Total Ionizing Dose Characterization of Microchip Programmable Current Limiting Power Switch LX7712

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Abstract: The total ionizing dose characterization results of the Microchip radiation hardened programmable current limiting power switch IC, the LX7712, are presented.

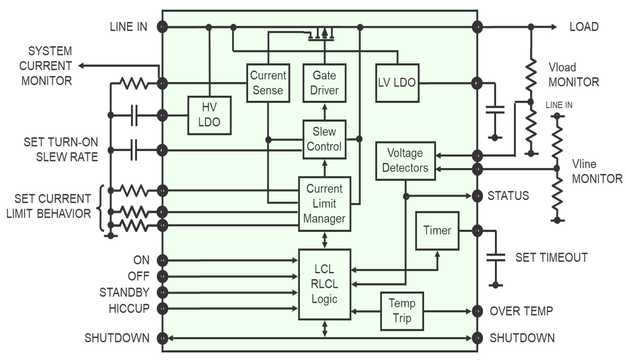
1. INTRODUCTION

A. Device Description

- The LX7712 is a programmable current limiting power switch.
- Contains a solid-state switch based on a P Channel MOSFET and a catch diode.
- Switches voltages up to 120 VDC and DC load with current up to 5A.
  - Multiple devices can be paralleled in a master/slave arrangement to increase the current rating.
- Configurable as a latch-able current limiter or a fold-back current limiter.
- Manufactured as a single die solution in a 48-pin HTF ceramic package.
- The LX7712 includes voltage and temperature monitors for system safety:
  - Line voltage monitor shuts off the switch immediately if the line drops below 10V.
  - Thermal fault detector outputs on the OT_FLT pin to alert die over-temperature and can be connected to the SHDN pin for thermal auto-shutdown.
  - A secondary, user-programmable, under voltage lock-out (UVLO) that performs a soft shut-off by ramping the current down before shut-off.
  - Load voltage monitoring comparator (VO_MON) is also user-programmable by external resistors and causes an alert via the STATUS pin.

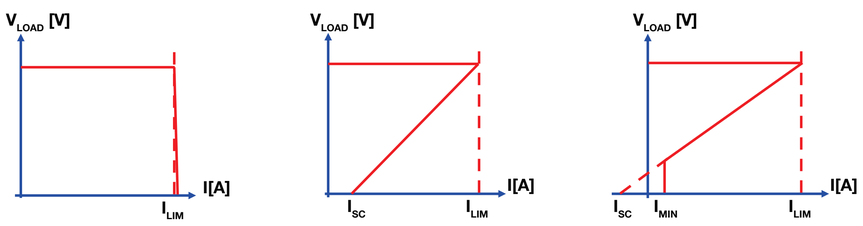
B. Part Rating and Classification

- Temperature range: -55 °C to 125 °C.
- Radiation rating goals:
  - TID tolerance is greater than 100 krad (Si).
  - ELDRS tolerance is greater than 50 krad (Si).
  - SEL immune up to >80 MeV.cm^2/mg and 125 °C.
- Qualification under MIL-PRF-38535 for QML-Q and QML-V.
- ESA Standards:
  - ECSS-E-HB-20-20A.
  - ECSS-E-ST-20-20C.
  - Meets ESA LCL Classes 1, 2, 3, 4, 4A, 4B with 28V and 50V nominal bus voltages.
  - Meets ESA RLCL Classes 0.5, 1, 1A, 1B, 2, 2A, 2B with 28V and 50V nominal bus voltages.
- The LX7712 is classified under EAR 9a515.e.



C. Modes of Operation

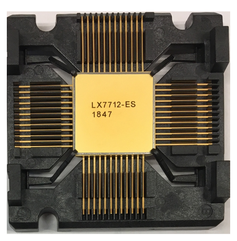
- Hard Current Limit:
  - The LX7712 operates as either a latching current limiter (LCL) or a re-triggerable latching current limiter (RLCL).
  - In latching mode, the power switch is turned off after a permanent (non-transient) fault is established and stays off until an external control system pulses the ON input.
  - In re-triggerable latching mode, the power switch is turned off as for latching mode but will autonomously attempt to turn back on again repeatedly (hiccup mode), with a programmable delay between attempts.
- Current Fold-Back:
  - Part folds back to the programmable safe minimum current (I_{SC}) to allow auto restart on fault recovery.
- Bi-level current Fold-Back:
  - Contains a soft short prevention provision that deters stable operation under high switch current with high switch voltage conditions. The current limit load line is purposely tilted so that a resistive overload will not settle at an intermediate level of fault current.
  - Part folds back to the programmable minimum operating fold-back current (I_{MIN}).



