



# **Soft Error Detection (SED)/Correction (SEC) User Guide for Nexus Platform**

## **Technical Note**

FPGA-TN-02076-1.8

July 2023

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## Contents

Acronyms in This Document .....	5
1. Introduction .....	6
2. SED Overview .....	7
2.1. Block Diagram .....	9
3. Port List .....	10
4. Port Descriptions .....	11
4.1. cfg_clk_i .....	11
4.2. sedc_mode_i .....	11
4.3. sedc_start_i .....	11
4.4. sedc_en_i .....	11
4.5. sed_en_i .....	11
4.6. sedc_cof_i .....	11
4.7. sedc_rst_i .....	11
4.8. sedc_busy_o .....	11
4.9. sedc_errc_o .....	12
4.10. sedc_err_o .....	12
4.11. sedc_errm_o .....	12
4.12. sedc_errcrc_o .....	12
4.13. sedc_frm_errloc_o[15:0] .....	12
4.14. sedc_dsr_errloc_o[12:0] .....	12
5. SED Clock and Reset .....	13
6. SEDC Flow .....	14
6.1. SED Mode .....	15
6.1.1. Continuous Mode .....	15
6.1.2. One-shot Mode .....	16
6.2. SEDC Error Handling .....	17
7. SEDC Run Time .....	23
8. Sample Code .....	24
8.1. SEDC Verilog Example .....	24
8.1.1. Verilog Example of SEDC IP .....	24
8.1.2. Verilog SEDC IP Instantiation .....	24
8.2. SEDC VHDL Example .....	25
8.2.1. VHDL Component Instantiation .....	25
8.2.2. VHDL Instantiation .....	25
9. Soft Error Injection (SEI) .....	26
10. Important Note .....	28
Technical Support Assistance .....	29
Revision History .....	31

## Figures

Figure 2.1. Bitstream Data Structure .....	7
Figure 2.2. SEDC System Block Diagram .....	8
Figure 2.3. SEDC Block Diagram .....	9
Figure 5.1. SEDC CLK/RST .....	13
Figure 6.1. SEDC Flow .....	15
Figure 6.2. SED Continuous Mode .....	16
Figure 6.3. SED One-Shot Mode .....	17
Figure 6.4. One-shot Mode with Correctable Error (sedc_cof_i = 0 / 1) .....	18
Figure 6.5. SEDC Continuous Mode with Correctable Error (sedc_cof_i = 0 / 1) .....	18
Figure 6.6. SEDC One-shot Mode or Continuous Mode with Multiple Error in One Frame (sedc_cof_i = 0) .....	19
Figure 6.7. SEDC One-shot Mode with Multiple Error in One Frame (sedc_cof_i = 1) .....	19
Figure 6.8. SEDC Continuous Mode with Multiple Error in One Frame (sedc_cof_i = 1) .....	20
Figure 6.9. SEDC One-shot Mode with CRC Error (sedc_cof_i = 0 / 1) .....	20
Figure 6.10. SEDC Continuous Mode with CRC Error (sedc_cof_i = 0 / 1) .....	21
Figure 6.11. SEDC One-shot Mode with SEC Disabled (sed_en_i = 0) .....	21
Figure 6.12. SEDC Continuous Mode with SEC Disabled (sed_en_i = 0) .....	22
Figure 10.1. SEI Editor .....	26
Figure 10.2. Device Properties .....	27

## Tables

Table 3.1. SEDC Primitive Port Definitions .....	10
Table 5.1. SEDC Internal Oscillator Divider Settings .....	13
Table 8.1. Configuration-related Parameters that Affect SED Run Time .....	23

## Acronyms in This Document

A list of acronyms used in this document.

Acronym	Definition
BCH	The Bose, Chaudhuri, and Hocquenghem (BCH) codes form a large class of powerful random error-correcting cyclic codes. This class of codes is a remarkable generalization of the Hamming code for error correction.
CRC	Cyclic Redundancy Check
DRAM	Dynamic Random Access Memory
ECC	Error Correcting Code
IP	Intellectual Property
PLD	Programmable Logic Device
SED	Soft Error Detection
SEC	Soft Error Correction
SEI	Soft Error Injection
SRAM	Static Random Access Memory

## 1. Introduction

This document describes the hard-logic based SED approach taken by Lattice Semiconductor for the Lattice Nexus™ platform devices, including Crosslink™-NX, Certus™-NX, CertusPro™-NX, and MachXO5™-NX families. Once soft error is detected, Lattice provides an easy way to optionally perform the Soft Error Correction (SEC) without disturbing the functionality of the device.

Memory errors can occur when high-energy charged particles alter the stored charge in a memory cell in an electronic circuit. The phenomenon first became an issue in Dynamic Random Access Memory (DRAM), requiring error detection and correction for large memory systems in high-reliability applications. As device geometries continue to shrink, the probability of memory errors in Static Random Access Memory (SRAM) becomes significant for some systems.

Designers are using a variety of approaches to minimize the effects of memory errors on system behavior. FPGA devices built on the Lattice Nexus platform, which include CrossLink-NX, Certus-NX, CertusPro-NX, and MachXO5-NX, are unique because the underlying technology used to build them is much more robust and less prone to soft errors.

SRAM-based programmable logic devices (PLDs) store logic configuration data in SRAM cells. As the number and density of SRAM cells in a PLD increase, the probability that a memory error alters the programmed logical behavior of the system increases. A number of traditional approaches are taken to address this issue, but most involve soft Intellectual Property (IP) cores that instantiate into the logic of user design, utilizing valuable resources and possibly affecting design performance.

The Nexus platform devices have an improved hardware implemented Soft Error Detection (SED) circuit which can be used to detect SRAM errors and allow them to be corrected. There are two layers of SED implemented in these devices that make them more robust and reliable.

## 2. SED Overview

The SEDC module in a Nexus platform device is an enhanced version as compared to the SED modules implemented in other Lattice devices. Enhancements include:

- Frame by Frame SED check
- Single bit and multi-bit error detection
- ECC to correct single bit error at the frame level
- Programmable SEDC clock with a wider clock frequency option

The device is based on the Lattice Nexus platform which is developed using FDSOI technology. FDSOI transistors have a less active region, which helps to reduce bit flipping when exposed to alpha and neutron particles.

Some of the key advantages of Nexus platform devices as compared to other devices are:

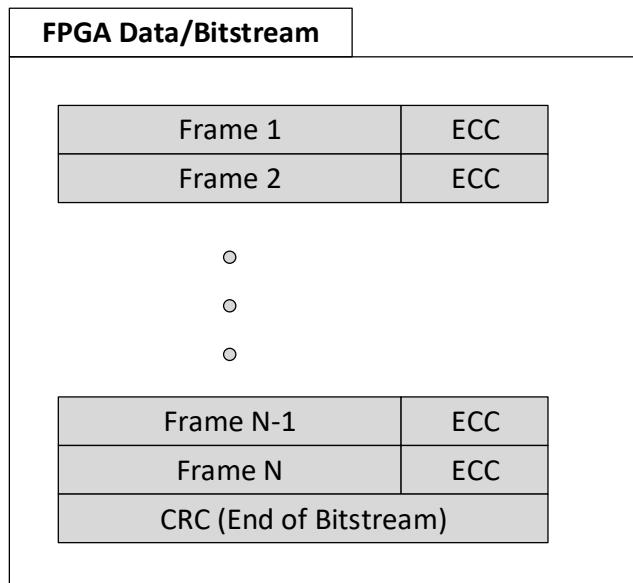
- Improved radiation tolerance due to reduction in critical area separated by a thin layer of buried oxide (BOX)
- 100x improvement in soft errors

Due to the above technology, Nexus platform devices have extremely low bit error rate and fit rate. Details about the fit rate calculation can be found in [Single Event Upset \(SEU\) Report for CrossLink-NX \(FPGA-TN-02174\)](#).

This SEDC module is part of the Configuration block in the Nexus platform devices. The configuration data is divided into frames so that the FPGA can be programmed as a whole or in precise parts. The SED hardware reads serial data from the FPGA's configuration memory frame-by-frame in the background while the device is in User mode and performs Error Correcting Code (ECC) calculation on every frame of configuration data (see [Figure 2.1](#)). Once a single bit error is detected, a Soft Error Upset (SEU) notification is generated and SED resumes operation. When Soft Error Correction (SEC) is enabled, single bit errors are corrected; the corrected value is rewritten to the particular frame using ECC information. If more than one-bit error is detected within one frame of configuration data, an error message is generated. In parallel, cyclic redundancy check (CRC) is calculated for the entire bitstream along with ECC.

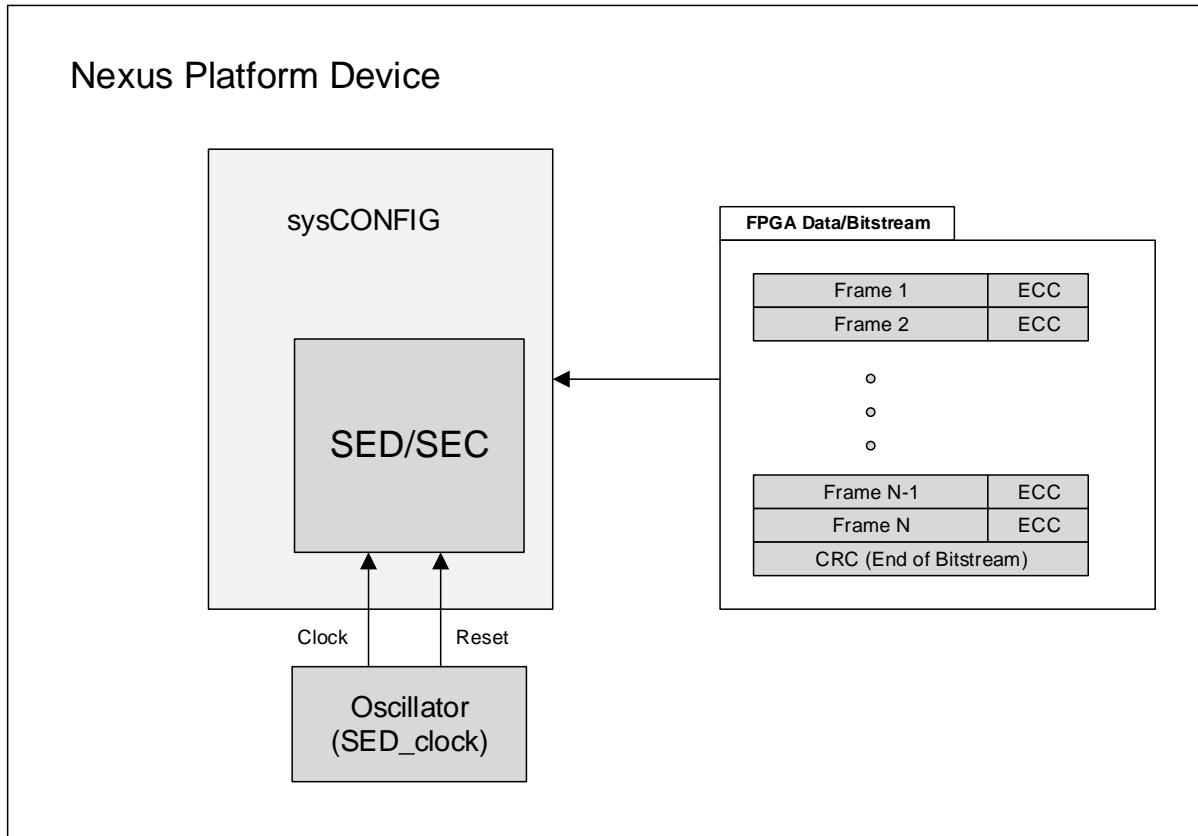
After the ECC is calculated on all frames of configuration data, cyclic redundancy check (CRC) is calculated for the entire configuration data (bitstream).

