International Journal of Emerging Engineering Research and Technology
Volume 3, Issue 11, November 2015, PP 71-76
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Understanding an Fram Technology Using MSP430 Microcontroller

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ABSTRACT

FRAM is a non volatile random access memory that uses a ferroelelctric capacitor to store the data, which retains stored data even when power is turned off. It offers higher write speed, data retention and endurance over Flash/EEPROM. This technology has been applied to manufacture a family of flow density memories that combine the fast write and reads of SRAM and non volatility of EEPROM with very high read/write endurance. FRAMs have been expressed in many applications such as smartcards, low density memories. FRAMs ares forefront of non volatile memories. Future technologies include high density products with high endurance, data retention and the ability to work at lower voltage. Finally, FRAM technology will become the superior non volatile memory technology by the end of decade.

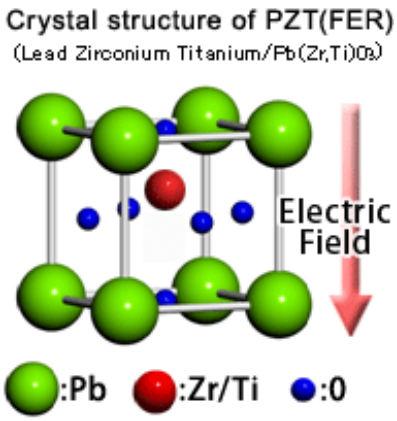
Keywords: Ferroelectric materials, FRAM technology, PZT crystal, MSP430microcontroller, MSP430FR5969.

INTRODUCTION

Established semiconductor memory technologies are classified into different categories. RAMs are random access memories, which have symmetric read and write access time.RAM is volatile memory, it can hold the temporarily. Non volatile memories are traditionally ROM (Read only memory) i.e., floating – gate technology produces electrically erasable memories like flash and EEPROM These products allows system programming's but write and access times are dissimilar. FRAM is a true non-volatile RAM because it combines the advantages of both non volatile and RAM memories. The write advantages of Flash or EEPROM and non-volatility make it quite suitable for storing data while power is turned off.

FRAM STRUCTURE

FRAM is also known as FeRAM. A single FRAM cell can be considered a capacitor it consists of a ferroelectric material between two electrode plates. This structure is made up of PZT crystal complex. Here we have to apply an electric field across the crystal, it causes the mobile retained when power is turned off, which makes FRAM is non-volatile. Here data can be stored in the form of "0"or "1".



Here Polarization occurs when an electric field is applied. Electric field polarization remains present even in the absence of an electric field. Here two stabilized states are stored in the form of 1 or 0 data.

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FRAM OPERATION

A Ferroelectric crystal has a mobile atom in the centre of the crystal. Whenever applying an electric field across a face of the crystal, it causes this atom to move in the direction of the given field. While reversing the field causes the atom to move in the opposite direction. Here atom positions at the top and bottom of the crystals are stable. Therefore removing an electric field leaves the atom in a stable position, while turning of the power. In case, a memory element, the ferroelectric crystal creates an digital memory.

Write Operation

All FRAM accesses are limited to 125 nanoseconds or 8MHs access frequency. However, the MSP430FRxx family supports system speeds up to 16 MHz or 24 MHz for the MSP430FR59xx devices, the wait –state generator can be controlled automatically or manually. As with a read, the change of state occurs in under 1ns with a full access taking under 700ns. As with a read operation , a pre charge operation follows a write access memory.

