Proton SEE Testing of Aeroflex UT54LVDS217 Serializer

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Purpose:

Aeroflex has previously tested the UT54LVDS217 serializer for sensitivity to single event transients (SETs). They reported a LET threshold of 3 MeV.cm^2/mg. SETs lasted for up to 100 clock cycles when the part was irradiated with high-LET heavy ions. The low LET threshold suggests that the part might exhibit SET sensitivity when irradiated with protons. Therefore, the goal of this experiment was to measure both the SET rate and the time duration of a SET when the UT54LVDS217 was exposed to 200 MeV protons.

Devices:

Two devices with the same date and lot codes were tested. The following markings were on the cover:

UT54LVDS217- UPC
UTMC WD19A
USA 0312
DWCO

Fig. 1 shows the functional block diagram of the serializer. There are 21 parallel inputs that are converted to 3 LVDS serial outputs. This requires a phase locked loop (PLL) that multiplies the clock-input frequency by a factor of 7. As a result the data transmitted across each LVDS line is at a rate seven times that of the clock. The maximum clock rate is 50 MHz, so the data on each line is transmitted at 350 MHz and the total date rate is 1.05 GHz. At the other end a de-serializer converts the data on its three input channels to 21 separate outputs at the original frequency.

The part is hardened to a total ionizing dose level of 300 krad(Si) and the single event latchup threshold is greater than 100 MeV.cm^2/mg. However, the part is sensitive to heavy-ion induced SETs. It is suspected that the cause of the low LET threshold is the PLL, which, once its operation is disrupted by a heavy ion, takes up to 100 clock cycles to recover.

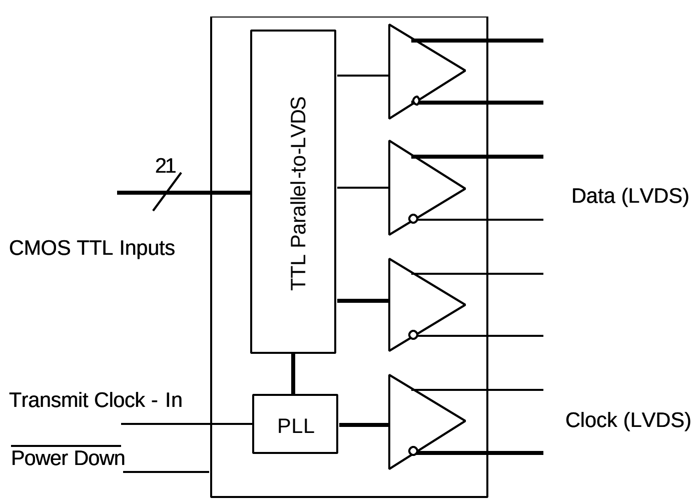

Fig. 1. Functional block diagram of the UT54LVDS217 serializer. There are 21 parallel input lines, a transmit clock and a power down.

Electrical Configuration:

The approach taken for SEE testing of the serializer consisted of comparing the outputs of two serializers connected in parallel to the same inputs and irradiating only one of the serializers. When neither serializer is irradiated, both should have the same outputs. However, if SETs are generated in one of the serializers when it is exposed to an ion beam, the outputs will differ. Normal practice would dictate the use of a Bit-Error-Rate-Tester (BERT) to provide a pseudo-random stream of "1's" and "0's" to the inputs of a single serializer and to compare the outputs with the inputs. However, because the BERT was out of commission, we used the above approach.

Figure 2 illustrates the setup for capturing SETs. All the components shown in Figure 2 were mounted on a single test board designed and manufactured specifically for this test. The board contains two serializers (A and B). Each serializer is connected to a different de-serializer. A marching stream of 1's and 0's is applied to all the inputs of both serializers at a clock rate of 25 MHz. The serializers convert the 21 parallel inputs to 3 serial outputs. The data is transmitted to the de-serializers over each of the LVDS lines at a rate of 175 MHz. The de-serializers convert the data on the 3 input lines back to 21 parallel outputs at a rate of 25 MHz. De-serializer A is well separated from de-serializer B to ensure that only one of them is exposed to the ion beam. The outputs of de-serializer A are compared with those of de-serializer B by the comparator. The number of miscompares is counted and sent to the controller.