Due to the dynamic contents of memories, the CRC and ECC calculations do not include EBR and Large RAM memory. Dynamic RAM should not be used with SED, otherwise, SED reports failures when normal RAM content changes occur.



**Figure 2.1. Bitstream Data Structure**

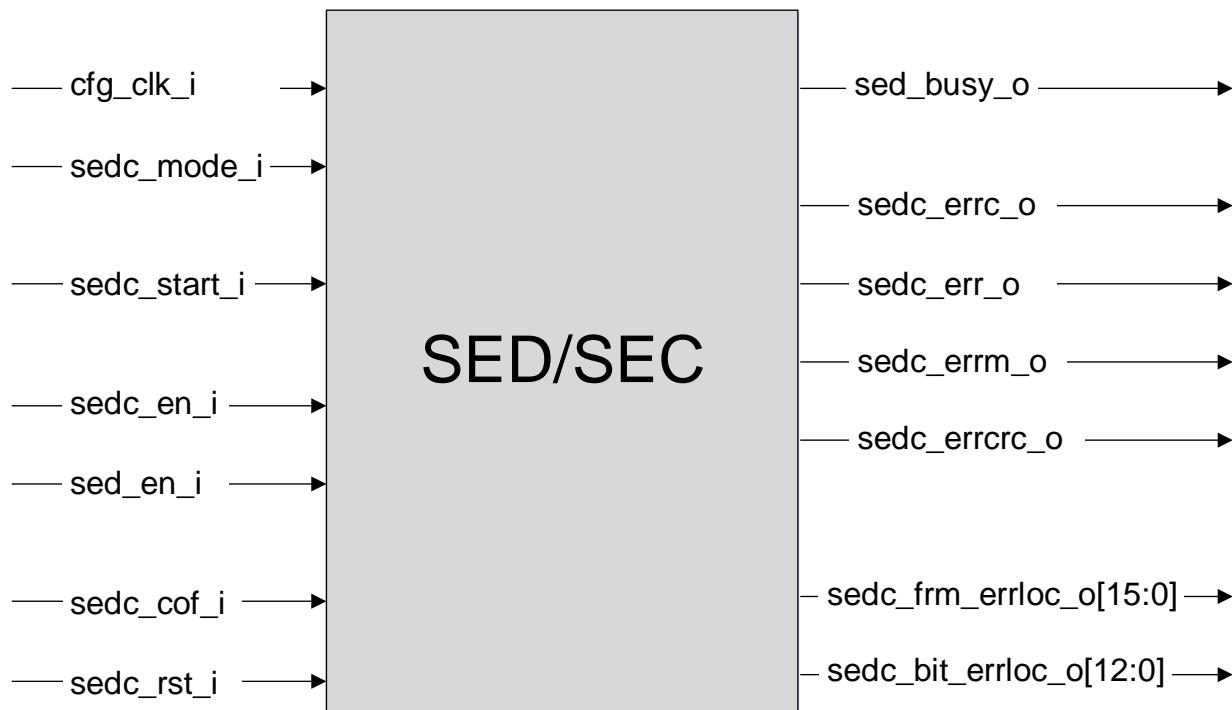
The SEDC IP is part of the sysCONFIG block of devices built on the Nexus platform. [Figure 2.2](#) shows the system-level view of the SEDC IP.



**Figure 2.2. SEDC System Block Diagram**

## 2.1. Block Diagram

The SED block in a Nexus platform device contains a number of inputs that control the actual SEDC block behavior. There are a number of modes that this SED block can operate in. A high-level block diagram showing the user input and output ports is shown in [Figure 2.3](#).



**Figure 2.3. SEDC Block Diagram**

### 3. Port List

To use the SEDC IP, instantiate the SEDC IP as well as the Oscillator primitive using the Lattice Radian<sup>TM</sup> IP Catalog. Refer to [Figure 2.1](#) that shows how to connect the Oscillator to the SEDC IP. Below is a list of port signals used by the SEDC IP.

**Table 3.1. SEDC Primitive Port Definitions**

Port Name	Default Value	Active	Description
cfg_clk_i	0	Input	User input clock for SED. Connect this signal to the OSC module port <i>cfg_clk_o</i>
sedc_mode_i	0	Input	SED mode signal Select between two modes.
sedc_start_i	0	Input	SED signal used to start SED
sedc_en_i	0	Input	Signal to enable SED
sed_en_i	0	Input	Signal to enable Soft Error Correction (SEC)
sedc_cof_i	0	Input	SED continue on failure signal
sedc_RST_i	0	Input	Reset the SED IP. Connect this signal to the OSC module port <i>sedc_RST_o</i> .
sedc_busy_o	0	Output	Signal to indicate SED is in progress
sedc_errc_o	0	Output	Indicate Current SED error
sedc_err_o	0	Output	1-bit (correctable) error detected; sticky bit
sedc_errm_o	0	Output	Multi-bit error detected within one frame; sticky bit
sedc_errcrc_o	0	Output	CRC error for entire bitstream data
sedc_frm_errloc_o[15:0]	0	Output	Frame Error location
sedc_dsr_errloc_o[12:0]	0	Output	Bit error location within a frame

## 4. Port Descriptions

### 4.1. **cfg\_clk\_i**

The *cfg\_clk\_i* is a user-selectable clock signal used to run the SEDC IP. Table 5.1 defines the various clock divider settings that can be used to define the desired clock speed of the SED block.

### 4.2. **sedc\_mode\_i**

The *sedc\_mode\_i* signal is used to choose the SED mode of operation. There are two SED modes that user can choose from: continuous mode and one-shot mode. For continuous mode, the *sedc\_mode\_i* signal is high and once *sedc\_start\_i* is HIGH, the SED operation keeps running continuously. For one-shot mode, the *sedc\_mode\_i* signal is low and once the SED module detects the low-to-high transition on the *sedc\_start\_i* signal, the SED operation runs once. For one-shot mode to operate correctly, user need to make sure *sedc\_start\_i* remains asserted until *sedc\_busy\_o* is deasserted. In other words, there should not be glitches in the *sedc\_start\_i* signal.

### 4.3. **sedc\_start\_i**

This *sedc\_start\_i* signal is used to start the SED operation. Once the *sedc\_start\_i* signal goes high, the SED cycle starts if *sedc\_en\_i* is high. In continuous mode, the *sedc\_start\_i* signal must remain high for the duration of SED. If *sedc\_start\_i* goes low during the SED cycle, the process is terminated and *sedc\_busy\_o* is deasserted.

### 4.4. **sedc\_en\_i**

The *sedc\_en\_i* signal is used to enable SED. The SED does not operate, and any in-progress operation aborted, if *sedc\_en\_i* is deasserted.

### 4.5. **sed\_en\_i**

If *sed\_en\_i* is set, the soft error correction is performed immediately as soon as a single correctable error is detected. If this bit is disabled, the correction is not done.

### 4.6. **sedc\_cof\_i**

The *sedc\_cof\_i* stands for SED\_Continue\_On\_Failure. This signal is used to tell the SED module to run or stop after a non-correctable multiple bit error is detected in a single configuration frame. If *sedc\_cof\_i* signal is set to HIGH, the SED operation continues even if non-correctable error is encountered. On the other hand, if the *sedc\_cof\_i* signal is LOW, the SED operation is terminated as soon as an error is detected. This bit is useful for debugging purposes but not recommended for normal use. Instead, it is recommended to reload the FPGA bitstream (through REFRESH, PROGRAMN assertion, power cycle, or through one of the slave sysCONFIG ports) in the event a non-correctable error is detected.

### 4.7. **sedc\_rst\_i**

The *sedc\_rst\_i* signal is used to reset the SEDC IP. This is an asynchronous reset signal.

### 4.8. **sedc\_busy\_o**

The *sedc\_busy\_o* signal indicates if SED/SEC operation is currently in progress. If the SED is running, the *sedc\_busy\_o* is set to HIGH. Once SED operation is complete, this signal goes LOW.

#### **4.9. sedc\_errc\_o**

The SED error current flag indicates if a soft error is detected. As soon as an error is detected, this flag goes high indicating it is a current error. This flag is not sticky.

#### **4.10. sedc\_err\_o**

The *sedc\_err\_o* flag is used to indicate if there is a single bit error in a frame. This flag is sticky. To clear this flag, the SED operation must be disabled.

This single bit error detected is also correctable. The correction is performed only if the *sed\_en\_i* signal is set.

#### **4.11. sedc\_errm\_o**

The SED error multiple is used to indicate if non-correctable errors are encountered, such as two or more errors detected in a single frame. Multiple errors are not correctable. This flag is asserted high when non-correctable error occurs. The flag will be asserted for two bits error (per frame), but it's not guaranteed to be asserted for more than 2 bits error due to the nature of the Hamming coding algorithm. This flag is sticky. To clear this flag, disable the SEDC module or reload the bitstream.

#### **4.12. sedc\_errcrc\_o**

The SED error crc indicates if there is a mismatch between calculated CRC of the bitstream as compared to the expected CRC. This error is generated once all the frames of bitstream are read. If there is a single bit error detected, this flag is set. Once the single bit error is corrected, this CRC flag is cleared when SED operation runs for the second time.

#### **4.13. sedc\_frm\_errloc\_o[15:0]**

The SED frame Error location reports the last location of the frame that errored out. It only provides the frame location for the last one-bit error. This signal reports the 16-bit error location for the frame that is causing error. This signal is only used for information purposes which can be used for further analysis of the SED errors. This field contains invalid data if multiple errors per frame are detected.

