DG0388
Demo Guide
SmartFusion2 SoC FPGA Error Detection and Correction of eSRAM Memory

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Contents

Figures

Tables

1 Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the current publication.

1.1 Revision 11.0

The following is a summary of the changes made in this revision.

- Updated the document for Libero SoC v12.6.
- Removed the references to Libero version numbers.

1.2 Revision 10.0

Updated the document for Libero SoC v11.8 SP1 software release.

1.3 Revision 9.0

Updated the document for Libero SoC v11.8 software release.

1.4 Revision 8.0

Updated the document for Libero SoC v11.7 software release (SAR 77402).

1.5 Revision 7.0

Updated the document for Libero SoC v11.6 software release (SAR 72777).

1.6 Revision 6.0

Updated the document for Libero SoC v11.5 software release (SAR 64979).

1.7 Revision 5.0

Updated the document for Libero SoC v11.4 software release (SAR 60476).

1.8 Revision 4.0

Updated the document for Libero SoC v11.3 software release (SAR 56852).

1.9 Revision 3.0

Updated the document for Libero SoC v11.2 software release (SAR 52960).

1.10 Revision 2.0

Updated the document for Libero SoC v11.0 software release (SAR 47858).

1.11 Revision 1.0

The first publication of this document.

2 SmartFusion2 SoC FPGA - Error Detection and Correction of eSRAM Memory

2.1 Introduction

This document describes the Error Detection and Correction (EDAC) capabilities of the SmartFusion®2 devices on the embedded static random access memory (eSRAM).

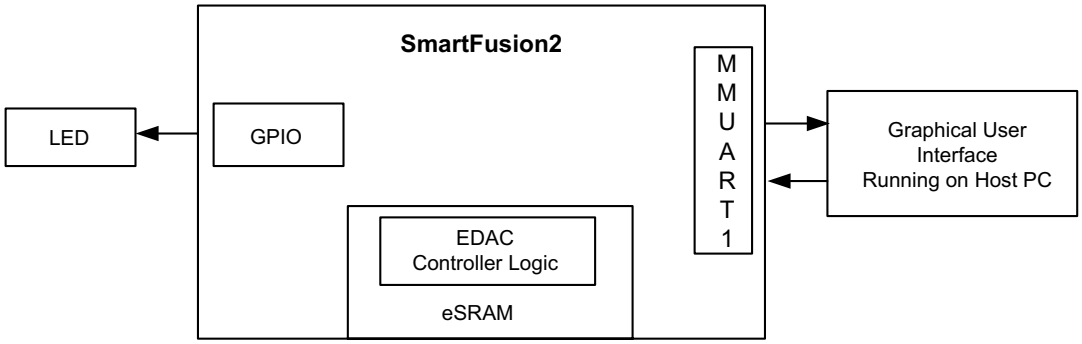
The EDAC controllers implemented in the SmartFusion2 devices support Single-Error Correction and Double-Error Detection (SECDED). All memories within the Microcontroller Subsystem (MSS) of the SmartFusion2 are protected by SECDED. The eSRAM memory can be eSRAM_0 or eSRAM_1. The address range of eSRAM_0 is 0x20000000 to 0x20007FFF and the address range of eSRAM_1 is 0x20008000 to 0x2000FFFF.

When SECDED is enabled:

- A write operation computes and adds 8 bits of SECDED code to every 32 bits of data.
- A read operation reads and checks the data against the stored SECDED code to support 1-bit error correction and 2-bit error detection.

In this demo, the EDAC can be identified by the blinking Llight-Emitting Diode (LED) on the board and by the Graphical User Interface (GUI).

Figure 1 • **Top-Level Block Diagram**



The EDAC of eSRAM supports the following features:

1. SECDED mechanism
2. Provides interrupts to the ARM Cortex- M3 processor and FPGA fabric upon the detection of a 1-bit error or 2-bit error.
3. Stores the number of 1-bit and 2-bit errors to the error counter registers.
4. Stores the address of the last 1-bit or 2-bit error affected memory location.
5. Stores 1-bit or 2-bit error data into the SECDED registers.
6. Provides error bus signals to the FPGA fabric.

Refer to the EDAC chapter of the *UG0443: SmartFusion2 and IGLOO2 FPGA Security and Reliability User Guide* and the eSRAM chapter of the *UG0331: SmartFusion2 Microcontroller Subsystem User Guide*.

2.2 Demo Requirements

The following table lists the hardware and software requirements for running the demo design.

Table 1 • **Design Requirements**

Requirement	Version
Operating System	64 bit Windows 7 and10
Hardware	
SmartFusion2 Security Evaluation Kit: • FlashPro4 programmer • USB A to Mini - B USB cable • 12 V Adapter	Rev D or later
Software	
FlashPro Express	Refer to the `readme.txt` file provided in the design files for the software versions used with this reference design.
Libero® System-on-Chip (SoC) software	
SoftConsole	
Host PC Drivers	USB to UART drivers
For launching demo GUI	Microsoft.NET Framework 4 client

Note: Libero SmartDesign and configuration screen shots shown in this guide are for illustration purpose only. Open the Libero design to see the latest updates.

