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MRAM supports sensor data, machine learning for longer, more complex space missions

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Mission to Mars, colonization of the moon, missions to the stars, and other long-term space exploration projects are in various stages of becoming reality. As one might suspect, each of these endeavors includes a large information gathering and problem-solving exercise to reduce chances of failure.

As these missions are significantly more complex than the missions we are all familiar with, such as the International Space Station, the Shuttle program, the Apollo missions to the moon, and even automobile telematics, predicting all the possible problems and outcomes increases exponentially based on both length of mission and complexity. This calls for an approach to development that includes intelligence to allow the determination of problems, and more importantly, to affect a solution and deploy it. Intelligent solutions, working alongside human astronauts and engineers can drastically reduce chances of failure.

As magnetoresistive random access memory (MRAM) technology becomes increasingly robust and available, it presents itself as a viable candidate to be developed into systems that learn and store sensor data, allowing learning systems to be developed.

This short discussion will explore some of the opportunities that MRAM can fulfill.

Characteristics making MRAM a memory of choice

MRAM has many features that make it an excellent choice for high-reliability (hi-rely) and exo-earth applications (Bennett, 2017). All the features of MRAM will be of paramount importance to achieve acceptance in the applications hypothesized above.

These characteristics include immunity to Single Event Upsets from differing forms of external radiation, virtually unlimited endurance, symmetric writes and reads, and very low power operations. Oftentimes, the speed is higher and the power is lower than dynamic random-access memory (DRAM) of equivalent density. All these attributes will be required to achieve the needs of long space travel.

As power will be limited and may even reduce as a spacecraft gets farther from our Sun (solar), or allowing a reduction in the power generation system used for these projects (nuclear), the speed (lower power due to cycle time) combined with the extremely low power for reading and writing inherent in the MRAM memory cells allows for more information to be processed while reducing the power requirements. As MRAM does not require a high-speed ongoing refresh cycle, the overall sustained system power requirements are ultimately reduced.

Error tolerance/recovery

Single Event Upsets, noted above, will need to be tolerated, and in fact corrected by the memory systems used in these future exploration projects. This is in addition to the basic memory configurations that will require error recovery mechanisms to be built into the memory arrays. As MRAM is a probabilistic memory device, a minute chance of a read error, when reading, and of a write error, when writing the device, exists.

Spin Transfer Technologies (STT) has developed methods to eliminate these errors through the use of several unique circuits that exist in the devices and arrays. These “Engines” provide the user with exceptional endurance and static random access memory (SRAM)-like, error-free operation. These same circuits can be applied to external events such as Single Event Upsets.

As complexity grows

In any autonomous system, a complete record of the inputs received and the actions executed must be kept in a journal or “log”. This implies a large number of sensors to record every activity of every function on board the craft, and the processing of this data to perform preventive as well as reactive feedback to prevent accidents.

By introducing low-power, non-volatile, memories to record this data, embedded into the controlling Integrated Circuits, the complexity of interconnect (fabric) used to capture and analyze these sensor outputs can be significantly reduced. In another paper written by STT, the complexities of the fabric usage in an automobile (the CAN bus) can be overtaxed to maintain the data flow as sensors are added. In more complex systems such as those described above, solving these problems could take a very long time, whereas the use of a small, local, non-volatile memory in the myriad sensors can significantly reduce this development by removing real-time constraints.

Interconnect will be simpler and the development of new interconnect will be determined by a different set of criteria no longer relied upon to manage all of the traffic in real time. Instead it would retrieve the recorded (logged) data in a background mode, or perhaps only when a post mortem is required. This becomes important to where development time is spent — more on algorithms and less on error recovery trees, reducing code complexity.

How MRAM enables a bright future for space travel

In proposing the use of MRAM in these near and far future systems to record events, record decisions made by other compute engines and assure accurate snapshots of the control functions and sensor-enabled components, it is possible to spend a significant amount of the development time on the algorithms that can mine this data to determine future failures, rather than to attempt to fix every human-conceived problem. This will lead to more machine learning and actions to help the engineering staff on these longer space missions to solve problems quickly and completely.

Conclusion

The future of flight and space travel is bright, and several companies have thrown out predictions on when some of these opportunities can be attempted. All the companies that are involved in this type of activity see the longer-term hurdles that must be overcome to make these complex efforts successful.

Defining an architecture that includes MRAM as a basic component of the subsystems, and taking advantage of the superior characteristics that MRAM provides to solve memory problems with high endurance, low power and with the added benefit of non-volatility, the requirements for systems developed to control these complex aircraft or spacecraft can be created in the simplest, most robust reduction to practice.

All designs are based on the idea that continuing process improvement is a desire, and with the latest technology advancements (which include MRAM), the availability for collection of large amounts of pertinent data enables a huge reduction in time to develop solutions for pathological error cases. These systems can be tested on the ground as well as in the final designs, thus allowing acceleration in the development time of the subsystems. This will be important for companies interested in participating in the new private sector-enabled space race to achieve the timelines they have set as goals.

REFERENCES

Bennett, Duncan (2/2017) Retrieved from: http://aerospacedefence.electronicspecifier.com/airforce/mram-earns-its-stripes-in-hirel-applications

ABOUT THE AUTHOR

Bob Warren has been in the storage industry for over 33 years. He began his career designing switching power supplies and developing signal processing hardware for automated fingerprint identification systems. Bob developed storage controller subsystems to house this fingerprint data initiating a career in memory, including storage systems, HDD and SSD controllers and other memory controllers. Developing a 1GB solid state drive based on DRAM in 1996 for Micro Technology Inc. (MTI), Bob gained an appreciation for the impact of differing memory types and their value to storage.

As System Architect for Western Digital and later Seagate, he was responsible for developing the hardware and firmware required for several generations of storage, both rotating and solid state. During this tenure, Bob did initial development of the world's first hybrid hard disc drive (both rotating and NAND memory media), and prototyping NAND flash based solid state drives, as well as looking at applications for emerging memory types. At LSI corporation, Bob architected rotating and solid-state disk controllers for flash and emerging memory technologies for internal and external use. This continued at Micron Technology.

Bob believes that the convergence of these new memory technologies, coupled with the rate of advancement of the other disciplines required to support these memories, enable far reaching artificial intelligence goals, including self-repair and redundant systems for failure mitigation.

Bob has presented keynotes at two technical conferences, IMW 2011 and Cadence Design Conference 2016 and has 25 US Patents at five different companies. He is currently working with Spin Transfer Technology to advance MRAM, one of these exciting new technologies.