**Note:** This signal is only valid when SEC is enabled (*sed\_en\_i* is true).

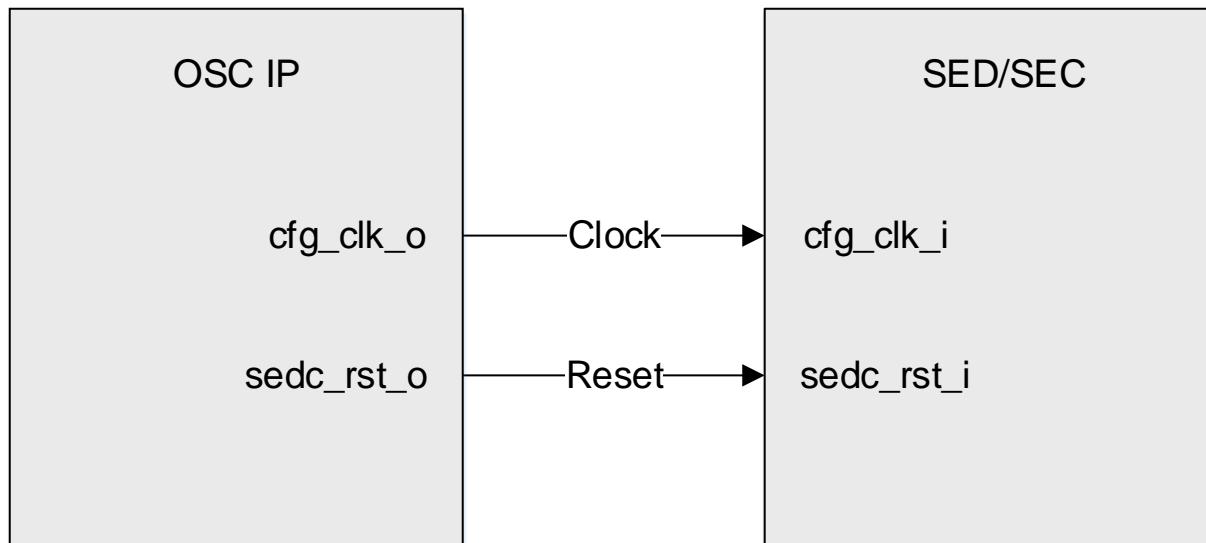
#### **4.14. sedc\_dsr\_errloc\_o[12:0]**

The SED bit error location reports the bit position in a particular frame that errored out. This information is useful so that user can perform detailed analysis of the bitstream (on a bit-by-bit basis). This field contains invalid data if multiple errors per frame are detected.

**Note:** This signal is only valid when SEC is enabled.

## 5. SED Clock and Reset

The SEDC circuitry is driven by the FPGA device internal oscillator. User must instantiate the oscillator IP (SEDCLK option enabled) along with the SEDC IP from the Lattice Radiant IP catalog, and route the clock and reset signals between them, as shown in [Figure 5.1](#).



**Figure 5.1. SEDC CLK/RST**

The default oscillator frequency is 225 MHz. User can choose to lower the oscillator frequency by configuring the oscillator IP using the Lattice Radiant IP catalog. User can set the SEDCLK\_divider setting anywhere between 2 to 256 in integer increments resulting frequency range from 225 MHz to 1.76 MHz (SED Oscillator Frequency = 450 MHz/SEDCLK\_divider).

**Table 5.1. SEDC Internal Oscillator Divider Settings**

Divider Setting	SEDCLK_Divider	Oscillator Frequency (MHz)
Divide by 2	2	225
Divide by 3	3	150
Divide by 4	4	112.5
—	—	—
—	—	—
—	—	—
Divide by 256	256	1.76

## 6. SEDC Flow

This section describes the SEDC flow. The SEDC flow is executed once  $V_{CC}$  reaches the data sheet  $V_{CC}$  minimum recommended level and *sedc\_en\_i* and *sedc\_start\_i* are asserted.

Devices built on the Nexus platform have an advanced SEDC flow with two levels of SED checks. In the first level of SED check, the bitstream is read one frame at a time and the SED check is performed on a frame-by-frame basis. After all frames of the device bitstream are read, the SEDC module checks for CRC of the entire bitstream, second level SED, to check for the bitstream integrity giving the device improved SED performance. [Figure 6.1](#) shows the SEDC flow in Nexus platform devices.

Devices built on the Nexus platform support real time Soft Error Correction (SEC) feature in which a single bit error can be corrected using ECC at the frame level. Once the SEC is enabled, the SEDC module reports the error location, providing details about the error frame and the exact location of a single bit error in that frame as shown in [Figure 6.1](#).

Devices built on the Nexus platform support real time Soft Error Correction (SEC) feature in which a single bit error can be corrected using ECC at the frame level. Once the SEC is enabled, the SEDC module reports the error location, providing details about the error frame and the exact location of a single bit error in that frame as shown in [Figure 6.1](#).

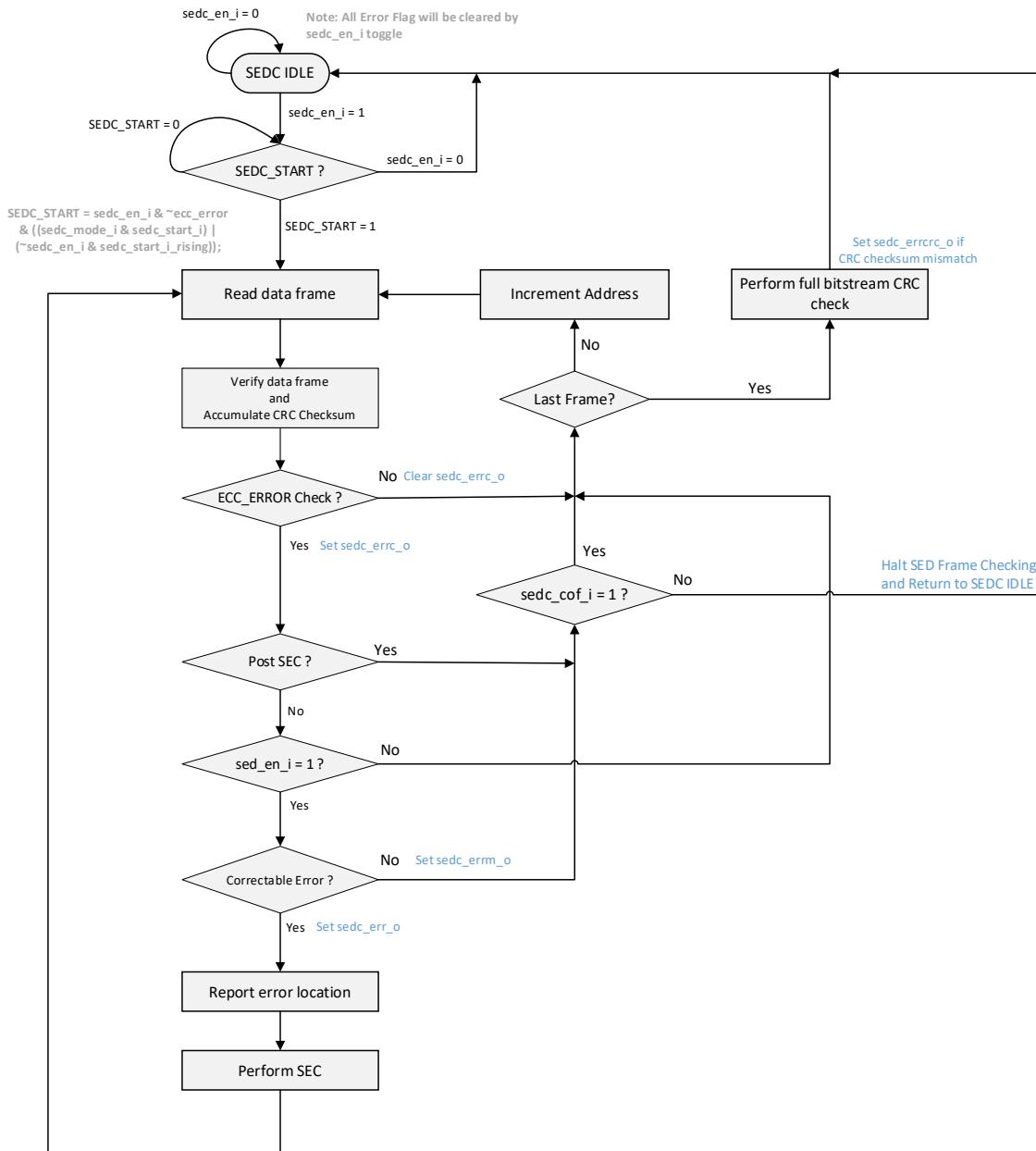


Figure 6.1. SEDC Flow

## 6.1. SED Mode

Devices built on the Nexus platform support two different SED modes. This provides the flexibility to run the SED. The first mode is the continuous mode in which the SED runs continuously. The other mode is one-shot mode in which SED runs once for each assertion of *sedc\_start\_i* signal.