2.3 Prerequisites

Before you begin:

Download and install Libero SoC (as indicated in the website for this design) on the host PC from the following location.

https://www.microsemi.com/product-directory/design-resources/1750-libero-soc

2.3.1 Design Files

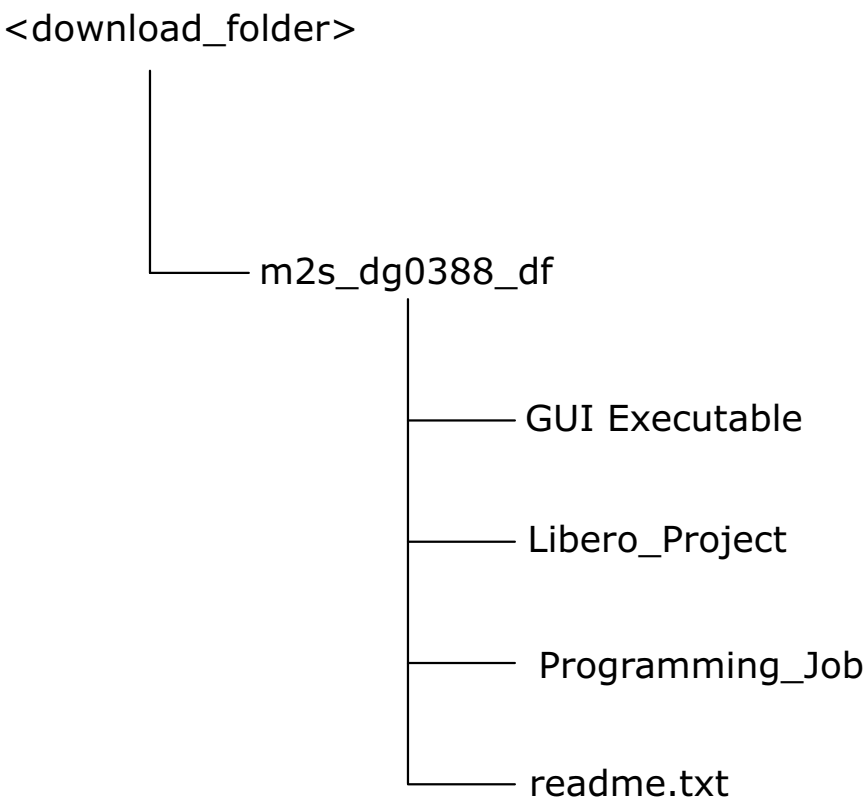
The demo design files are available for download from the following path in the Microsemi website: *http://soc.microsemi.com/download/rsc/?f=m2s_dg0388_df*

Design files include:

- GUI Executable
- Libero_Project
- Programming_Job
- Readme file

The following figure shows the top-level structure of the design files. For further details, refer to the `readme.txt` file.

Figure 2 • **Demo Design Top-Level Structure**



2.4 Demo Design Description

Each eSRAM within the MSS is protected by a dedicated EDAC controller. EDAC detects a 1-bit error or 2-bit error when data is read from the memory. If EDAC detects the 1-bit error, the EDAC controller corrects the same error bit. If EDAC is enabled for all the 1-bit and 2-bit errors, corresponding error counters in the system registers are incremented and corresponding interrupts and error bus signals to the FPGA fabric are generated.

In a Single Event Upset (SEU) susceptible environment, Random Access Memory (RAM) is prone to transient errors caused by heavy ions. This happens in real-time. To demonstrate this, an error is introduced manually and detection and correction is observed.

This demo design involves implementation of following tasks:

- Enable EDAC
- Write data to eSRAM
- Read data from eSRAM
- Disable EDAC
- Corrupt one or two bits
- Write data to eSRAM
- Enable EDAC
- Read the data
- In the case of a 1-bit error, the EDAC controller corrects the error, updates the corresponding status registers, and gives the data written in step 2 at the read operation done at step 8.
- In the case of a 2-bit error, a corresponding interrupt is generated, and the application must correct the data or take the appropriate action in the interrupt handler. These two methods are demonstrated in this demo.

Two tests are implemented in this demo: loop test and manual test, and they are applicable to both 1-bit and 2-bit errors.

2.4.1 Loop Test

Loop Test is executed when the SmartFusion2 receives a loop test command from the GUI. Initially, all the error counters and EDAC related registers are placed in the **RESET** state.

The following steps are executed for each iteration:

