family is quite unique. In standard flash products, every write operation, as small as writing a few bytes, requires erasing a 4 kByte block as a minimum. The AT25EU devices require erasing only of one page or 256 bytes. For applications that make small random write operations, this is ideal.

Let's look at a case where an application needs to modify one byte in the memory array. This is the sequence of operations for the AT25EU family of devices compared to a standard flash device.

AT25EU	Standard Flash
Copy page (256 bytes) to RAM	Copy 4 kBytes to RAM
Modify one byte in RAM	Modify one byte in RAM
Erase page	Erase a 4 kByte block
Program page from RAM	Program 16 pages from RAM

This is a scenario that applications try to avoid, if possible, by combining write operations. However, it puts much less pressure on applications using an AT25EU device because it reduces the number erase/program cycles applied to each memory cell. In fact, it reduces the complexity of software algorithms used to combine writes to big blocks in order to avoid over-cycling.

5. Energy Consumption

The combination of lower current consumption and much shorter erase times makes the AT25EU consume much less energy in write operations. Energy, of course, is calculated by multiplying power and time.

Energy = power x time = current x voltage x time

Here are a few examples of the AT25EU energy consumption compared to the competing standard products mentioned above.

Category	AT25EU0021A	Product A	Product B	Units
4 kByte block erase	22	324	1215	µJ
Chip erase	22	41850	13500	µJ
Write 256 bytes	30	525	1388	µJ
Write 4K bytes	160	525	1388	µJ

6. Conclusion

The new AT25EU family of devices of NOR flash products feature ultra-low energy consumption. They consume very low current, especially during read, erase, and write operations. This, combined with an unrivaled erase time that is fixed and unaffected by the erased block size, often results in an order-of-magnitude lower energy during flash write operations when compared to standard flash devices of the same memory size.

7. Revision History

Revision	Date	Description
A0	08-2022	Initial release.
A1	11-2023	Corrected table in Section 3.

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

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