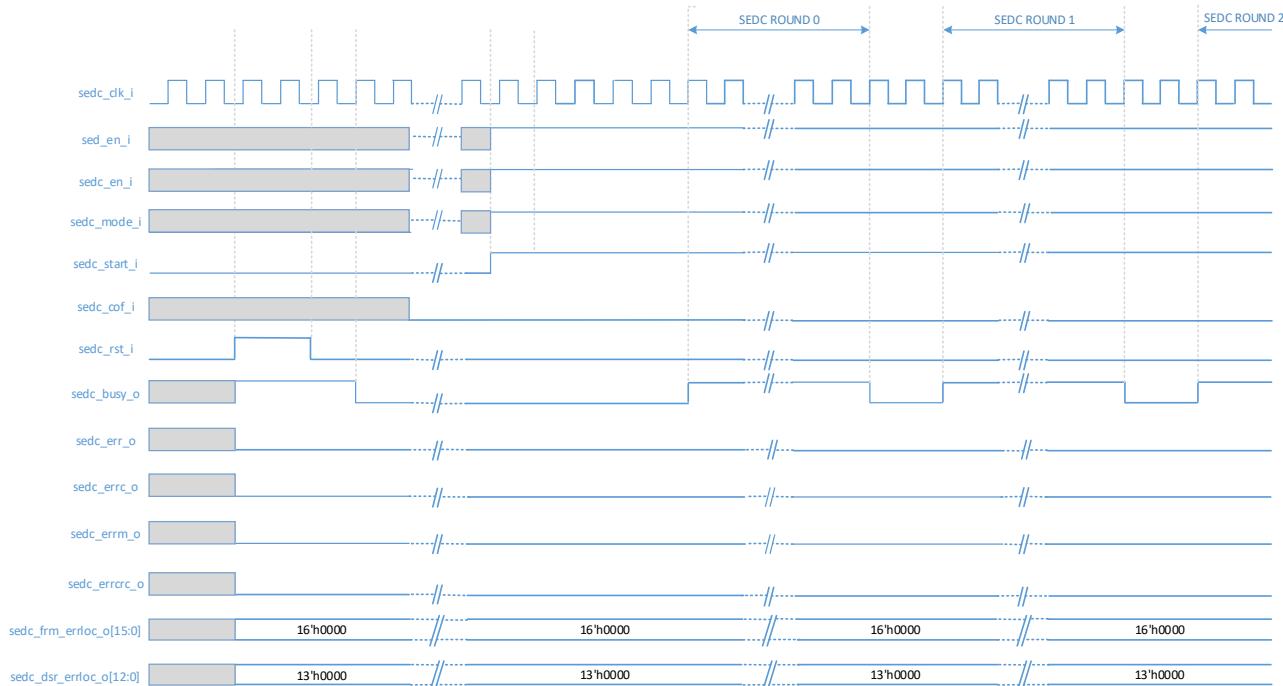
### 6.1.1. Continuous Mode

As the name suggests, in continuous mode, the SED runs continuously as long as the *sedc\_start\_i* signal is high.

- Once the SED is enabled, it starts reading bitstream data frame by frame and verifies if the data is read correctly from configuration SRAM. The *sedc\_busy\_o* signal is HIGH as long as SED is running.
- Once SED finishes checking, the *sedc\_busy\_o* goes LOW (once the SED cycles through for the first time).

3. The SED cycles through for the second time as long as *sedc\_start\_i* is HIGH since the operation is in Continuous Mode.

Once *sedc\_mode\_i* is set to 1 and *sedc\_start\_i* is always HIGH, the SED operation runs continuously, as shown in [Figure 6.2](#).



**Figure 6.2. SED Continuous Mode**

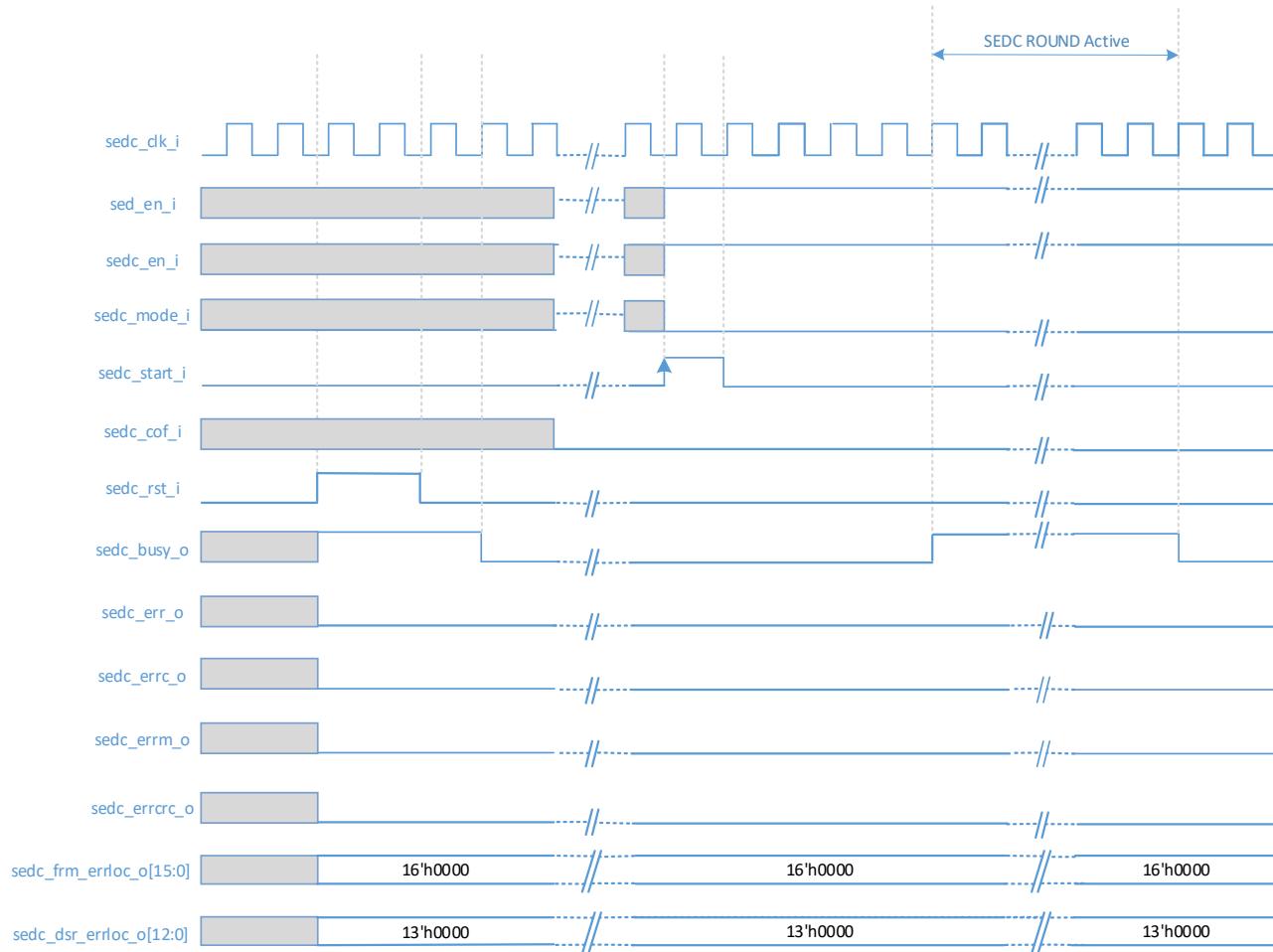
### 6.1.2. One-shot Mode

In this mode, the SED runs once for each assertion of *sedc\_start\_i* signal.

1. For One-shot Mode, the *sedc\_start\_i* signal must have a LOW to HIGH transition to start the SED operation.
2. The SED starts reading bitstream data frame by frame and verifies if the data is read correctly from configuration SRAM. The *sedc\_busy\_o* signal is HIGH as long as SED is running.
3. The SED finishes checking. The SED error flags are updated and the *sedc\_busy\_o* flag goes LOW. Another SED cycle is started by making a LOW to HIGH transition on the *sedc\_start\_i* signal.

**Note:** If there is any error, disable the *sedc\_en\_i* signal to reset all error flags.

In this mode, the *sedc\_mode\_i* signal is set to zero. As soon as there is a low to high transition on the *sedc\_start\_i* signal, the SED operation starts. The SED operation is run once for each assertion of *sedc\_start\_i* signal and when done, this *sedc\_busy\_o* goes LOW, as shown in [Figure 6.3](#).



**Figure 6.3. SED One-Shot Mode**

The preferred action to take when an error is detected is to reconfigure the PLD. Reconfiguration can be accomplished by driving the PROGRAMN pin low. This can be done by externally connecting a GPIO pin to PROGRAMN.

## 6.2. SEDC Error Handling

The figures in this section show the different types of errors reported by the SEDC module in different mode and error condition by Nexus platform devices. The *sedc\_errc\_o* signal flags as soon as there is an error. The *sedc\_err\_o*, *sedc\_errm\_o*, and *sedc\_errrc\_o* are sticky flags and the SED module had to be restarted to reset these error flags.

### Single Bit Error in Frame N

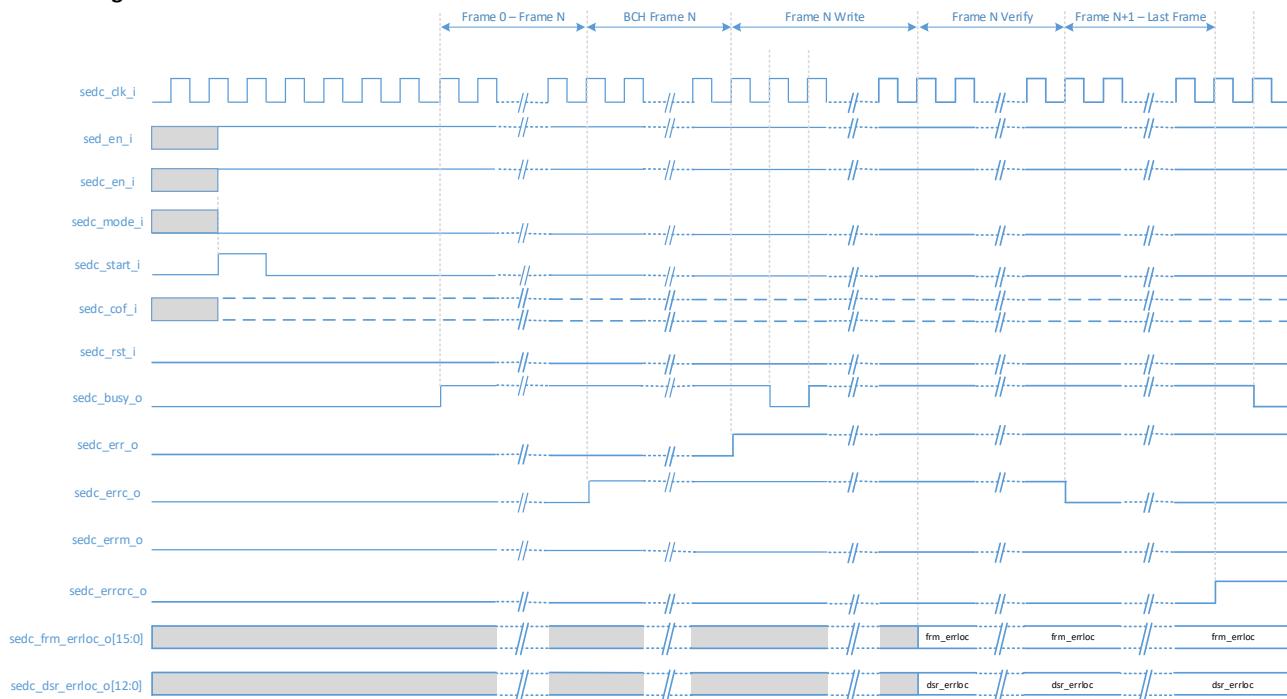


Figure 6.4. One-shot Mode with Correctable Error (**sedc\_cof\_i** = 0 / 1)