Hard Current Limit | Current Fold-back | Bi-Level Current Fold-back

2. LX7712 – RADIATION TOLERANT BY DESIGN

- The Microchip hardening solution involves a series of test chips and careful device characterization of the power MOSFET in order to optimize layout, voltage breakdown and switch resistance (RDSON) for maximum performance.
- The LX7712 is designed using a Dielectric Isolated technology process capable of high voltage operation up to 350V which is well beyond the absolute max rated operating voltage of the LX7712 of 150V.



3. LX7712 TID TEST PLAN AND TEST SUMMARY

A. TID Test Plan

- The LX7712 TID testing was performed at 100 krad (Si) total dose.
- The TID testing was completed at the Defense Microelectronics Activity (DMEA) test facility in McClellan, California, radiation source Co-60.
- The TID testing followed MIL-STD-883 test method 1019.9, condition A with a dose rate of 50 rad/s. The devices used were part of the first engineering samples.
- The devices were characterized pre-radiation and post-radiation using the ATE characterization test program. Two bias conditions were used during irradiation: output load ON and output load OFF.

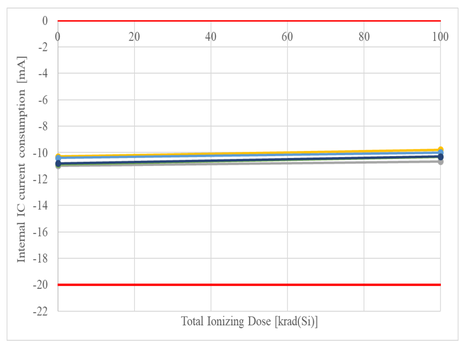
B. 100 krad(Si) TID Test Summary

- The LX7712 performance after 100 krad(Si) exposure is overall very stable and comparable to pre-irradiation.
- Results show very good results on all key parameters of the part:
  - Stable supply current consumptions.
  - Stable under-voltage detection thresholds.
  - Stable internally regulated voltages.
  - Stable leakages.
  - Increase 10% - load ON and 30% - load OFF of the switch voltage drop, still within pre-irradiation specification.
  - Small decrease (~5 us) in shutdown reaction time.
- Results also exhibit an increase in turn-on time dependent on the bias condition during irradiation. The increase was 150 us if the load was on and 30 us if the load was kept off.
  - This shift is not expected to pose any problem at system level as it is only a short additional delay to the nominal 350 us needed to turn on the load.
- Thus, we conclude that the performance of the LX7712 is TID tolerant up to 100 krad(Si).

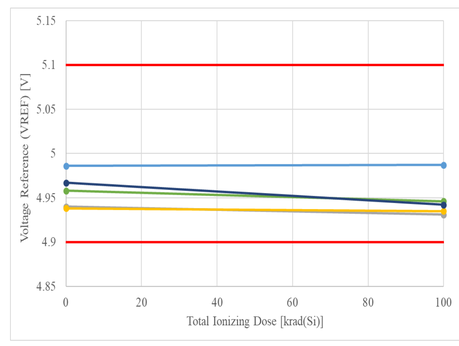
4. TID TESTING RESULTS: 100 krad (Si)

Parameter	Min	Typ	Max	Pre TID	Post 100krad	Units	Comments
Operating Characteristics							
Internal IC current consumption, switch ON	-20		0	-11.0 – -10.3	-10.7 – -9.8	mA	Stable
Internal Under Voltage Threshold	14.5	15	15.5	14.7 – 14.9	14.8 – 15.0	V	Stable
HS_RAIL voltage below line	9	10	11	9.91 – 9.97	9.87 – 9.94	V	Stable
LS_RAIL voltage above ground	9	10	11	10.48-10.53	10.43 – 10.50	V	Stable
Reference voltage VREF	4.9	5	5.1	4.93-4.99	4.93 – 4.99	V	Stable
Reference voltage VREF Current Limit	-2	-9	-15	-8.9 – -8.5	-8.9 – -8.2	mA	Stable
Switch Characteristics							
Switch Voltage drop	0	150	210	112 – 127	131 – 167	mV	Increase ~20%
Switch off leakage	0		55	11.2 – 12.8	12.7 – 14.1	uA	Stable
Switch turn-on time	0		450	329 – 369	380 – 520	us	Stable
Reverse Voltage at 5A	-1		0	-0.93 – -0.92	-0.95 – -0.90	V	Stable
Timer Characteristics							
Shutdown reaction time	0		50	33.0 – 37.1	28.2 – 33.3	us	Decrease ~5us
Timer threshold voltage rising	99	100	101	99.7 – 100.5	99.6 – 100.1	% of VREF	Stable
Timer threshold voltage falling	19	20	21	20.1 – 20.3	19.7 – 20.1	% of VREF	Stable
Timer discharged voltage	0		100	13 – 24	13 – 25	mV	Stable
Timer trip to SH_DN delay	0		5	3.7 – 4.5	3.9 – 4.5	us	Stable
Logic Inputs Characteristics							
Input logic high level	0.8		2.0	1.5 –1.6	1.6 – 1.7	V	Increase 0.1V
Input logic low level	0.8		2.0	1.3– 1.4	1.4 – 1.6	V	Increase 0.1V
Leakage Current ON, OFF, FB_LVL, HICCUP	0		10	1.0 – 5.0	1.0 – 5.0	uA	Stable
Leakage Current SHDN	-50		50	-12 – -10	-12 – -10	uA	Stable