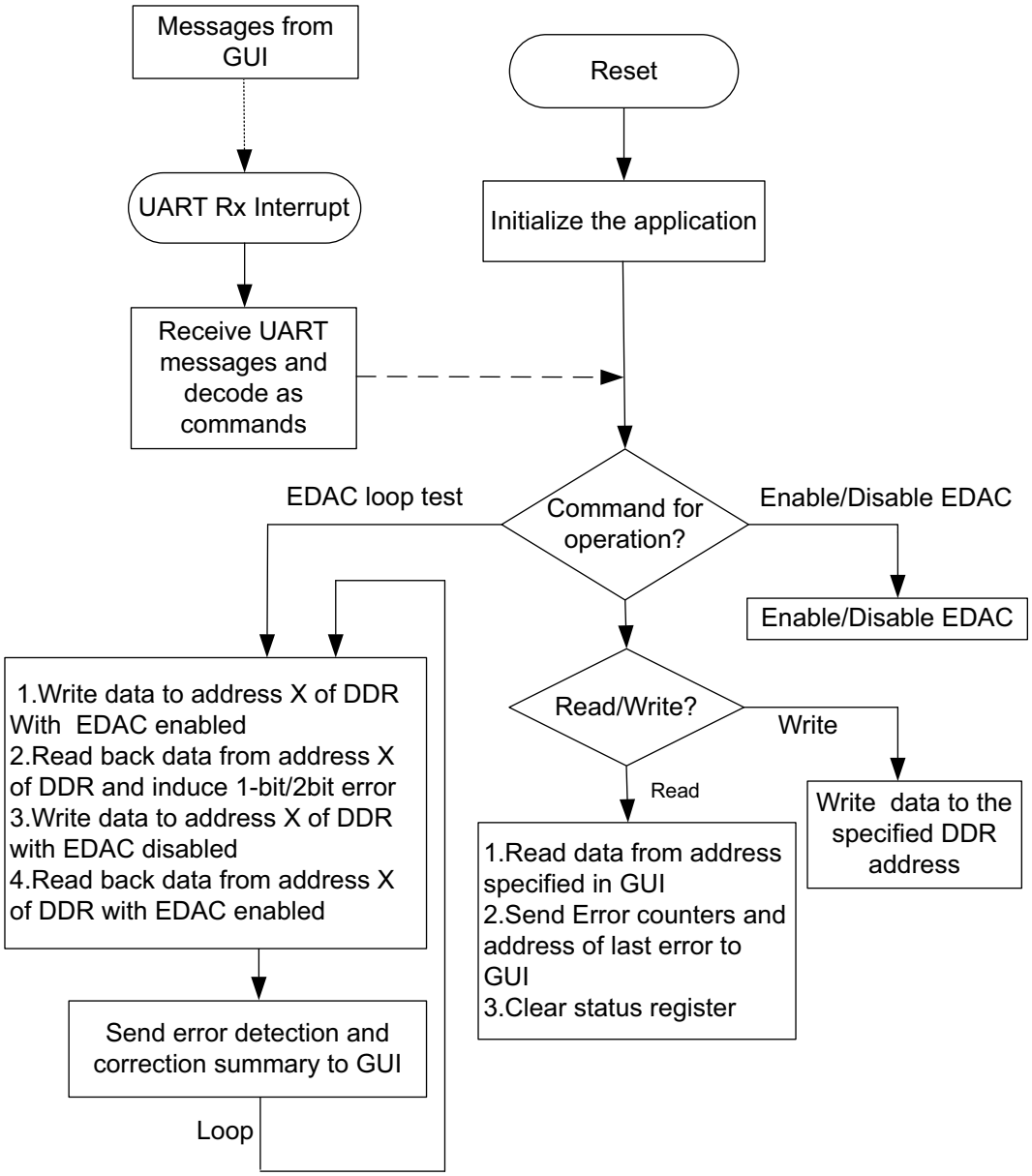
1. Enable the EDAC controller.
2. Write the data to the specific eSRAM memory location.
3. Disable the EDAC controller.
4. Write the 1-bit or 2-bit error induced data to the same eSRAM memory location.
5. Enable the EDAC controller.
6. Read the data from the same eSRAM memory location.
7. Send the 1-bit or 2-bit error detection and 1-bit error correction data in case of 1-bit error to the GUI.

2.4.2 Manual Test

This method allows manual testing for enabling or disabling EDAC and write or read operation. Using this method, 1-bit or 2-bit errors can be introduced to any location within the eSRAM. Enable the EDAC and write data to the specified address using the GUI fields. Disable the EDAC and write 1-bit or 2-bit corrupted data to the same address location. Enable the EDAC and read the data from the same address location then the LED on the board toggles to notify the detection and correction of errors. The corresponding error counter is displayed on the GUI. The GUI Serial Console logs all the actions performed in SmartFusion2.

The following figure shows the eSRAM EDAC demo operations.

Figure 3 • **Design Flow**



2.5 Running the Demo

This section describes the SmartFusion2 Security Evaluation Kit board setup, the GUI options, and how to execute the demo design.

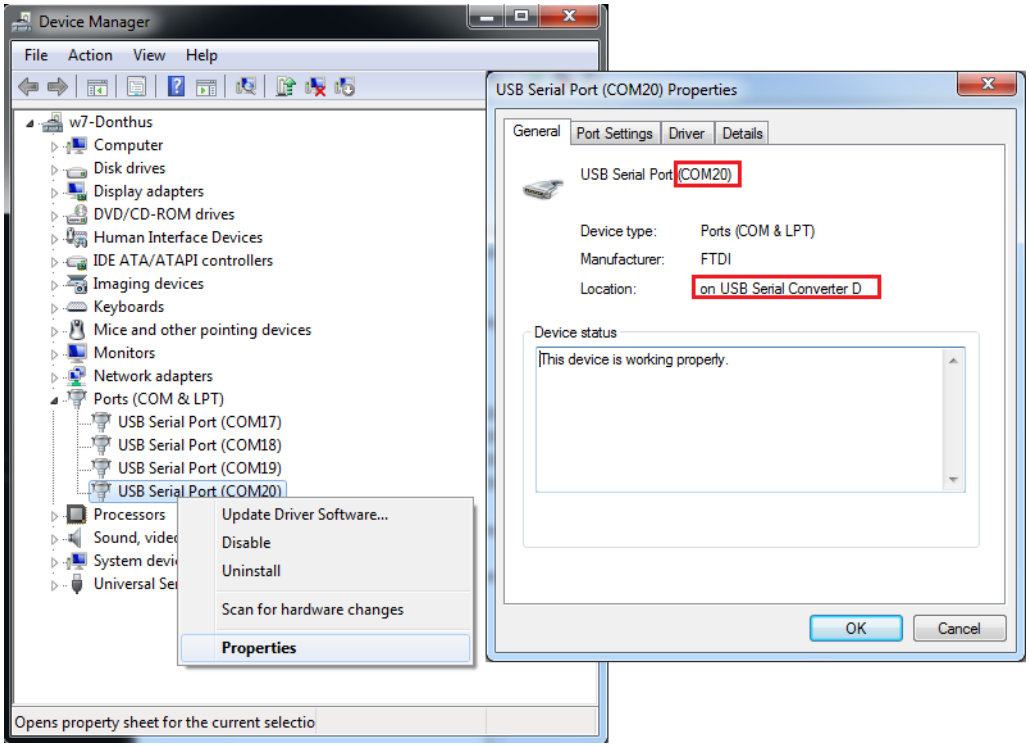
2.5.1 Demo Setup

The following steps describe how to setup the demo:

1. Connect the FlashPro4 programmer to the **J5** connector of SmartFusion2 Security Evaluation Kit board.
2. Connect one end of the USB mini-B cable to the **J18** connector provided in the SmartFusion2 Security Evaluation Kit board. Connect the other end of the USB cable to the host PC. Ensure that the USB to UART Bridge drivers are automatically detected (can be verified in the Device Manager), as shown in Figure 4, page 7.