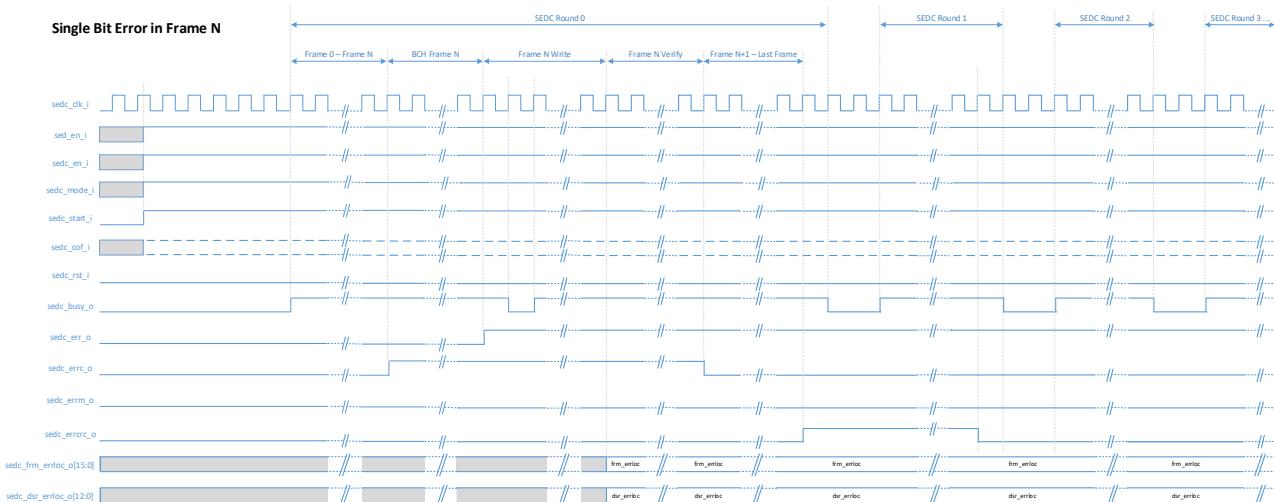
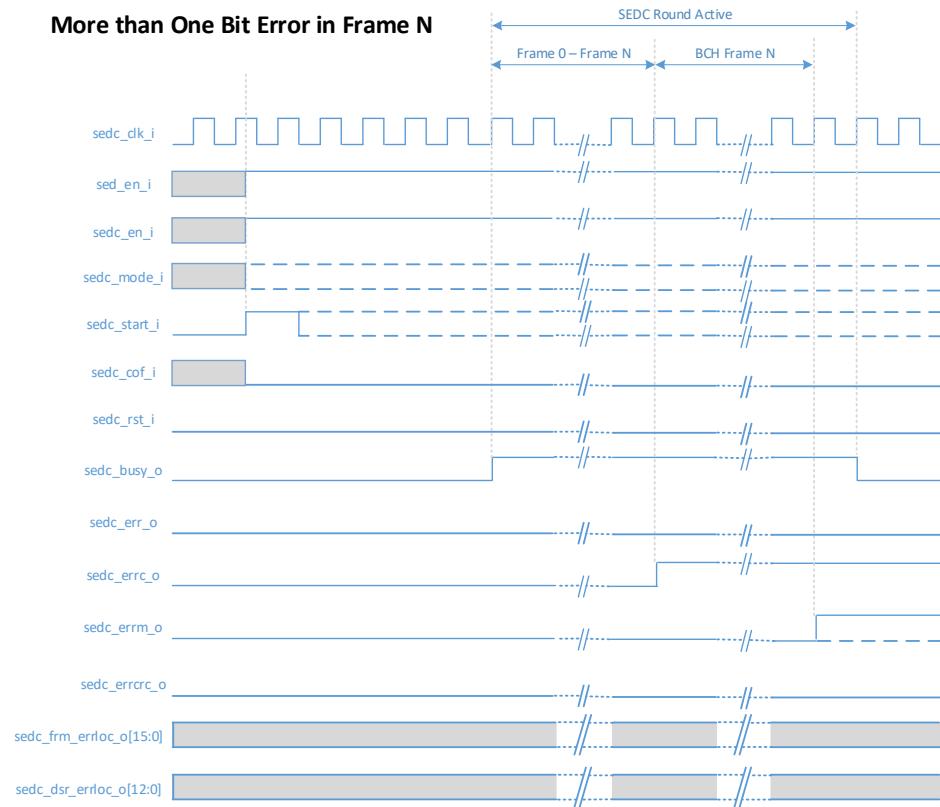
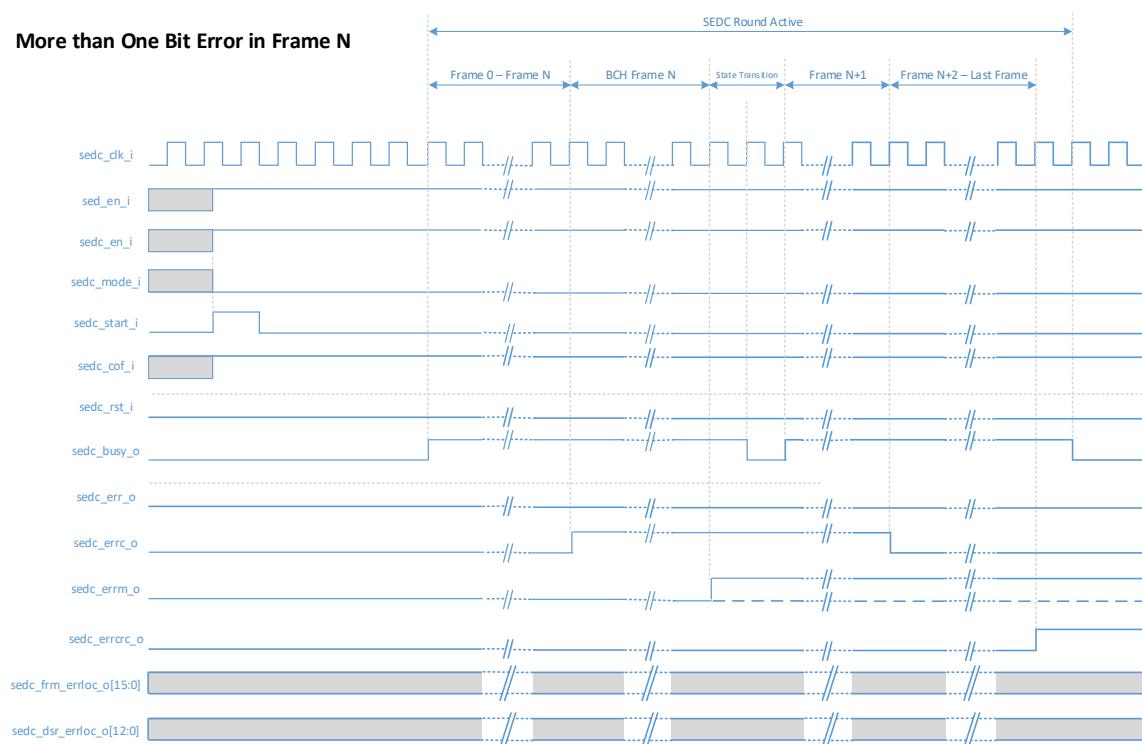
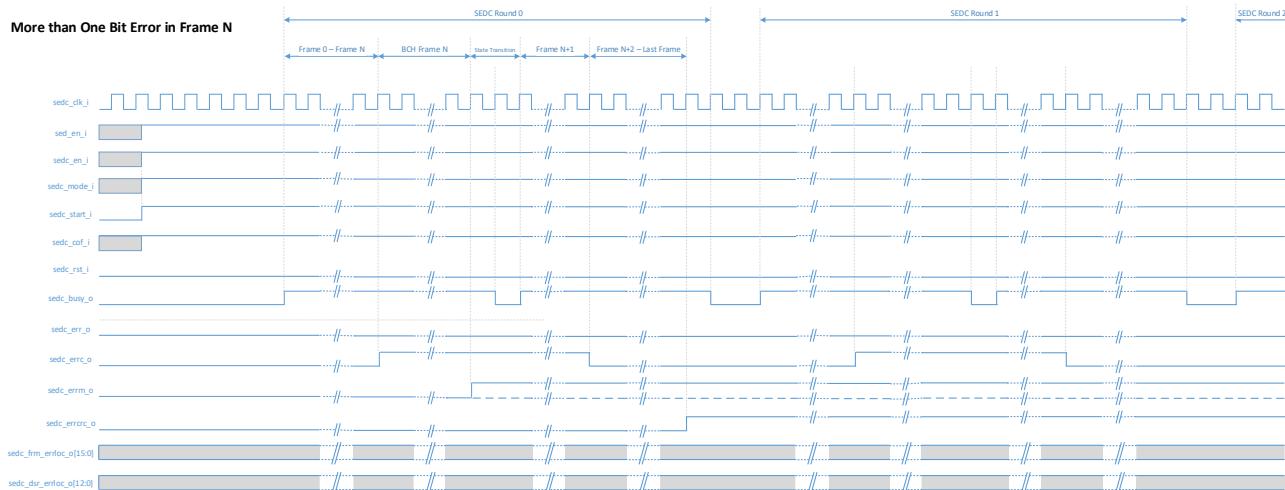


Figure 6.5. SEDC Continuous Mode with Correctable Error (**sedc\_cof\_i** = 0 / 1)