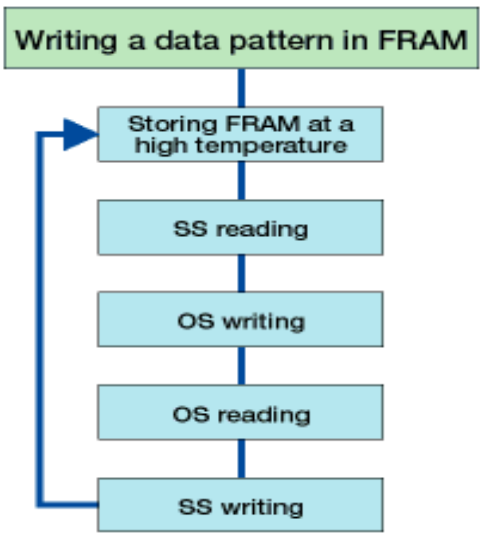
Read Operation

An electric field is applied across the capacitor. Then the mobile atoms will be moved across the crystals in the direction of the field if they are not already in the appropriate positions. The state which occurs in under one nano sec, with the total circuit access taking less than 70ns. Since read operation memory involves a change of state, the circuit will automatically restore the memory state. Therefore each read access is accompanied by a pre charge operation that restores the memory state. Although the read is destructive, the time during which the memory cell is invalid is under 50 ns.

RELIABILITY OF FRAM

Same-state refers to the logic state of FRAM; that is, the state of polarization of the Fram ferroelectric crystal prior to the high-temperature bake whenever testing for imprint. • Opposite-state refers to the polarization of the given crystal in a direction of opposite state to that in which it was imprinted. To test for imprint, a data configuration with a set logic state is written onto FRAM, and then the device is exposed to a high-temperature i.e., 125°C. This temperature bakes the bit-cells in one logic state referred to as similar-state. This temperature bake is followed by a read-restore to further strengthen the same-state data. Opposite-state data is written into an FRAM. This state is followed by a thermal depolarization bake to stress the opposite-state data. This temperature bake is performed at the maximum operating temperature for the device (85°C for the MSP430). After the depolarization is completed, then the data is read out to ensure the integrity of the reverse-state data. Then the test is repeated until the testing time is reached. The opposite-state identifies potential imprint issues, while the read operation protects that the FRAM cells have maintained the ability to be polarized with opposite-state data as well maintained enough polarization to be read access without data loss. MSP430 FRAM data retention is tested for a cumulative bake time of 1000 hours at 125°C.

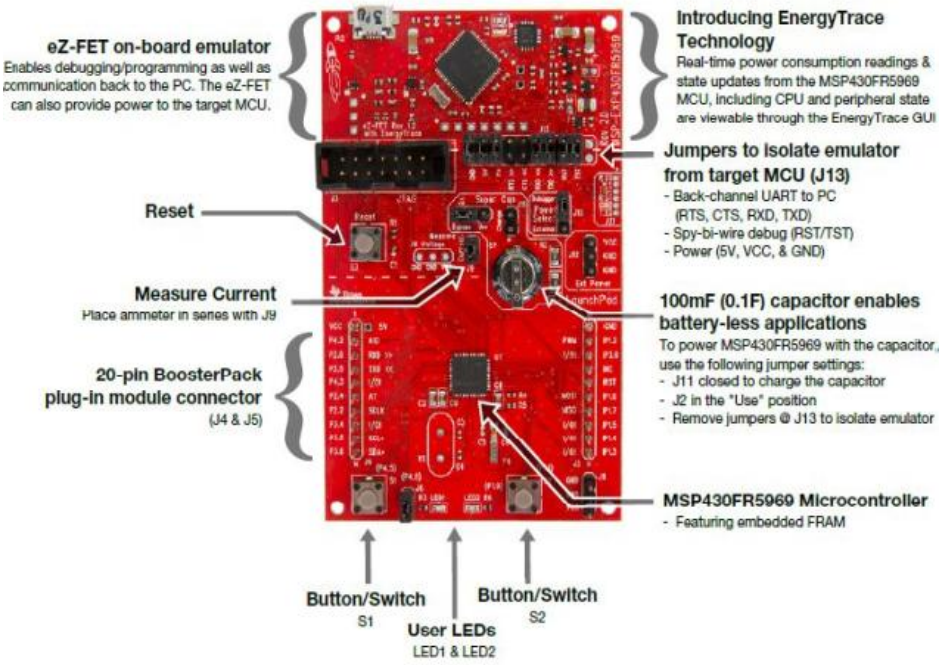
Test Flow



SS: Same state OS: Opposite state

HARDWARE IMPLEMEMNTATION

The MSP430FR5969 launch pad is an easy to use consideration module for the MSP 430FR5969 microcontroller. This MSP430FR5969micro controller contains everything needed to start developing on MSP430's ultra low power FRAM technology; it includes on-board emulation for pre-programming, debugging and energy measurements. The board features on-board buttons and LED's for high speed integration of a simple user interface as well as a capacitor that allows standalone applications without applying an external power supply. The MSP430FR5969 microcontroller device features embedded FRAM a non volatile memory known for its, maximum high endurance high speed and ultra low power write and read access.