Note: Copy the COM port number for serial port configuration. Ensure that the COM port **Location** is specified as **on USB Serial Converter D**, as shown in the following figure.

Figure 4 • **USB to UART Bridge Drivers**



3. If USB to UART bridge drivers are not installed, download and install the drivers from *www.microsemi.com/soc/documents/CDM_2.08.24_WHQL_Certified.zip*
4. Connect the jumpers on the SmartFusion2 Security Evaluation Kit board, as shown in the following figure. The power supply switch **SW7** must be switched **OFF** while making the jumper connections.

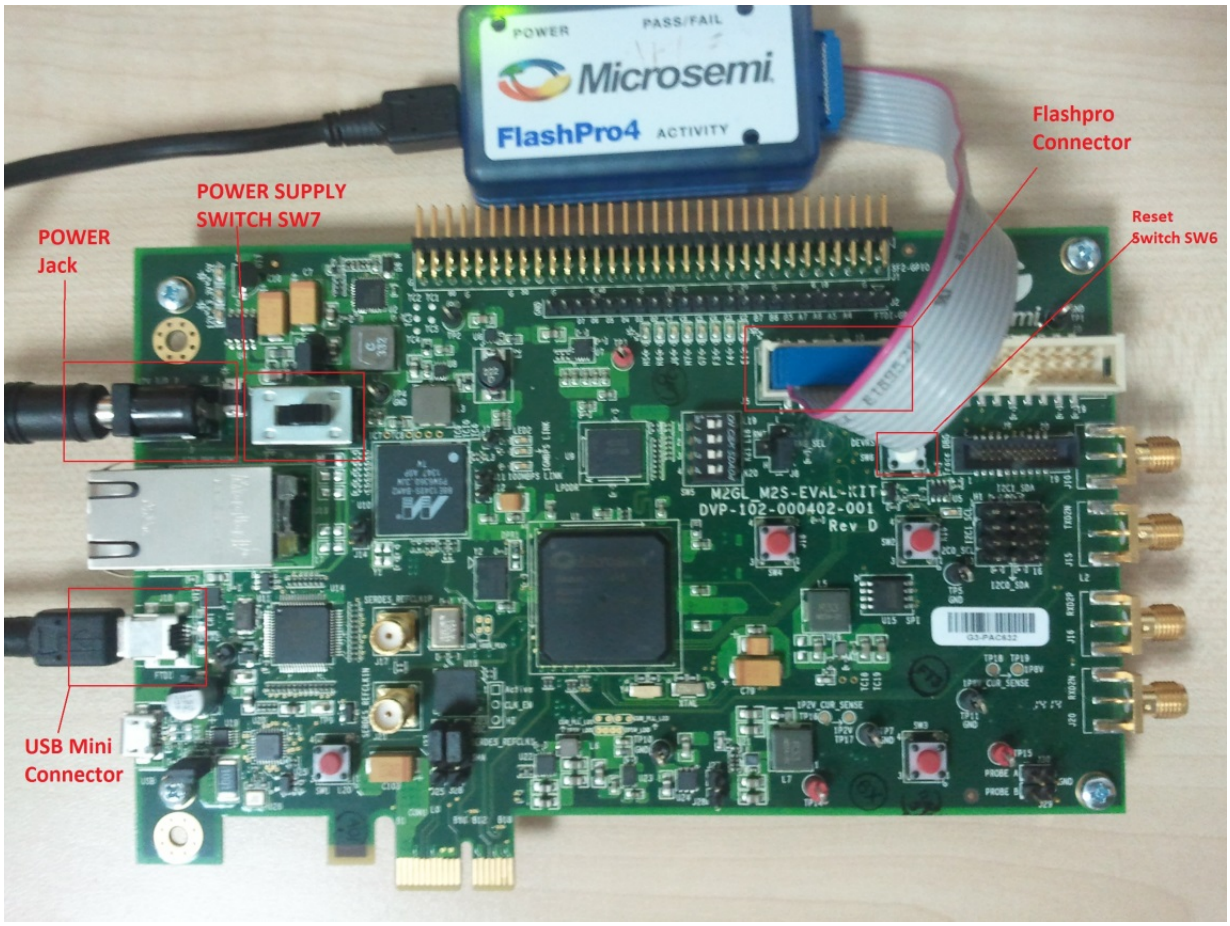
Table 2 • **SmartFusion2 Security Evaluation Kit Jumper Settings**

Jumper	Pin (From)	Pin (To)	Comments
J22, J23, J24, J8, J3	1 (default)	2	These are the default jumper settings of the SmartFusion2 Security Evaluation Kit board. Ensure that these jumpers are set accordingly.

5. Connect the power supply to **J18** connector.

The following figure shows the board setup for running the demo on the SmartFusion2 Security Evaluation Kit.