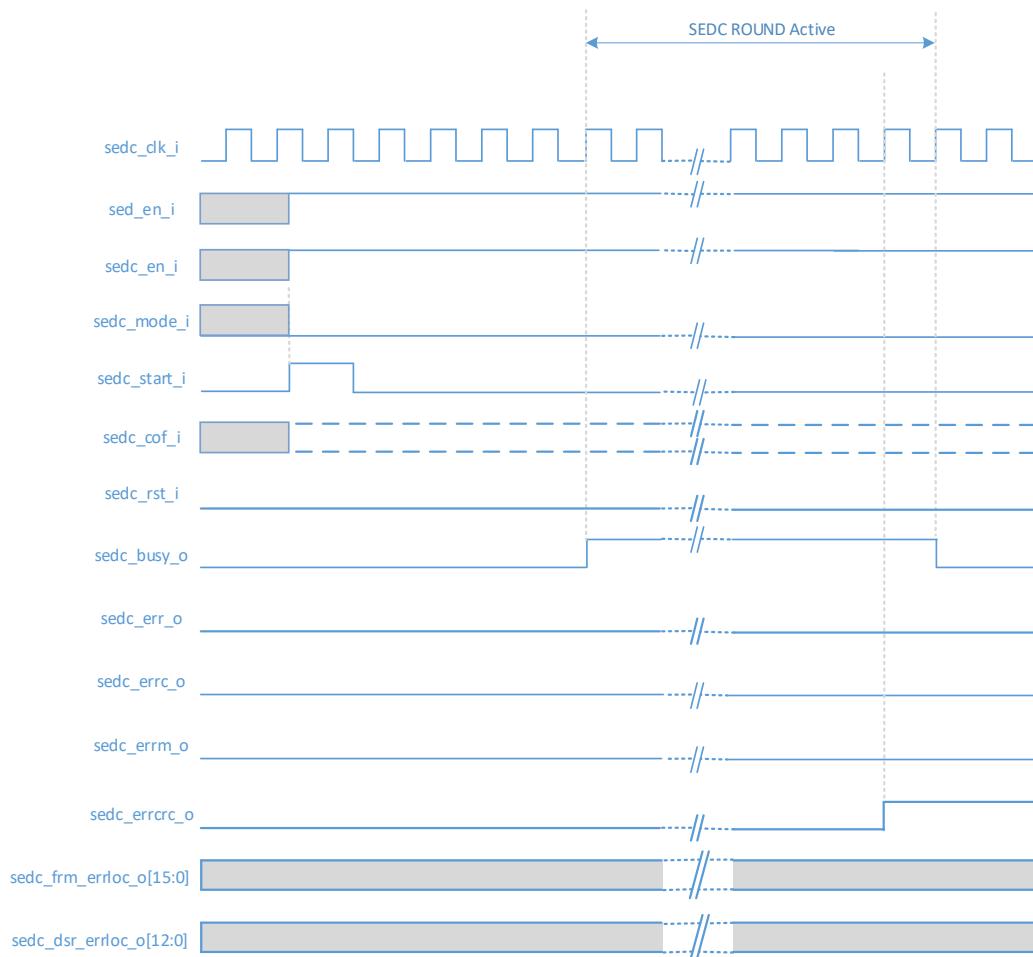
**Note:** Soft Error Correction only occurs if **sed\_en\_i** (soft error correction enable) is set. If **sed\_en\_i** is not set, **sedc\_busy\_o** remains asserted high until all frames are checked, regardless of error state as shown in .

**More than One Bit Error in Frame N**

**Figure 6.6. SEDC One-shot Mode or Continuous Mode with Multiple Error in One Frame (sedc\_cof\_i = 0)**
**More than One Bit Error in Frame N**

**Figure 6.7. SEDC One-shot Mode with Multiple Error in One Frame (sedc\_cof\_i = 1)**

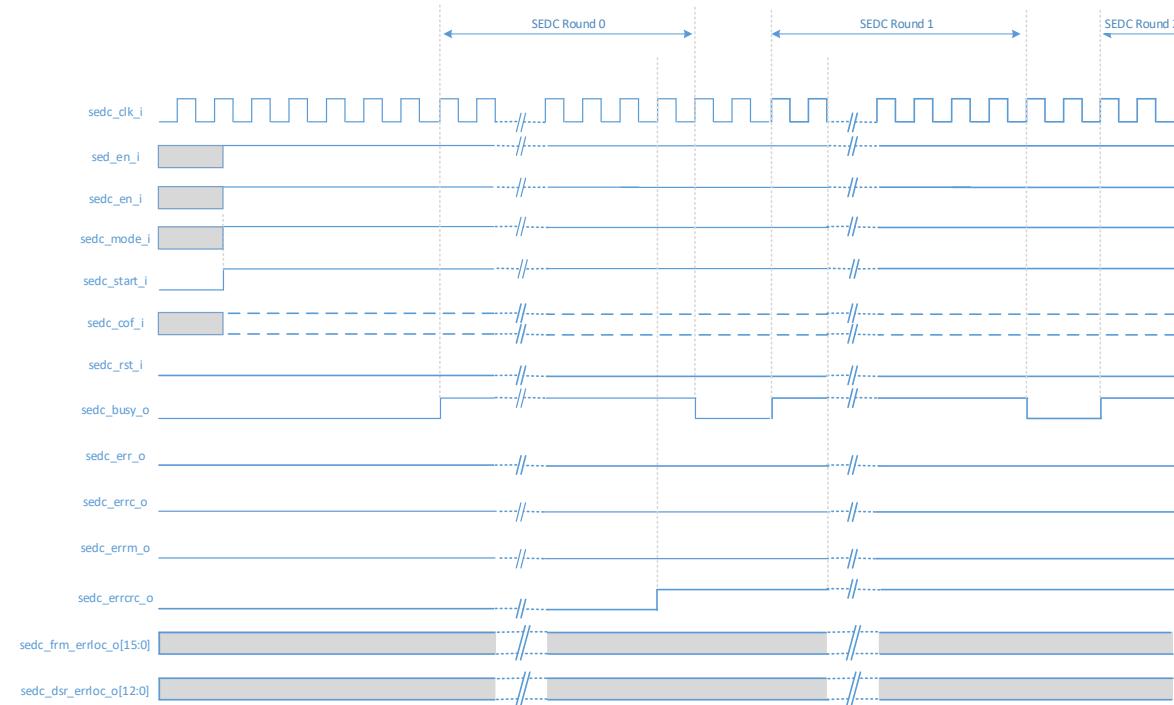


**Figure 6.8. SEDC Continuous Mode with Multiple Error in One Frame (sedc\_cof\_i = 1)**

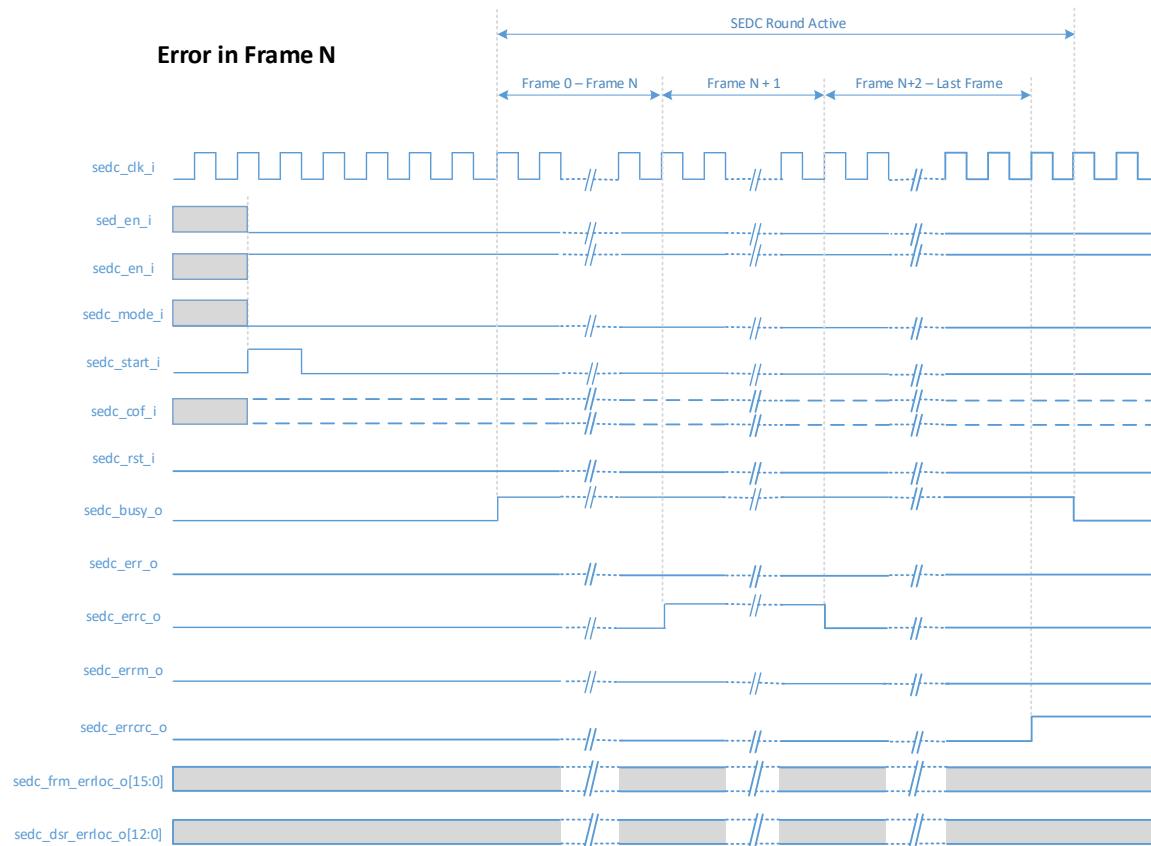
In case of multiple errors in one frame and cannot be detected by the ECC logic, or the CRC checksum is not programmed (in bitstream) correctly, the **sedc\_errrc\_o** will be set to indicate the CRC checksum mismatch, as shown in [Figure 6.9](#) and [Figure 6.10](#) below.



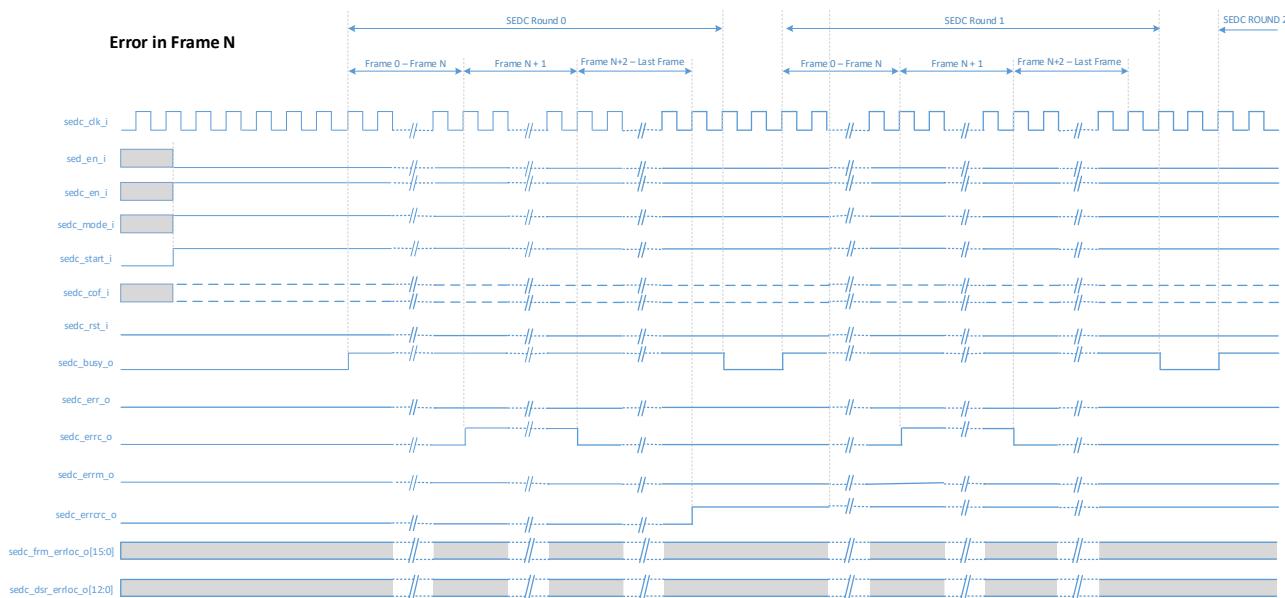
**Figure 6.9. SEDC One-shot Mode with CRC Error (sedc\_cof\_i = 0 / 1)**



