Radiation Report

LMX1860-SEP Single-Event Effects Report

ABSTRACT

The LMX860-SEP was tested under heavy ions and monitored for Single-Event Latchup (SEL) and Single-Event Functional Interrupt (SEFI). No incidences of SEL or SEFI were detected at an effective linear energy transfer (LETeff) greater than 43MeV-cm^2/ mg with a fluence of 1 × 10^7 ions / cm^2. SEL testing was performed at maximum operating temperature and voltage. Single-Event Upsets (SEU) of the outputs were detected but not characterized. The SEP family of devices are radiation tested products for space missions with reduced radiation and reliability requirements.

Table of Contents

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1 Product Description

The LMX1860-SEP(1) is part of TI's family of Space Enhanced Plastic products(2) released for space missions with reduced radiation and reliability requirements. The LMX1860-SEP(1) is a radiation hardened low noise, high frequency JESD buffer, multiplier, or divider. The flight grade part is orderable as LMX1860MPAPSEP or V62/24630-01XE (3). A LMX1860PAP/EM prototype (which did not receive full space grade processing and testing) can be ordered for engineering evaluation.

A block diagram of the LMX1860-SEP is shown in Figure 1-1. Each of the four high frequency clock outputs and additional LOGICLK output with a larger divider range is paired with a SYSREF output clock signal. The SYSREF signal for JESD interfaces can either be internally generated or passed in as an input and re-clocked to the device clocks. The main clock outputs are all the same frequency. This frequency can be the same, divided, or multiplied relative to the input clock. Each of these clock outputs features a programmable power level. The LOGICLK output frequency is independent and typically is lower frequency than the other four main clocks and features programmable output formats (CML or LVDS) and power level.

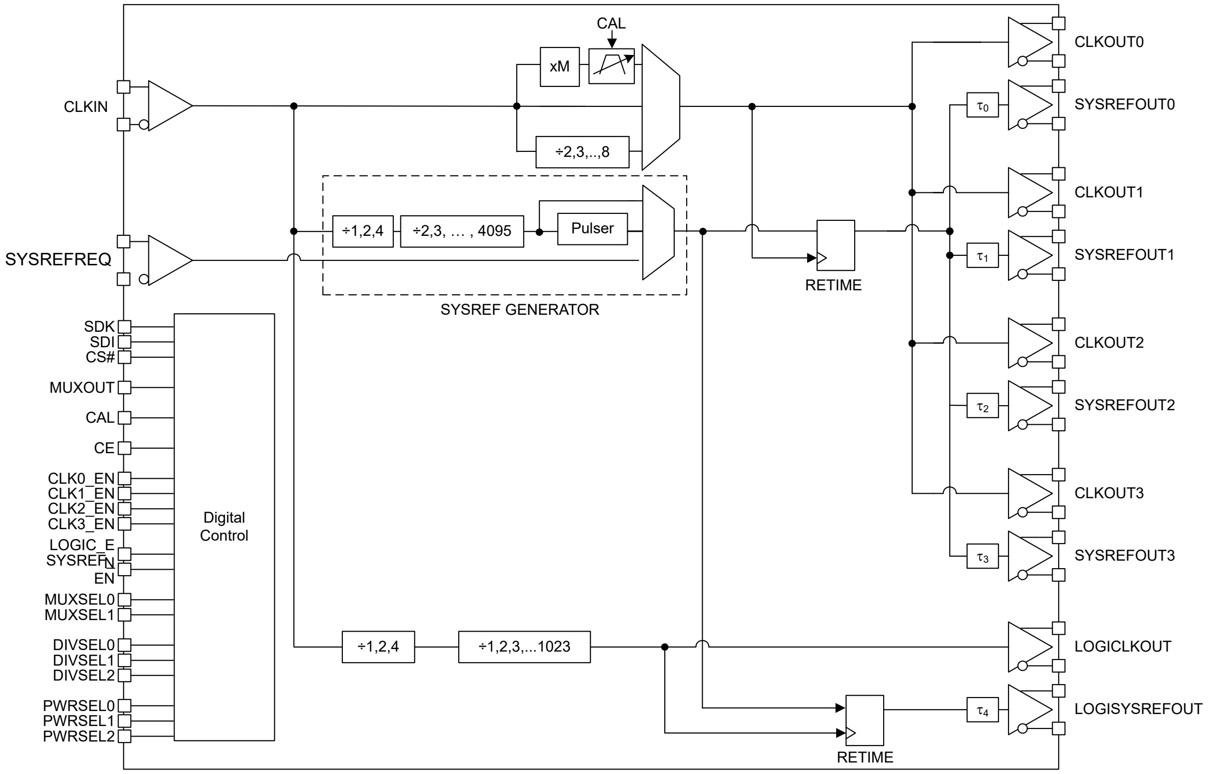

Figure 1-1. LMX1860-SEP Block Diagram

The LMX1860-SEP can be configured with control pins with a limited number of configuration options. The part can also be programmed through a Serial Peripheral Interface (SPI) with an expanded range of configuration options. In SPI mode, the programmed configuration is held in registers which can be read out. The device features an onboard temperature diode that can be read out through the SPI.