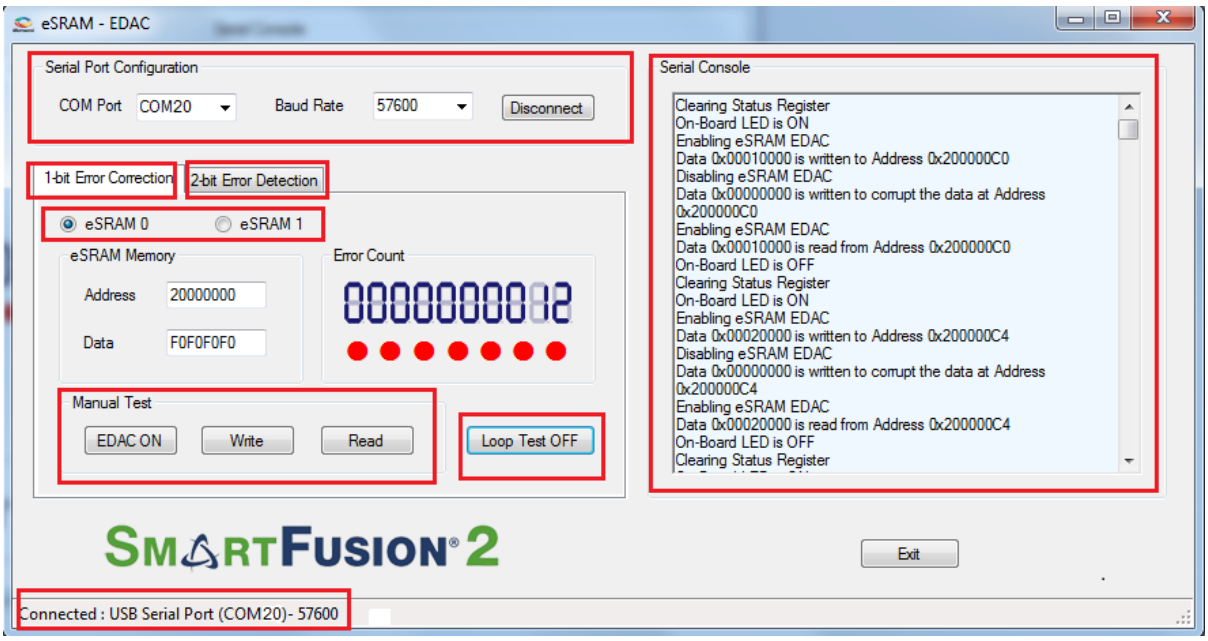
Figure 5 • **SmartFusion2 Security Evaluation Kit Board Setup**



2.5.2 Graphical User Interface

The following section describes about eSRAM - EDAC demo GUI.

Figure 6 • **eSRAM – EDAC Demo GUI**



The GUI supports the following features:

1. Selection of COM port and Baud Rate.
2. Selection of 1-bit error correction tab or 2-bit error detection tab.
3. Selection of eSRAM0 or eSRAM1.
4. Address field to write or read data to or from specified eSRAM address.
5. Data field to write or read data to or from specified eSRAM address.
6. Serial Console section to print the status information received from the application.
7. **EDAC ON/OFF**: Enables or disables the EDAC.
8. **Write**: Allows writing data to the specified address.
9. **Read**: Allows reading data from the specified address.
10. **LOOP test ON/OFF**: Allows testing the EDAC mechanism in a loop method.

2.5.3 Running the Design

The following steps describe how to run the design:

1. Switch **ON** the supply switch, **SW7**.
2. Program the SmartFusion2 Security Evaluation kit board with the job file provided as part of the design files (`\Programming_job\eSRAM_0\eSRAM0.job` or `\Programming_job\eSRAM_1\eSRAM1.job`) using FlashPro Express software, refer to Appendix: Programming the Device Using FlashPro Express, page 12.
3. Press **SW6** switch to reset the board after successful programming.
4. Launch the **EDAC_eSRAM Demo** GUI executable file available in the design files (`\GUI Executable\ EDAC_eSRAM.exe`). The GUI window is displayed, as shown in Figure 6, page 9.
5. Select the appropriate COM port (to which USB to UART Bridge drivers are pointed) from the **COM Port** drop-down list.
6. Select the **Baud Rate** as 57600 and click **Connect**. After establishing the connection, **Connect** changes to **Disconnect**.
7. Select eSRAM 0 or eSRAM 1 depending upon the programming file selected in step 2.
8. Select the 1-bit **Error Correction** tab or 2-bit **Error Detection** tab, as shown in Figure 7, page 10. and Figure 8, page 11.
9. Two types of tests can be performed: Manual and Loop.

2.5.3.1 Performing Loop Test

Click **Loop Test ON**. It runs in loop mode where continuous correction and detection of errors is done. The loop runs for 200 iterations. All actions performed in SmartFusion2 are logged in the **Serial Console** section of the GUI. The 2-bit error detection loop test prints the error affected eSRAM address offset in Serial Console. Click **Loop Test OFF** after 200 iterations are completed.

Table 3 • **eSRAM Memory Addresses Used in Loop Test**

Memory	1-Bit Error Correction	2-Bit Error Detection
eSRAM0	0x20000000	0x20002000
eSRAM1	0x20008000	0x2000A000

2.5.3.2 Performing Manual Test

In this method, errors are introduced manually using GUI. Use the following steps to execute 1-bit error correction or 2-bit error detection:

1. Input Address and Data fields (use 32-bit Hexadecimal values).
2. Click **EDAC ON**.
3. Click **Write**.
4. Click **EDAC OFF**.
5. Just change 1-bit (in case of 1-bit error correction) or 2 bits (in case of 2-bit error detection) in Data field (introducing error).
6. Click **Write**.
7. Click **EDAC ON**.
8. Click **Read**.
9. Observe **Error Count** display and **Data** field in the GUI. The error count value increases by 1.