**Figure 6.10. SEDC Continuous Mode with CRC Error (sedc\_cof\_i = 0 / 1)**



**Figure 6.11. SEDC One-shot Mode with SEC Disabled (sed\_en\_i = 0)**



**Figure 6.12. SEDC Continuous Mode with SEC Disabled (sed\_en\_i = 0)**

## 7. SEDC Run Time

In the Nexus platform devices, the amount of time needed to perform a SED check depends on the density of the device, frequency of the SED clock driver signal and the number of shift lanes used to shift data into the device. There is also some overhead time for calculation, but it is short in comparison. An approximation of the SED run time can be found by using the following formula:

For LIFCL-17 and LFD2NX-17:

*Read Cycles per frame = 93*

*SED run time (ms) = (Total no of frames × Read Cycles per frame) / SED clock (MHz)*

For LIFCL-40, LFD2NX-40, LFCPNX-50, LFCPNX-100, and LFMXO5-25:

*SED run time (ms) = (Total no of frames × (bytes per frame + overhead bytes)) / SED clock (MHz)*

For example, for LIFCL-17, the run time for SED clock running at 150 MHz is:

*Total no. of frame = 7900*

*SED Run time = (7900 × 93) / 150 MHz = 4.9ms*

For example, for LIFCL-40, the run time for SED clock running at 150 MHz is:

*Total no. of frame = 9172*

*Bytes per frame = 85*

*Overhead bytes = 5*

*SED Run time = (9172 × (85 + 5)) / 150 MHz = (9172 × 90) / 150 MHz = 5.5ms*

**Table 7.1. Configuration-related Parameters that Affect SED Run Time**

Device	Total Number of Frames	Bytes per Frame	Overhead Bytes
LIFCL-17	7900	44	N/A
LIFCL-33	5344	127	5
LIFCL-40	9172	85	5
LFD2NX-17	7900	44	N/A
LFD2NX-40	9172	85	5
LFCPNX-50	10444	98	5
LFCPNX-100	16822	112	5
LFMXO5-25	6622	85	5

## 8. Sample Code

The following simple example code shows how to instantiate the SED primitive. Note that the SED IP can be created using the IP catalog in Lattice Radiant software version 2.0 or later. Refer to the [Important Note](#) section for additional design considerations once the SED primitive is instantiated.

### 8.1. SEDC Verilog Example

#### 8.1.1. Verilog Example of SEDC IP

```
module sed_test (sed_en_i, sedc_cof_i, sedc_en_i, sedc_mode_i, sedc_start_i, cfg_clk_i,  
sedc_rst_i, sedc_busy_o, sedc_err_o, sedc_errc_o, sedc_errcrc_o, sedc_errm_o,  
sedc_frm_errloc_o, sedc_dsr_errloc_o)/* synthesis syn_black_box syn_declare_black_box=1 */;  
  
    input sed_en_i;  
    input sedc_cof_i;  
    input sedc_en_i;  
    input sedc_mode_i;  
    input sedc_start_i;  
    input cfg_clk_i;  
    input sedc_rst_i;  
    output sedc_busy_o;  
    output sedc_err_o;  
    output sedc_errc_o;  
    output sedc_errcrc_o;  
    output sedc_errm_o;  
    output [15:0] sedc_frm_errloc_o;  
    output [12:0] sedc_dsr_errloc_o;  
  
endmodule
```

#### 8.1.2. Verilog SEDC IP Instantiation

```
sed_test sed_module_name (.sed_en_i(sed_enable), .sedc_cof_i(sedc_cof),  
    .sedc_en_i(sedc_en), .sedc_mode_i(sedc_mode), .sedc_start_i(sedc_start),  
.cfg_clk_i(sedc_clk), .sedc_rst_i(sedc_rst), .sedc_busy_o(sedc_busy),  
.sedc_err_o(sedc_err1), .sedc_errc_o(sedc_err_current), .sedc_errcrc_o(sedc_errcrc),  
.sedc_errm_o(sedc_errm), .sedc_frm_errloc_o(sedc_frm_loc),  
.sedc_dsr_errloc_o(sedc_bit_err_loc) );
```

## 8.2. SEDC VHDL Example

### 8.2.1. VHDL Component Instantiation

```
component sed_test is
  port(
    sed_en_i: in std_logic;
    sedc_cof_i: in std_logic;
    sedc_en_i: in std_logic;
    sedc_mode_i: in std_logic;
    sedc_start_i: in std_logic;
    cfg_clk_i: in std_logic;
    sedc_rst_i: in std_logic;
    sedc_busy_o: out std_logic;
    sedc_err_o: out std_logic;
    sedc_errc_o: out std_logic;
    sedc_errcrc_o: out std_logic;
    sedc_errm_o: out std_logic;
    sedc_frm_errloc_o: out std_logic_vector(15 downto 0);
    sedc_dsr_errloc_o: out std_logic_vector(12 downto 0)
  );
end component;
```

### 8.2.2. VHDL Instantiation

```
SED_instance: sed_test port map(
  sed_en_i=> sed_enable,
  sedc_cof_i=> sed_cof,
  sedc_en_i=> sedc_en,
  sedc_mode_i=> sedc_mode ,
  sedc_start_i=> sedc_start,
  cfg_clk_i=> sedc_clk,
  sedc_rst_i=> sedc_rst,
  sedc_busy_o=> sedc_busy,
  sedc_err_o=> sedc_err1,
  sedc_errc_o=> sedc_err_current,
  sedc_errcrc_o=> sedc_errcrc,
  sedc_errm_o=> sedc_errm,
  sedc_frm_errloc_o=> sedc_frm_loc,
  sedc_dsr_errloc_o=> sedc_bit_err_loc );
```

## 9. Soft Error Injection (SEI)

The Radiant SEI tool offers an easy and economical way to emulate soft error impact to the overall system. This tool allows user to randomly generate and program one or multiple soft errors into the device in background mode without disturbing the device function. Radiant SEI tool is supported in Radiant versions 2.1 and higher.

To use the Radiant SEI tool:

1. Select or enable the **BACKGROUND\_RECONFIG** option in the Global setting under Device Constraint Editor when user generate the bitstream.
2. Run the SEI Editor (as shown in [Figure 9.1](#)) under Tools. This allows user to create one frame special bitstream that has one bit different from original bitstream.

	Enable	ID	SEI File Name	Method	Block	Site	Frame	Bit In Frame
Run Button		1 <input checked="" type="checkbox"/>	0	impl_1_sei_0	Unused	PFU	R15C21B	data frame 6950 bit 485
Add Button		2 <input checked="" type="checkbox"/>	1	impl_1_sei_1	Unused	EBR	EBR_CORE_R46C57	data frame 3022 bit 113
Remove Button		3 <input checked="" type="checkbox"/>	2	impl_1_sei_2	Unused	DSP	PREADD9_CORE...	data frame 8248 bit 437

Figure 9.1. SEI Editor

Some of the main menus in the SEI Editor are described below:

- **Enable** – Select the checkbox of the specific bitstream to be generated when user click the **Run** button.
- **ID** – Continuous number assigned by the software.
- **File Name** – Default bitstream name. This may be changed by the user.
- **Method**
  - **Unused** – Error bit introduced is not used by customer design.
  - **Random** – Error bit introduced is random and can be used by customer design.
- **Block**
  - **Unused** – The Block can be selected among PFU, EBR or DSP.  
Note: Selecting EBR inserts an error into its configuration (personality) bits. The EBR data field is not modified.
  - **Random** – Any functional block including routing. This cannot be selected by the user.

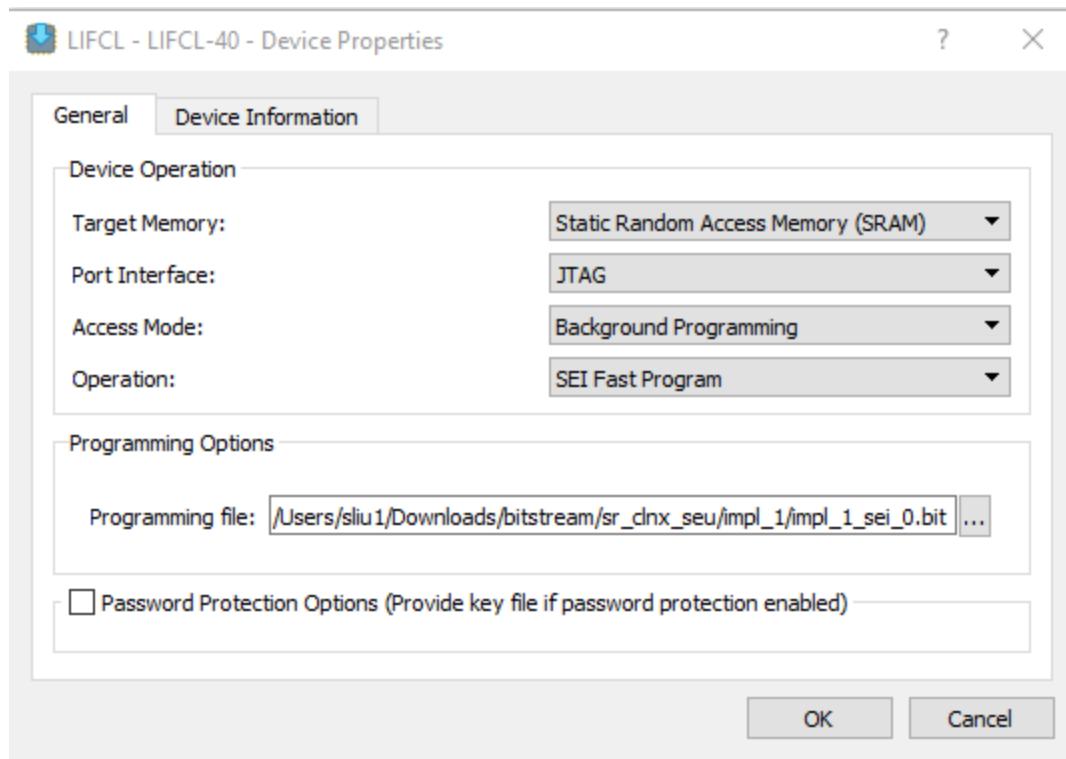
The major buttons on the SEI Editor are described below.