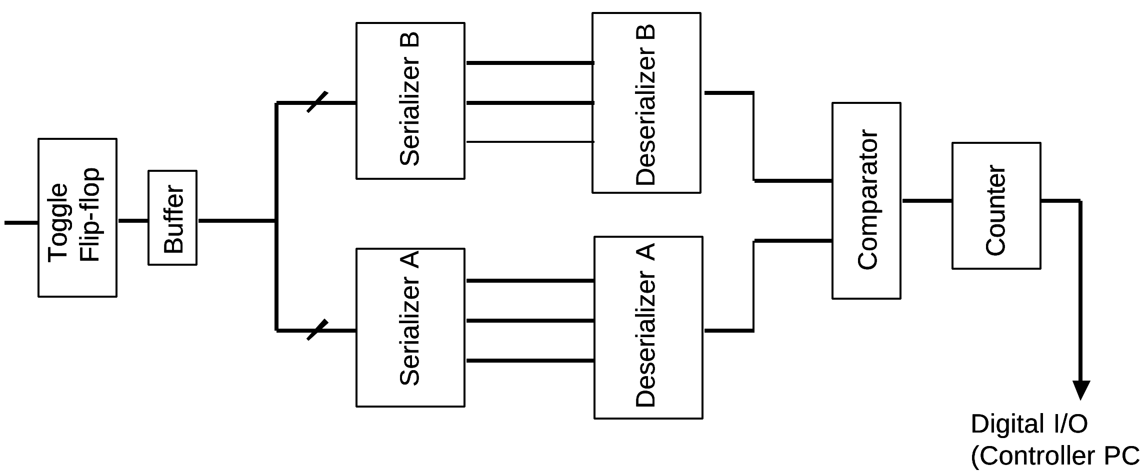

Fig. 2. Diagram illustrating the experimental setup used for SET testing

Experimental Configuration:

The board was mounted in front of the exit port of the cyclotron's beam line. An aperture was used to ensure that only one of the serializers was exposed to the proton beam. Operation of the part was done remotely from outside the experimental room. A 25 MHz clock was applied to the serializer. The number of SETs was recorded on the computer monitor.

Experimental Procedure:

Power was supplied to the part and the clock was turned on. Once the part was operating the counter on the computer was monitored to check for SETs. An error was injected electrically to check that the system was working properly before exposing the part to the proton beam. Once it was determined that the serializer was operating properly, the beam was turned on. The parts were first exposed to 198 MeV protons with a flux of approximately 3×10^9 protons/sec/cm^2 to a fluence of 1×10^{12} protons/cm^2. Data was also obtained for 74 MeV protons by inserting a copper degrader with a thickness of 1.375" in the beam. From the data the length of a burst of errors could be determined.

Results:

Proton-induced SETs caused were characterized by a series of miscompares that lasted for several clock cycles. Such a burst of miscompares was termed an event. The results of SET testing with protons are summarized in Tables I and II.

Table I

Proton Induced Upsets for Part 1

Proton Energy (MeV)	Fluence (cm^{-2})	Number of Events	Number of Upsets in each Event	Total Number of Upsets	Cross Section (cm^2)	Max. Number bits in a burst	Av. Number bits per burst
74	5×10^{11}	1	22	22	2×10^{-12}	22	22
198	1×10^{12}	8	3,17,7,4,9,20,2,6	68	8×10^{-12}	20	8.5

Table II

Proton Induced Upsets for Part 2

Proton Energy (MeV)	Fluence (cm^{-2})	Number of Events	Number of Upsets in each Event	Total Number of Upsets	Cross Section (cm^2)	Max. Number bits in a burst	Av. Number bits per burst
74	5×10^{11}	5	12,3,3,13,3	34	1×10^{-11}	13	7
198	1×10^{12}	29	9,5,4,2,6,21,3,4,7,5, 2,6,3,7,8,11,8,6,20, 9,2,6,7,10,6,5,5,7,17	212	3×10^{-11}	20	8.5

Analysis:

The error rate was calculated using the following formula:

$$BER = \frac{Ne}{DR * t * Fl}$$

where:

Ne is the number of events (see above for definition)
DR is the data rate (25 MHz for all measurements)
t is time obtained from dividing fluence by flux
Fl is fluence

Table III

Bit Error Rate for Two Serializers and Two Proton Energies

	74 MeV	198 MeV
Serializer A	$2x10^{-22}$	$1.02x10^{-21}$
Serializer B	$1x10^{-21}$	$2.73x10^{-21}$