White Paper

Accurate Temperature Sensing in a Radiation Environment

Abstract

The best-in-class radiation performance of the ISL71590SEH 2-pin flatpack temperature sensor provides assured precision performance over any mission life eliminating the need for spot shielding, radiation lot acceptance, or complex calibration schemes.

The ISL71590SEH is a radiation-hardened temperature sensor that brings best in class radiation performance to the present marketplace with notable low dose rate total dose hardness. The part has a maximum accuracy error of -1.5 °C after 50 krad (Si), including -0.5 °C of ambient error.

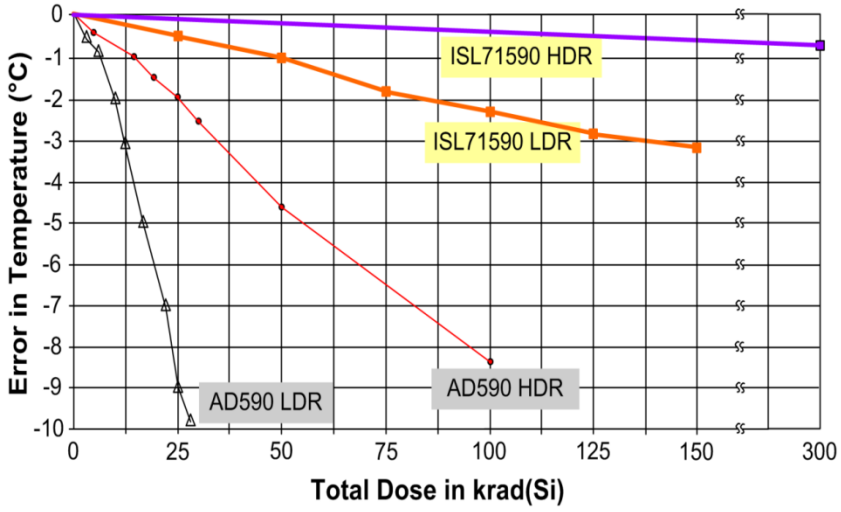

Figure 1. Low and high dose rate performance of the ISL71590 and AD590, illustrating the TID performance superiority of the ISL71590 over the AD590M at both dose rates

The ISL71590SEH is available in both a 2-lead hermetically sealed flatpack package specified over the -55 °C to +125 °C temperature range and in die form. It has a high impedance (>10MΩ) output allowing it to be insensitive to voltage drops across long lines and within spec voltage variations.

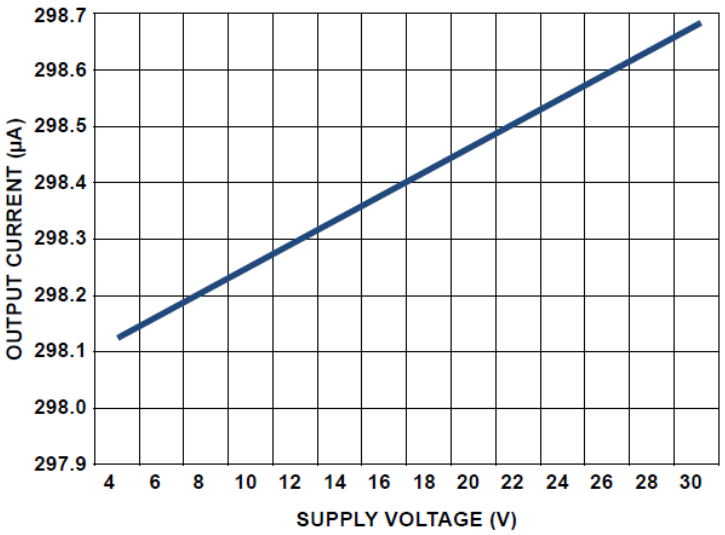

Figure 2. Output current immunity to supply voltage.

When provided with a voltage between 4V and 31V on the input pin, the device acts as a temperature dependant current generator with a scale factor of 1µA/K. The ISL71590SEH can operate over the -55 °C to 150 °C temperature range without the need of additional circuitry and produces results within ±1.7 °C accuracy over the temperature range.