All the actions performed in SmartFusion2 are logged in **Serial Console** section of GUI.

Note: To switch from **1-bit Error Correction** tab to **2-bit Error Detection** tab or vice versa in EDAC_eSRAM Demo GUI, reset the hardware board.

Figure 7 • **1-Bit Error Correction Tab**

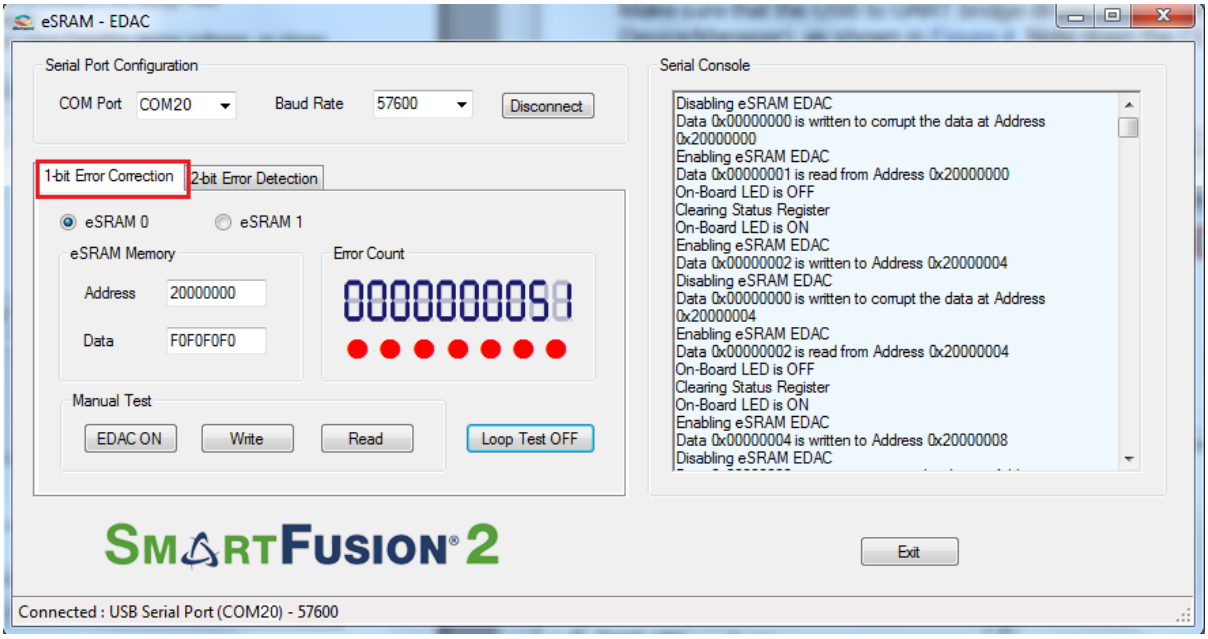
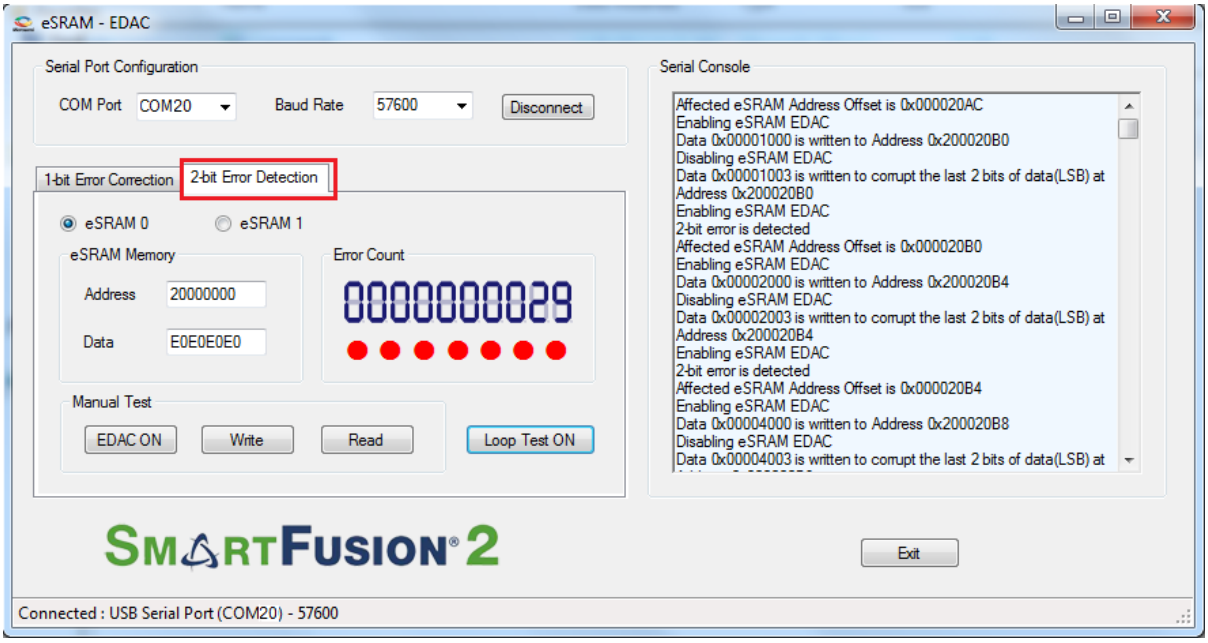


Figure 8 • **2-Bit Error Detection Tab**



2.6 Conclusion

This demo shows SmartFusion2 SECDED capabilities of the eSRAM.

3 Appendix: Programming the Device Using FlashPro Express

This section describes how to program the SmartFusion2 device with the programming job file using FlashPro Express.

