# Radiation Hardened by Design SONOS embedded Non-Volatile Memory in 180nm

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In this article we report about a design of new mixed-signal eNVM IP in XFAB 180nm technology with HV and SONOS (silicon–oxide–nitride–oxide–silicon) options and hardened against radiation effects. The purpose is to create a non-volatile memory (eNVM) solution for space applications. The design is in final completion stage and test vehicle building is due to be sent to manufacturing shortly afterwards.

The main specifications of the IP are memory size 256x64 of 32-bit words, clock frequency 16MHz (+/-10%), power supply 1.8V/3.3V, area 21.15mm2.

The IP consists of three main parts: digital controller, full custom memory core and high voltage control with third-party charge pump IP (provided by XFAB).

This IP is in scope of DARE180XH platform, in XFAB’s xh018 technology.

The mission profile does not imply to use HV operations like program and erase. So, the design boundaries were dictated by the mission requirements. That is why radiation hardening design efforts were concentrated on data safety in read operations.

To address the overall data integrity threats, ECC with data path scrubbing and scrambling/descrambling were implemented. Variable-speed read operation and triple read options were made available for the user to increase confidence in read safety. Degradation caused by TID effects and general aging is mitigated by limited self-calibration techniques.

Further immunity of the analogue circuitry against TID and latchup is preserved by layout design. For that purpose, special DRC were implemented. To improve read operations in harsh environment, especially at the end of life, configurable sense amplifiers were developed.

For testability and functional safety, DFT approach was used.

The digital memory controller was synthesized from RTL and was mapped to a radiation hardened standard cell library with DICE flops and specially designed combinational cells for clock and reset signals SET hardening. Furthermore, all analogue and digital IP blocks were systematically scanned for SET sensitive nodes using an in-house tool and special testbenches. SET filters were added on all critical control signals to improve SEE behaviour.

The test vehicle containing this IP is expected to be taped out in Q2 2022. The characterization, irradiation and reliability tests are planned to use the test vehicle. Space-grade radiation hardened memory is expected to be ready for production in 2023.

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