OBC Subsystem Report
Comparison of external supervisory ICs (hardware watchdogs)
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1 Summary

The radiation-wise harsh space environment can be fatal for the electronic parts of the CubeSat, if proper precautions are not taken. One of the ways to prevent long-term damage is to periodically reset the systems, in order to ensure that any erratic bit-flip in a critical memory or processing area is corrected. However, this measure cannot account for severe failures outside of the reset window, such as bit-flips causing the MCU to get stuck in an infinite loop. Therefore, external supervisory circuits are required to account for such errors. This report concerns itself with a basic comparison of the available options and provides recommendations on them.

2 What is a watchdog?

A watchdog timer is a countdown timer that power-cycles the component connected to it (usually an MCU) when the component in question doesn't toggle a pin of the timer in a specific (sometimes adjustable) timeframe. For instance, a charged particle flips a bit in an important part of the processor, causing it to get stuck in an infinite loop. The watchdog can detect that the MCU is not responding, and power-cycle it automatically. This timer can be either implemented in software, or in a special IC for maximum reliability.
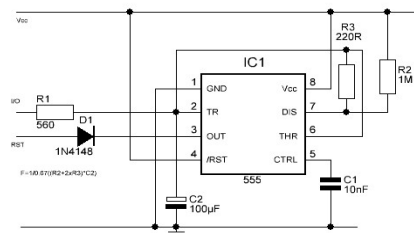

Figure 1: A simple 555-based watchdog circuit.

3 Requirements

The basic requirements set forth by the subsystem in order for a watchdog to be considered for use are:

1. The **minimum** operating temperature range is the same used for all the other electronic components, which is from -40 to 85°C.
2. Maximum current should be below 100 mA.
3. Operating voltage should be at least 3.3V.
4. The watchdog shall be offered at least in some surface-mounted package (excluding BGA packages).
5. The watchdog's output shall be active-low, in order to be able to use the MCU's reset line.

Note that these are the *bare* minimum requirements. Anything more than that is obviously welcome.

4 Options under consideration

There is a wide range of watchdog ICs available, catering to different end users and use cases. For this reason, it was sometimes difficult to choose between them, since the minimum requirements above are covered by most of the circuits on the market (barring certain ICs that had an operating range of 0-70°C, for example) which led the selection process to judge according to additional features. Without further ado, the candidates to be evaluated are listed below (in no particular order):

1. Renesas Electronics **ISL88705IB846Z**
   - Maximum supply: 5.5V, 19μA
   - Operating temperature range: -40...85°C
   - Manual reset: Yes
   - Watchdog timeout: 1.6 sec
   - Reset pulse width: 140 ms (minimum, adjustable up to 260 ms)
   - Package: SOIC-8 (SMD)
   - Extra features: Immunity from power-supply transients, Power-On Reset (POR)
2. MaxLinear **SP706SEN-L/TR**
   - Maximum supply: 5.5V, 40μA
   - Operating temperature range: -40...85°C
   - Manual reset: Yes (debounced)
   - Watchdog timeout: 1.6 sec
   - Reset pulse width: 200 ms
   - Package: SOIC-8 (SMD)
   - Extra features: Watchdog enable/disable at will

3. Maxim Integrated **MAX6705ASKA+T**
   - Maximum supply: 6V, 25µA (no load)
   - Operating temperature range: -40...125℃
   - Manual reset: Yes
   - Watchdog timeout: 1.6 sec
   - Reset pulse width: 140 ms
   - Package: SOT23 (SMD)
   - Extra features: Immunity to V_{CC} transients

4. STMicroelectronics **STWD100YNYWY3F**
   - Maximum supply: 5.5V, 26µA
   - Operating temperature range: -40...125℃
   - Manual reset: No
   - Watchdog timeout: 6.3 ms
   - Reset pulse width: 210 ms
   - Package: SOT23-5, SOT323-5 (SMD)
   - Extra features: Automotive qualified (AEC-Q100), Enable/disable at will

5. Maxim Integrated **MAX6323HUT29+TDKR-ND**
   - Maximum supply: 6V, 57µA
   - Operating temperature range: -40...125℃
   - Manual reset: Yes
   - Watchdog timeout: 719 ms (fast), 1.3 sec (slow)
   - Reset pulse width: 100 ms (minimum)
   - Package: SOT23 (SMD)
   - Extra features: Power-On Reset

5   Thoughts on the "candidate" watchdogs

The final choice of a watchdog is not easy, given the fact that there are so many options to choose from, and that many variables are still unknown as of the time of this report, such as the thermal environment of the satellite. Therefore, I would suggest the `SP706SEN-L/TR` IC watchdog by `MaxLinear` as an overall "good enough" choice, if I may, because of its ability to be enabled and disabled at will in case of failure and also due to it offering a manual reset capability, which will be essential for restarting the on-board computers whenever it is needed via a telecommand. In case additional current spike protection is needed (due to EPS failing to provide constant voltages, for example) a solid choice would also be either the `MAX6705ASKA+T` circuit by `Maxim Integrated`, which offers immunity to V_{CC} transients and also a wider temperature range than most of the other circuits considered, if the need ever arises, or the `ISL88705IB846Z` by `Renesas Electronics`, which also offers power-on reset capabilities and adjustable reset pulse width, apart from the power spike protection capability.

6   Datasheets and store pages

This section contains the datasheets of each considered circuit, in case more information is needed, and also their store pages.

- Renesas Electronics **ISL88705IB846Z** (Datasheet, Store Page)
- MaxLinear **SP706SEN-L/TR** (Datasheet, Store Page)
- Maxim Integrated **MAX6705ASKA+T** (Datasheet, Store Page)
- STMicroelectronics **STWD100YNYWY3F** (Datasheet, Store Page)
- Maxim Integrated **MAX6323HUT29+T** (Datasheet, Store Page)