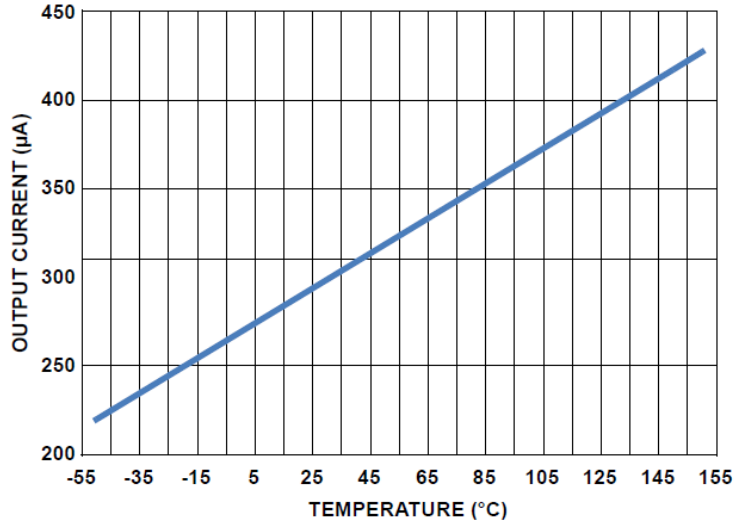

Figure 3. Output current linearity as a function of temperature.

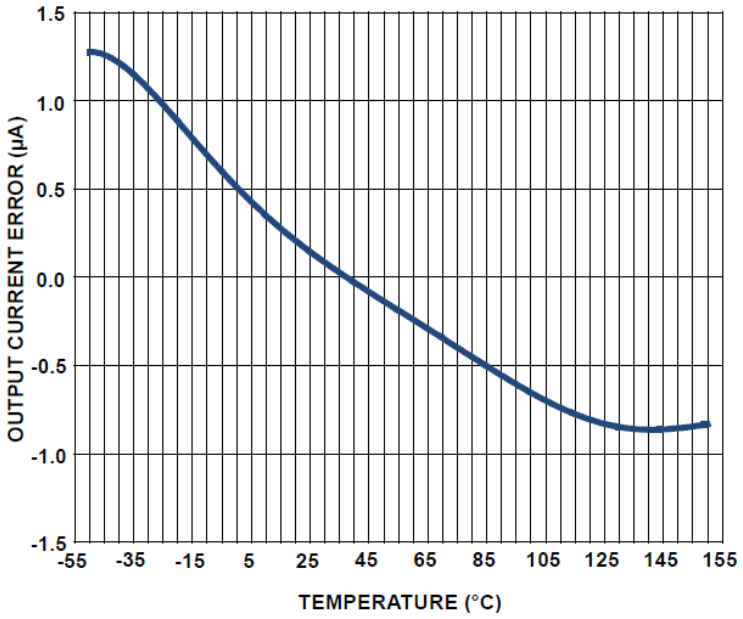

Figure 4. Output current error as a function of temperature.

To achieve these performance levels the ISL71590SEH is manufactured in Intersil's PR40, silicon-on-insulator process, which makes this device immune to single event latch-up and provides excellent radiation tolerance

With power requirements as low as 1.5mW (5V at 25 °C), this part is a good choice for remote payload and booster temperature sensing as any well-insulated twisted pair cable will allow for proper operation. It can be used in several additional applications including temperature compensation networks, laser diode temperature compensation, sensor bias and linearization functions and proportional to absolute temperature (PTAT) biasing.

Although limited to 31V maximum operating voltage over the temperature range, the ISL71590 is electrically durable withstanding a forward voltage of 40V outside of the heavy ion environment (with a 37V maximum in-beam rating) and a reverse voltage of -40V. The case to lead breakdown voltage is ±200V.