- **Add** Button – Click this button to add SEI files.
- **Remove** Button – Click this button to remove SEI files.
- **Run** Button – Click this button to generate SEI files.

**Note:** The grey area cannot be selected.

3. To program the one-bit-different bitstream, select the **SEI Fast Program** operation in the Radiant Programmer.
4. Once it is programmed into the device, user can use the general SED routine to detect the soft error. During the SEI Fast Program, user can see the DONE pin go *low* during configuration and back to *high* after the configuration.

**Note:** While programming the device with soft error bitstream, SED checking must stop. User can deassert **SEDENABLE** to stop the SED checking.

**Figure 9.2. Device Properties**

## 10. Important Note

When the SEDC primitive is instantiated in a user design, the customer must take two (2) additional steps to ensure the PROGRAMN\* pin and REFRESH\* command behave as expected:

1. Reset the boot address register, using one of the following:
  - If using Radiant 3.1 or later, generate the bitstream as usual. No further action is required.
  - If using Radiant 3.0 or earlier, perform one of the following:
    - Manually set the *Bulk Erase Enable One-Time Programmable (OTP)* bit using the Programmer Tool > Device Properties > Operation: Program Control NV Register1 in Radiant 3.0 or earlier. This must be done to every target device, but no special bitstream modification is required.
    - Manually set the *Bulk Erase Enable* register setting in Control Register 1 (CR1:16) in the bitstream file using the Programmer Tool > Deployment Tool or Programmer Tool > Programming File Utility > Tools > Control Register1 Editor in Radiant 3.0 or earlier. This must be done on every generated bitstream, but no extra programming step for the device is required.
  - 2. The SEDC primitive must be held in reset: the *sedc\_rst\_i* port on the primitive must be asserted low a) before or while asserting PROGRAMN low, or b) before issuing REFRESH command using one of the following methods:
    - External to the device, tie PROGRAMN to a GPIO pin which is routed to *sedc\_rst\_i*.
    - Route *sedc\_rst\_i* to external pin which can be asserted independently of PROGRAMN, if desired.  
Create user logic which can communicate with an external controller that PROGRAMN is asserted, and assert *sedc\_rst\_i* prior to PROGRAMN assertion.

If primary conditions 1 and 2 are met, then PROGRAMN and REFRESH operate as expected. If these conditions are met, the PROGRAMN and REFRESH does not operate as expected. The device may hang and not enter user mode. A power cycle is required to recover the device.

**\*Note:** See [sysCONFIG User Guide for Nexus Platform \(FPGA-TN-02099\)](#) to learn more about PROGRAMN pin and REFRESH command.

## References

- [CrossLink-NX FPGA web page](#)
- [Certus-NX FPGA web page](#)
- [CertusPro-NX FPGA web page](#)
- [MachXO5-NX FPGA web page](#)

## Technical Support Assistance

Submit a technical support case through [www.latticesemi.com/techsupport](http://www.latticesemi.com/techsupport).

For frequently asked questions, refer to the Lattice Answer Database at  
[www.latticesemi.com/Support/AnswerDatabase](http://www.latticesemi.com/Support/AnswerDatabase).

## Revision History

### Revision 1.8, July 2023

Section	Change Summary
Acronyms in This Document	Added acronyms for BCH.
Port Descriptions	Added description for <code>sedc_errm_o</code> output when non-correctable error occurs. The flag will be asserted for two bits error (per frame), but it's not guaranteed to be asserted for more than 2 bits error due to the nature of the Hamming coding algorithm in <a href="#">sedc_errm_o</a> section.
SEDC Flow	<ul style="list-style-type: none"> <li>Updated Figure 6.1. SEDC Flow in SEDC Flow Section.</li> <li>Moved paragraph <i>Devices built on the Nexus platform support real time Soft Error Correction (SEC) feature in which a single bit error can be corrected using ECC at the frame level. Once the SEC is enabled, the SEDC module reports the error location, providing details about the error frame and the exact location of a single bit error in that frame as shown in Figure 6.1</i> from previous Section 7 to <a href="#">SEDC Flow</a> Section.</li> <li>Deleted previous Section 7 SEDC Flow, and Figure 7.1.</li> <li>Updated <a href="#">Figure 6.3. SED One-Shot Mode</a> to add SEDC Round Active label.</li> <li>Updated <a href="#">Figure 6.4. One-shot Mode with Correctable Error (sedc_cof_i = 0 / 1)</a> to update the label.</li> <li>Updated <a href="#">Figure 6.5. SEDC Continuous Mode with Correctable Error (sedc_cof_i = 0 / 1)</a> to update the label.</li> <li>Updated <a href="#">Figure 6.6. SEDC One-shot Mode or Continuous Mode with Multiple Error in One Frame (sedc_cof_i = 0)</a> to change <code>sedc_mode_i</code> for both 1 &amp; 0 and add label.</li> <li>Updated <a href="#">Figure 6.7. SEDC One-shot Mode with Multiple Error in One Frame (sedc_cof_i = 1)</a> to add label.</li> <li>Updated <a href="#">Figure 6.8. SEDC Continuous Mode with Multiple Error in One Frame (sedc_cof_i = 1)</a> to correct the <code>sedc_mode_i</code>, <code>sedc_start_i</code> state and update label.</li> <li>Updated <a href="#">Figure 6.9. SEDC One-shot Mode with CRC Error (sedc_cof_i = 0 / 1)</a> to add label.</li> <li>Updated <a href="#">Figure 6.10. SEDC Continuous Mode with CRC Error (sedc_cof_i = 0 / 1)</a> to correct the <code>sedc_mode_i</code>, <code>sedc_start_i</code> state.</li> </ul>
SEDC Error Handling	<ul style="list-style-type: none"> <li>Added <a href="#">Figure 6.11. SEDC One-shot Mode with SEC Disabled (sed_en_i = 0)</a>.</li> <li>Added <a href="#">Figure 6.12. SEDC Continuous Mode with SEC Disabled (sed_en_i = 0)</a>.</li> </ul>
References	Added Reference section.

### Revision 1.7, May 2023

Section	Change Summary
All	Change the module name from SED or SED/SEC to SEDC which is the actual primitive name in Radian.
SEDC Flow	<ul style="list-style-type: none"> <li>Updated Figure 6.2. SED Continuous Mode in Continuous Mode section.</li> <li>Updated Figure 6.3. SED One-Shot Mode in One-shot Mode section.</li> </ul>
SEDC Error Handling	<ul style="list-style-type: none"> <li>Added below figures in SEDC Error Handling section:           <ul style="list-style-type: none"> <li><a href="#">Figure 6.4. One-shot Mode with Correctable Error (sedc_cof_i = 0 / 1)</a></li> <li><a href="#">Figure 6.5. SEDC Continuous Mode with Correctable Error (sedc_cof_i = 0 / 1)</a></li> <li><a href="#">Figure 6.6. SEDC One-shot Mode or Continuous Mode with Multiple Error in One Frame (sedc_cof_i = 0)</a></li> <li><a href="#">Figure 6.7. SEDC One-shot Mode with Multiple Error in One Frame (sedc_cof_i = 1)</a></li> <li><a href="#">Figure 6.8. SEDC Continuous Mode with Multiple Error in One Frame (sedc_cof_i = 1)</a></li> <li><a href="#">Figure 6.9. SEDC One-shot Mode with CRC Error (sedc_cof_i = 0 / 1)</a></li> <li><a href="#">Figure 6.10. SEDC Continuous Mode with CRC Error (sedc_cof_i = 0 / 1)</a></li> </ul> </li> </ul>
Technical Support Assistance	Added link for Lattice FAQ website.

### Revision 1.6, October 2022

Section	Change Summary
SEDC Run Time	Updated Table 8.1. Configuration-related Parameters that Affect SED Run Time adding LIFCL 33 device support.

### Revision 1.5, March 2022

Section	Change Summary
All	Minor adjustments in formatting across the document.
Introduction	Updated section content to add MachXO5-NX support.
SED Run Time	Updated section content to add LFMXO5-25, including in Table 8.1. Configuration-related Parameters that Affect SED Run Time.

### Revision 1.4, February 2022

Section	Change Summary
All	Changed document name from Soft Error Detection (SED)/Correction (SEC) <b>Usage</b> Guide for Nexus Platform to Soft Error Detection (SED)/Correction (SEC) <b>User</b> Guide for Nexus Platform.
Soft Error Injection	<ul style="list-style-type: none"> <li>Updated step 1 to correct the location of the BACKGROUND_RECONFIG option. This option is in the Global setting under Device Constraint Editor when generating the bitstream.</li> <li>Updated step 3 and corrected the operation (SEI Fast Program operation) to program the one-bit-different bitstream, in the Radian Programmer.</li> </ul>

### Revision 1.3, July 2021

Section	Change Summary
SED Run Time	Added Table 7.1 to show configuration information and SED run times for different NX devices.
Important Note	New section to describe special handling of boot address register and 'sedc_lrst_n' port to ensure PROGRAM and Refresh command works correctly.

### Revision 1.2, June 2021

Section	Change Summary
All	Minor adjustments in formatting.
Introduction	Added CertusPro-NX support.

### Revision 1.1, June 2020

Section	Change Summary
All	<ul style="list-style-type: none"> <li>Changed document name from CrossLink-NX Soft Error Detection/Correction Usage Guide to <i>Soft Error Detection/Correction Usage Guide for Nexus Platform</i>.</li> <li>Added Nexus platform across the document.</li> </ul>
Introduction	Updated section content.
SEC Overview	<ul style="list-style-type: none"> <li>Updated section content.</li> <li>Updated Figure 2.2 and Figure 2.3.</li> </ul>
Port List	Updated Table 3.1.
Port Descriptions	Updated section content.
SED Clock and Reset	Updated content to add Figure 5.1.
SED Flow	Updated Figure 6.4.
Sample Code	Updated codes in SED Verilog Example and SED VHDL Example.

Soft Error Injection (SEI)	Added this section.
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**Revision 1.0, February 2020**

Section	Change Summary
All	Initial release



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