MSP-EXP430FR5969 Overview

The Texas instruments MSP430FR59xx family of ultra low power microcontroller consist of several devices featuring different sets of peripherals. The architecture, joined with seven low power modes are efficient to achieve extended battery life for example in portable measurement applications. The device features a powerful 16 bit registers and constant generators that contribute to maximum code efficiency. The MSP430FR5969 devices are mixed signal microcontroller configurations with up to five 16 bit timers, comparator, universal serial communication interfaces supporting UART, SPI, I2C and hardware multiplier, 12 bit ADC. The FRAM memory can be programmed through the JTAG port, spy-bi-wire, the BSL, or in system by the CPU. Features of MSP430FR5969 FRAM memory include: Ultra low power and ultra fast write non volatile memory, Byte and word access capability and Programmable wait state generation.

SOFTWARE IMPLEMEMNTATION

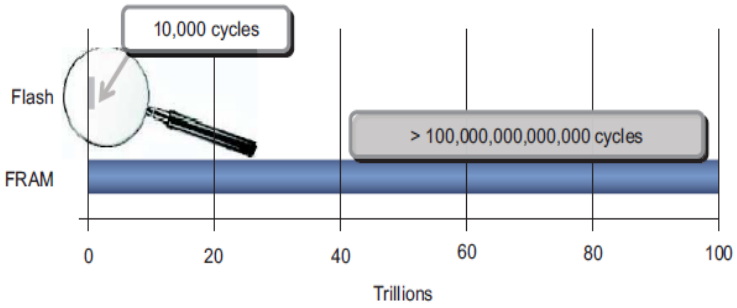
Code Composer Studio

CCS is the integrated development environment for TI's DSP, microcontroller and application processors. It includes compilers for each of TI's device families, source code editor, project build environment, debugger, profiler, simulators and many other features. Following are the steps for implementing application.

- Open CCS and select a workspace directory.
- Select project > import existing CCS/CCE eclipse project.
- Make sure the project is selected and click finish.
- Build and Debugg the code on MSP430F5529.
- Connect "eZ-FET" USB to the PC.

FRAM FEATURES

Write Endurance



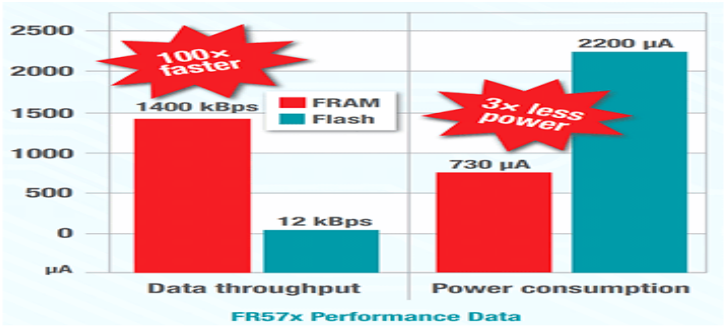
The endurance of maximum 10^13=10 trillion write/read cycles. FRAM Endurance is more than 10 million times of EEPROM.