The operating voltage of the LMX1860-SEP is 2.4V to 2.6V, and the temperature range is -55°C to +125°C. The LMX1860-SEP is manufactured on a TI BiCMOS process with SiGe NPN bipolar transistors.

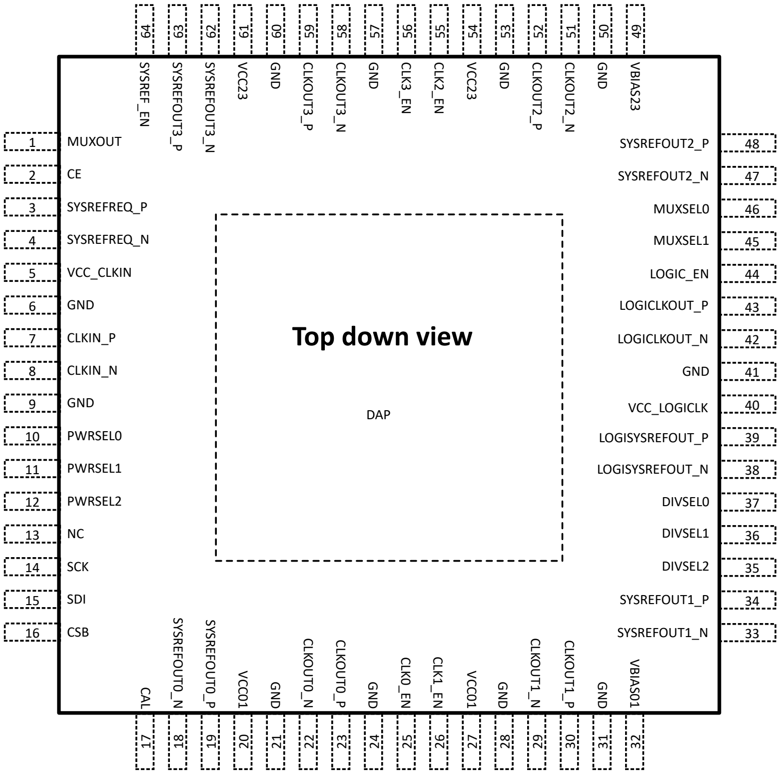

Figure 1-2. LMX1860-SEP Pinout

2 Test Setup

The LMX1860-SEP was monitored for Single-Event Latchup (SEL), Single-Event Functional and Interrupt (SEFI). Single-Event Upsets (SEU) were monitored but not characterized.

The device under test (DUT) was soldered to a custom evaluation board. The DUT was delidded by a chemical process to expose the die surface to the ion beam prior to being soldered to the board.

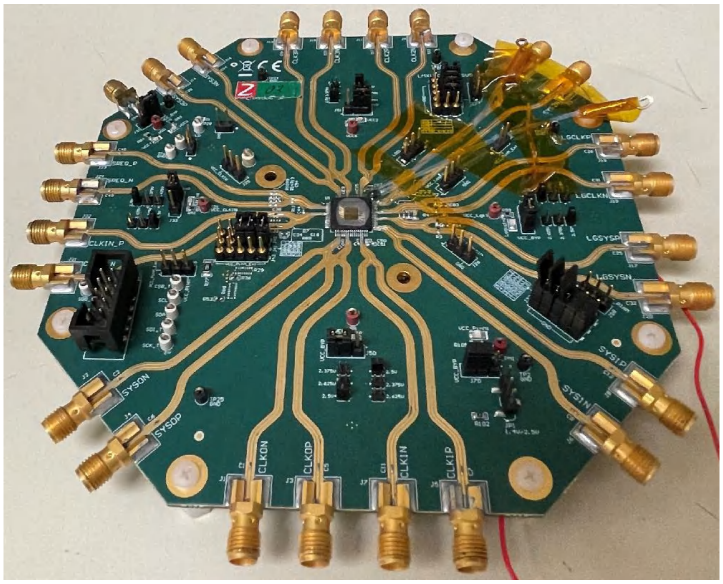

Figure 2-1. LMX1860-SEP SEE DUT Board

A single power supply was used supply the DUT. The power supply current was monitored during each ion run. The voltage was set to 2.6V as measured at the DUT board.

The registers were written using Texas Instruments USB2ANY PC interface and TICS PRO software (4).

An 800MHz single was supplied to the input using a Rohde & Schwarz® SMB100A signal generator. The CLKOUT3 and SYSREFOUT1 were connected to a Teradyne® DPO7354 oscilloscope.

The DUT was configured in buffer mode with all outputs enabled, so that all CLKOUTx outputs were at 800MHz. The SYSREFOUTx outputs were configured to 6.25MHz.