A. Operating Characteristics

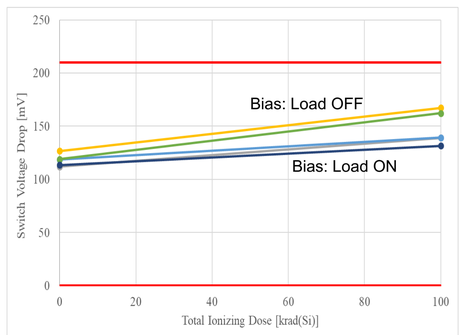


Current Consumption, Switch ON
Very Stable

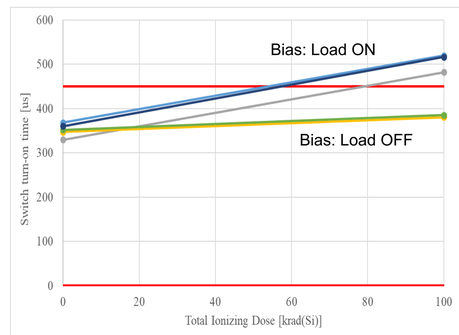


Voltage Reference
Very Stable

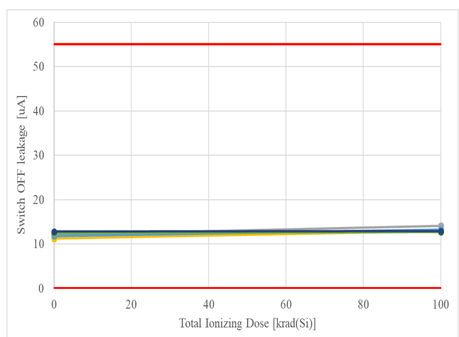
B. Switch Characteristics



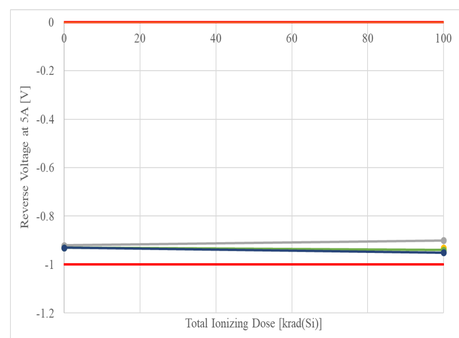
Switch Voltage Drop at 1A
10-30% increase depending on bias condition



Switch Turn-on Time at 1A
30-150 us increase depending on bias condition

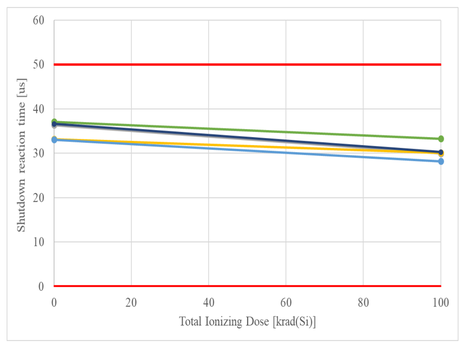


Switch OFF Leakage at 120V
Very Stable

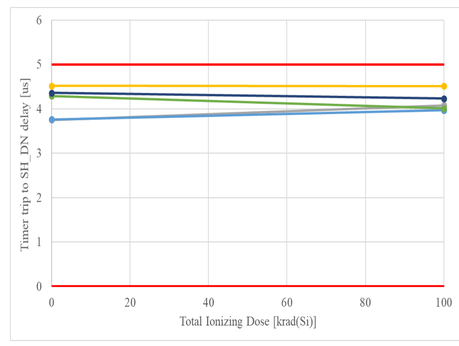


Switch Reverse Voltage at 5A
Very Stable

C. Timer Characteristics



Shutdown Reaction Time
5 us Decrease



Trip to Shutdown Delay
Very Stable

5. CONCLUSION

The LX7712 performance after 100 krad(Si) TID under two biasing conditions is determined to be good and comparable to pre-irradiation. Only a few parameters exhibited some shifts. However, none of the shifts will impact the system-level performance.