Data Performance

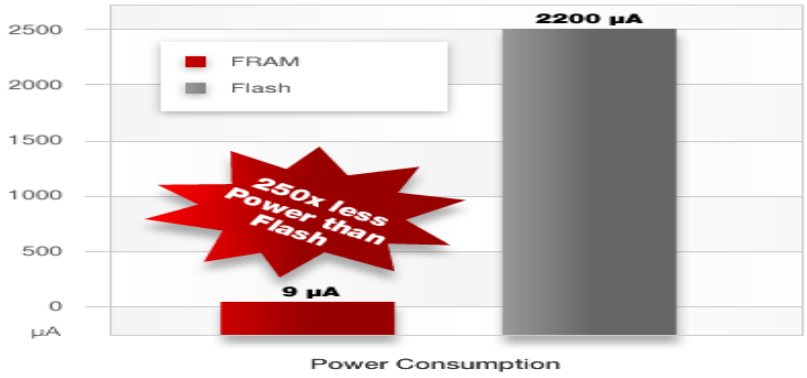
FRAM maximum throughput is greater than 100times faster than flash maximum throughput, while still consuming 3times lower power than flash.

FRAM maximum throughput=1400kbps@730µA

Flash maximum throughput=12kbps@2200µA.



Power Consumption:



FRAM memory consumes 9µA @12 kbps

Flash memory consumes 2200µA @12kbps.

8. APPLICATIONS

FRAM memory technologies are used in different applications, those applications are

Metering:

Power meters, gas meters water meters and smart meters.

Industrial machines:

Control units, PLC, motors, process monitors robots, solar power, ATM, vending machines, elevators, breakers.

Consumer Electronics:

Car navigation systems, drive recorders, games, battery and ID cards for authentication.

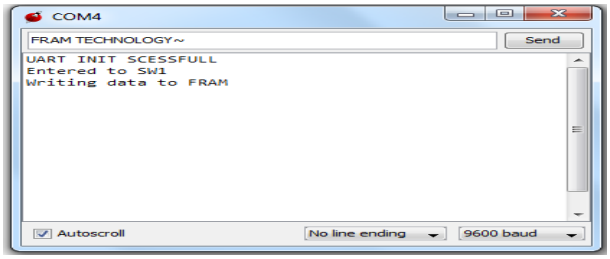
Medical field:

CT scan, Insulin pump, vital meters and oxygen saturation meters.

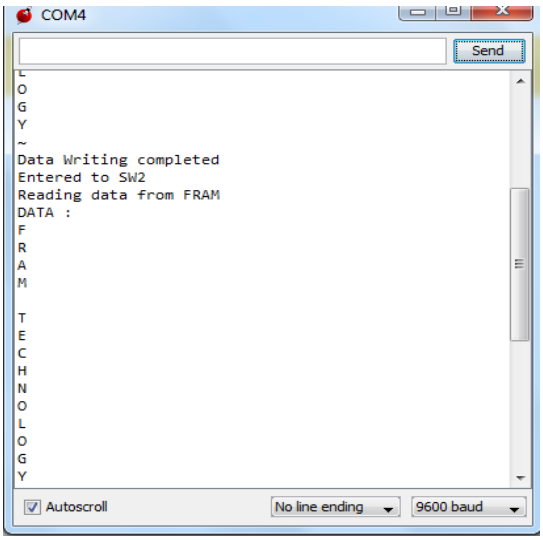
RESULT

The implementation of UNDERSTANDING AN FRAM TECHNOLOGY USING MSP4305969 MICROCONTROLLER is done successfully. Communication between microcontroller and system work is properly done. In our project writing to FRAM and reading from FRAM is successfully done.

Writing to an FRAM



Reading from an FRAM



Writing to FRAM and reading from an FRAM successfully done. In our project, the writing and reading data is retained whenever the power is turned off Since FRAM is non-volatile memory technology.

FUTURE SCOPE AND CONCLUSION

FRAM is undoubtedly the fastest non volatile embedded memory option available today. Being embedded with the ultra-low power MSP430 architecture makes it a perfect choice for applications needing extremely fast write speeds, low power and high endurance. Some of these applications include data logging using remote sensors, energy harvesting applications, and critical response time

applications. The key factors that influence the maximum possible FRAM write throughput were discussed and the tradeoffs presented. In analyzing the bench test results for the MSP430FR5969, it is seen that the achievable practical write speed is very close to the theoretical maximum. It is up to the user to determine the available resources and design their application in a way that can achieve the fastest possible write speed for FRAM.

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