2.1 SEL Test

The DUT was heated to a junction temperature of 125°C using a heat gun supplied by LBNL. Prior to the ion runs, the on die temperature diode was monitored through the SPI and the heat gun was adjusted until a temperature readout of 125°C was achieved. The DUT board temperature was monitored during the ion runs using a thermistor epoxied to the DUT that was correlated to the temperature diode of the DUT.

The supply current to the DUT was monitored in real time. A current jump of greater than 1mA will be investigated.

2.2 SEFI Test

CLKOUT3 and SYSREF1 output signals were monitored with the oscilloscope on each ion run. If the output permanently changed from an ion strike and the DUT had to be reprogrammed, this is considered a SEFI.

2.3 Test Facility

Heavy ion irradiation testing was performed at the Berkeley Accelerator Space Effects (BASE) Facility at the Lawrence Berkeley National Lab (LBNL), using the 16AMeV cocktail with the DUT board in air (5).

The effective linear energy transfer (LETeff) of each ion was calculated at the silicon surface of the die using the SEUSS GUI from Texas A&M University(6). The calculations were based on the 2mil Mylar window used at LBNL and the metal and passivation stack above the silicon on the die. All ion runs were greater than 43MeV-cm^2/ mg, but different ions were used.

Three ion runs were done with the junction temperature of the DUT at 125°C, with a total effective fluence of 1.96×10^7 ions / cm^2 and one ion run was done at ambient temperature with the DUT junction temperature at 41°C to an effective fluence of 1×10^7 ions / cm^2.

3 Results

3.1 SEL Results

No current spikes were detected on any ion runs.

3.2 SEFI Results

The CLKOUT and SYSREF outputs can be momentarily upset due to an ion strike. Signatures included a momentary change in the frequency or a loss of the output for a period time up to one microsecond. The outputs always returned to the programmed frequency and power. The DUT did not have to be reset or the registers reprogrammed after an SEU. The output can recover out of phase from the signal before the SEU. Figure 3-1 is an example of an SEU on SYSREF1 where the pulse momentarily broadened, but then returned to the proper frequency.

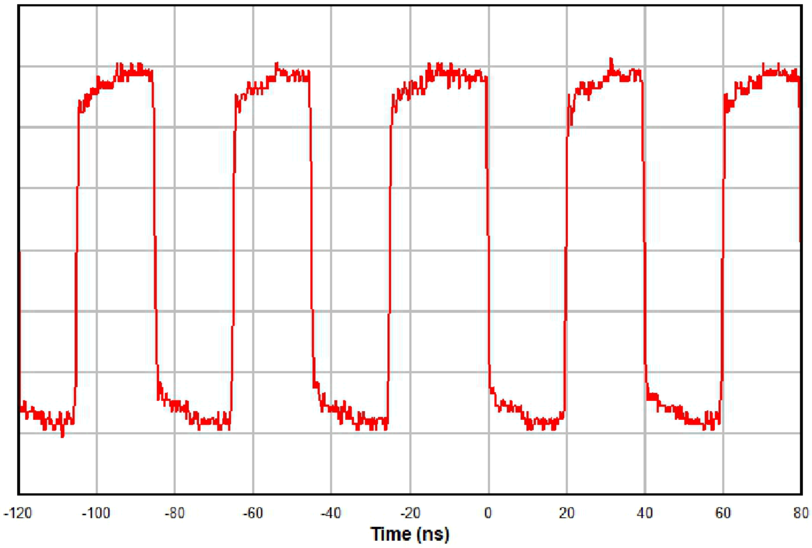

Figure 3-1. Example of SEU on SYSREF1

4 Summary

Under heavy ion testing of the LM1860-SEP, no SEFIs or SELs were detected at an LETeff greater than 43MeV-cm^2 / mg, which was the maximum LET tested. SEL testing was performed at maximum operating voltage (2.6V) and with the junction at the maximum operating temperature (125°C).

The outputs could be upset, with events lasting as long as one microsecond before the output returned to the programmed frequency and power. The outputs did not always return in phase.

5 References

1. Texas Instruments, *LMX860-SEP Space Grade Low-Noise, High-Frequency JESD204B/C Buffer, Multiplier and Divider*, data sheet.
2. Texas Instruments, *Reduce the Risk in Low-Earth Orbit Missions with Space Enhanced Plastic Products*, application note.
3. Department of Defense, DLA Land and Maritime, *Vendor Item Drawing V62/22612*, webpage.
4. Texas Instruments, *LMX860EVM User's Guide*, EVM user's guide.
5. UC Berkeley,The Berkeley Accelerator Space Effects (BASE) Facility, webpage.
6. Texas A&M University, *Cyclotron Institute TAMU Radiation Effects Facility (Control Software Download Page)*, webpage.
7. JEDEC, *Test Procedures for the Measurement of Single-Event Effects in Semiconductor Devices From Heavy Ion Irradiation*, webpage.

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