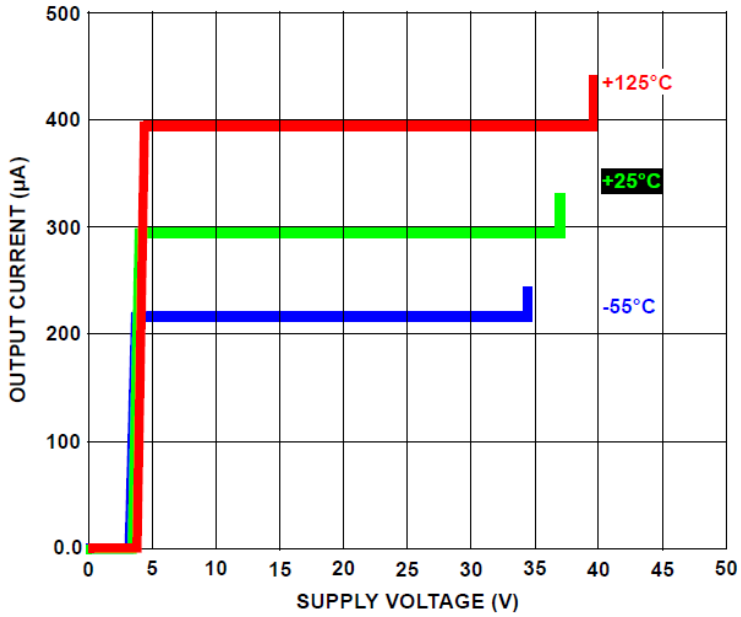

Figure 5. Output current as a function of supply voltage and temperature illustrating the -55 °C supply voltage limitation on supply voltage range.

The superior radiation hardness and temperature performance makes the ISL71590SEH an ideal choice for high reliability applications in harsh radiation prone environments. To test and confirm these performance levels, and for predictable and reliable space system operation, where the intense proton and heavy ion environment can cause a variety of destructive and nondestructive single-event effects (SEE) in electronic circuitry, individual electronic components must be characterized to determine their SEE response.

The ISL71590SEH was tested to determine its susceptibility to destructive single-event effects including single-event burnout (SEB) and single-event latch up (SEL). The part is an all-bipolar design, so single-event gate rupture (SEGR) is not a direct concern; however the part does contain a polysilicon – oxide – silicon capacitor and single-event dielectric rupture (SEDR) is a concern. In order to determine destructive damage the output current (Iout) was monitored recording the pre- and post irradiation values. Each sample was irradiated at an LET of 86.3 MeV.cm2/mg to a fluence of 2 x 106 ions/cm2 at a flux of 1 x 104 ions/cm2 at increasing voltage levels, starting at 31V with 2V increments. Allowing ±1µA of measurement repeatability variation, only the tests at 39V were seen to damage the parts. All parts passed at voltages of 37V and below as shown in Table 1.

Table 1: Results of destructive SEE testing of the ISL71590SEH.

Unit SN	Supply (V)	I_{OUT} Pre (µA)	I_{OUT} Post (µA)	I_{OUT} Delta (µA)	Result
1	31	422	423	1	Pass
2		423	424	1	Pass
3		423	422	-1	Pass
4		420	421	1	Pass
1	33	423	423	0	Pass
2		424	424	0	Pass
3		421	422	1	Pass
4		422	422	0	Pass
1	35	424	423	-1	Pass
2		424	424	0	Pass
3		422	422	0	Pass
4		423	423	0	Pass
1	37	424	424	0	Pass
2		424	424	0	Pass
3		423	423	0	Pass
4		422	422	0	Pass
1	39	424	427	3	**Fail**
2		424	2000	1576	**Fail**
3		423	423	0	Pass
4		423	423	0	Pass

SEE testing of the ISL71590SEH temperature sensor demonstrated that the devices are not susceptible to destructive single-event burnout with a worst case package temperature of 150 °C, when irradiated with gold at zero degrees incidence for an effective surface LET of 86.3 MeV.cm^2/mg and up to an input voltage of 37V. This value is 19% over the recommended operating maximum input voltage of 31V.

With the superior accuracy over low and high dose radiation exposure and the overall robust capability of the ISL71590SEH, you are guaranteed precision performance over any mission life. In addition, no additional spot shielding, radiation lot acceptance testing, or any other techniques are required to get this assurance. Furthermore, with the ISL71590SEH compact and easy-to-use 2-pin flatpack or die and its linear response over temperature, the device does not require any additional compensation or external components to get the accuracy and response that is needed. Find out more about Renesas' space and harsh environment solutions at https://www.renesas.com/products/space-harsh-environment.html.

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