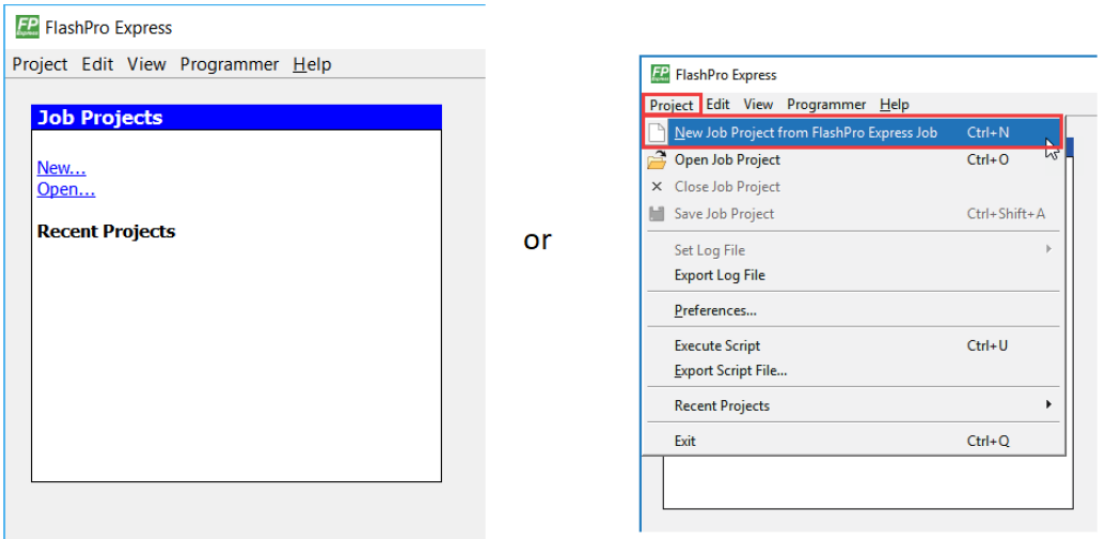
To program the device, perform the following steps:

1. Ensure that the jumper settings on the board are the same as those listed in Table 2, page 7.

Note: The power supply switch must be switched off while making the jumper connections.

2. Connect the power supply cable to the **J6** connector on the board.
3. Power **ON** the power supply switch **SW7**.
4. On the host PC, launch the **FlashPro Express** software.
5. Click **New** or select **New Job Project from FlashPro Express Job** from **Project** menu to create a new job project, as shown in the following figure.

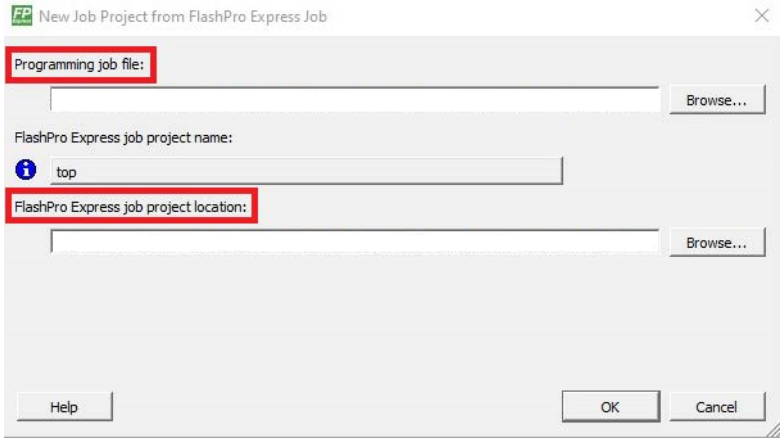
Figure 9 • **FlashPro Express Job Project**



6. Enter the following in the **New Job Project from FlashPro Express Job** dialog box:

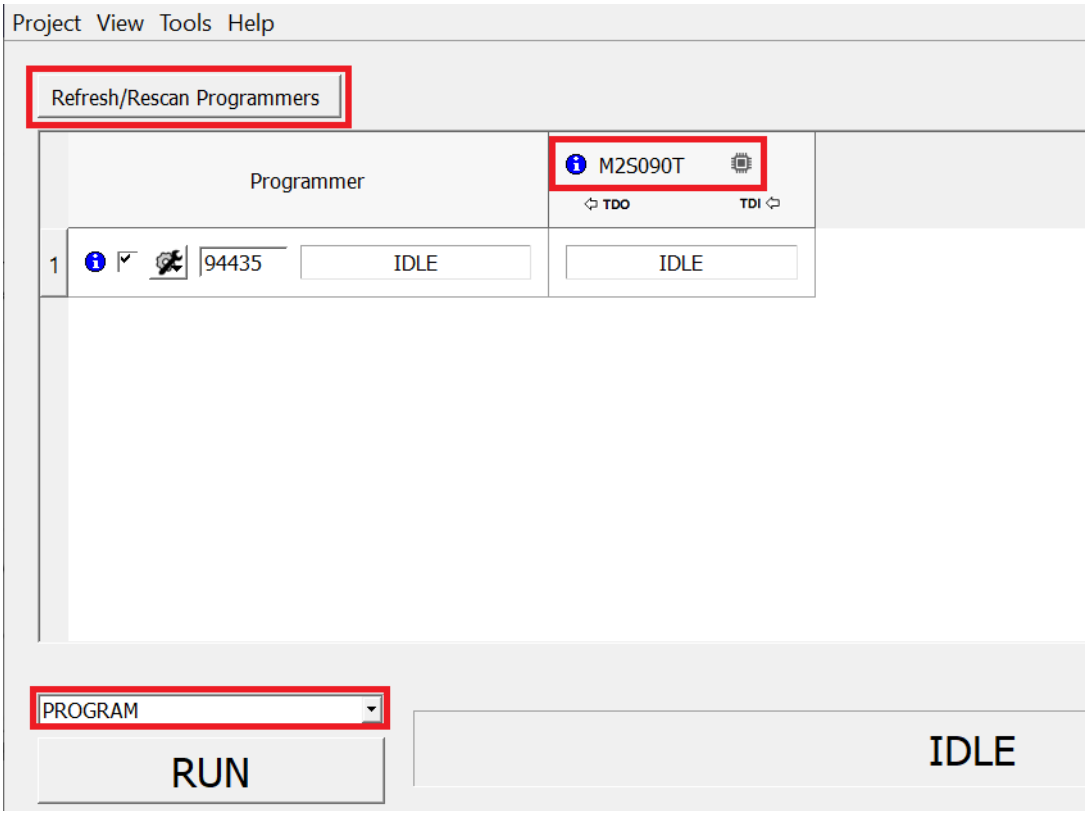
- **Programming job file:** Click **Browse**, and navigate to the location where the .job file is located and select the file. The default location is:
  <download_folder>\m2s_dg0388_df\Programming_Job
- **FlashPro Express job project name:** Click **Browse** and navigate to the location where you want to save the project.

Figure 10 • **New Job Project from FlashPro Express Job**



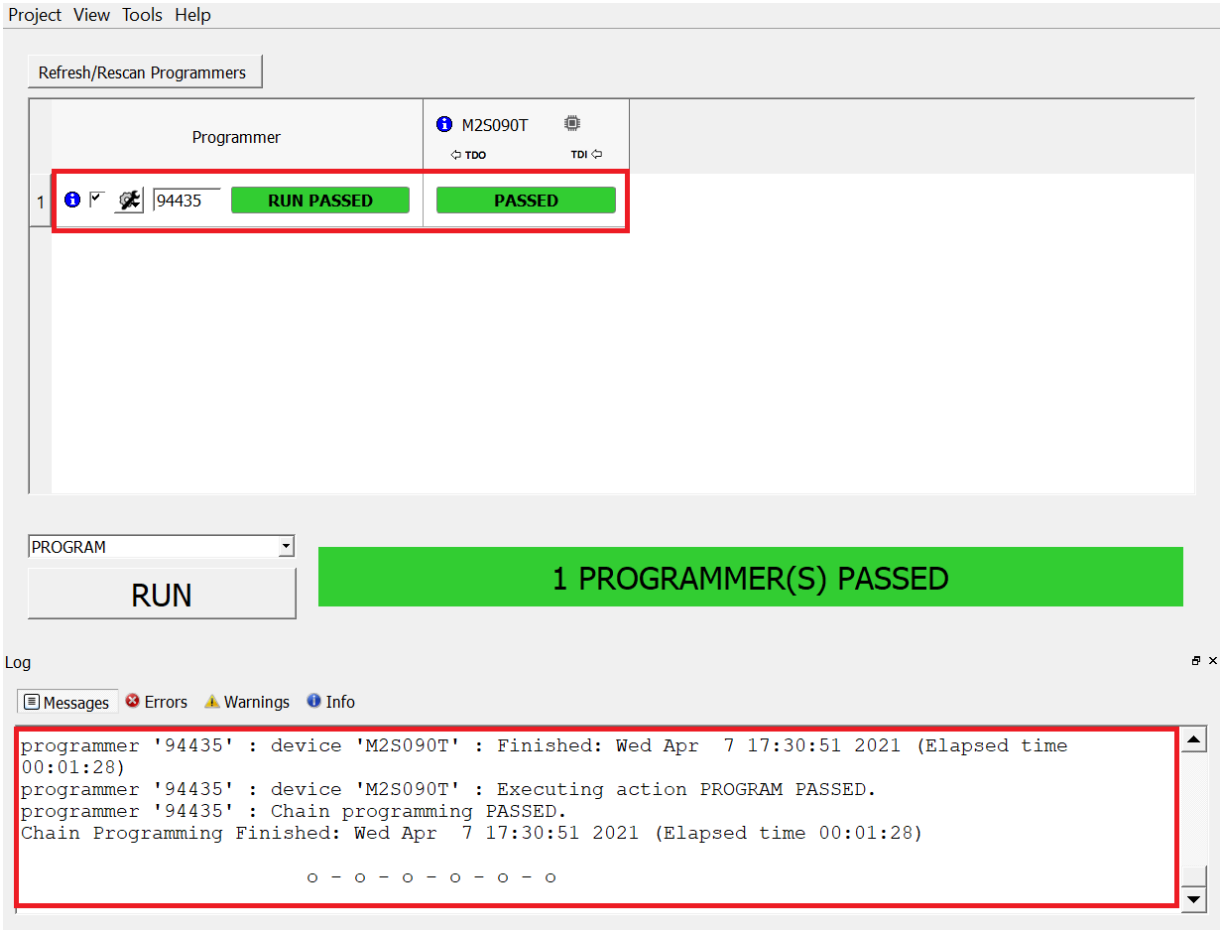
7. Click **OK**. The required programming file is selected and ready to be programmed in the device.
8. The FlashPro Express window appears as shown in the following figure. Confirm that a programmer number appears in the Programmer field. If it does not, confirm the board connections and click **Refresh/Rescan** Programmers.

Figure 11 • **Programming the Device**



9. Click **RUN**. When the device is programmed successfully, a **RUN PASSED** status is displayed as shown in the following figure.

Figure 12 • **FlashPro Express—RUN PASSED**



10. Close **FlashPro Express** or in the Project tab, click **Exit**.