ADAPTION OF AN INDUSTRIAL HIGH END MICRO SWITCH FOR SPACE APPLICATIONS

Matthias Schmalbach[(1)], Max Eigenmann[(1)], Reto Lutz[(2)]

[(1)] RUAG Space, Schaffhauserstrasse 580, CH-8052 Zürich, Switzerland, Email: Matthias.Schmalbach@ruag.com, Max.Eigenmann@ruag.com
[(2)] Baumer Electric AG, Frauenfeld, Hummelstrasse 17, 8500 Frauenfeld, Switzerland, Email: reto.lutz@baumer.com

ABSTRACT

Micro switches with a high repeatability are commonly used components in space mechanisms and instruments, e.g. for end-stop position detection, counting or displacement sensoring. Due to the harsh space environment, standard industry switches or components can usually not sustain the environmental conditions required for space applications. In the frame of a current mechanism development project, RUAG started a cooperation with Baumer Electric AG, a supplier of innovative and high class quality sensor products for applications in factory and process automation. The aim of this cooperation was to adapt and qualify an existing, proven and reliable high quality industrial micro switch and its components for space applications. Therefore the complete design as well as the manufacturing processes have been reviewed and modified in accordance to the ECSS Standards and the relevant mission performance requirements. Non-suitable materials have been replaced by space proven materials; manufacturing processes have been adapted according to ECSS Standards (e.g. soldering). Qualification tests have been executed to verify the performance, e.g. life cycles testing in cold environment.
RUAG intends to use this component generally as a preferred part for space mechanisms and instruments and to further extend its qualification range considering the needs and requirements of future programmes. RUAG will offer this space adapted and qualified product, which is exclusively manufactured for RUAG, including the required engineering support to the open space community.

1. INTRODUCTION

Based on the needs and the requirements of a current development and qualification project for a space mechanism, RUAG was searching for a competent supplier for end stop switches with space heritage. A market research showed that such a switch was not available on the market within a reasonable cost frame. Therefore RUAG started the cooperation with Baumer Electric AG in Frauenfeld, with the aim, to adapt and qualify a high standard industrial micro switch for space applications.

Baumer Electric AG is one of the market leaders for innovative sensors and solutions, setting standards and investing in the technological advantage. During the past years, the main focus was particularly on miniaturization, precision, measuring speed and robustness of the products. Today Baumer is known for their outstanding quality and their ability and experience to adapt or tailor their standard products to customers needs.

2. THE HIGH STANDARD PRODUCT

The MyCom precision switches family, having a repeat accuracy of less then 0.001mm (<1 micron), Baumer Electric AG provides one of the most accurate and compact mechanical switches worldwide.

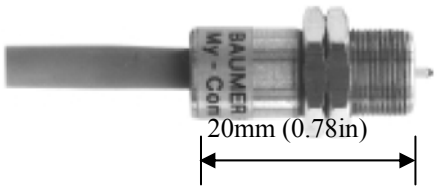

Figure 1. MyCom industrial precision micro switch from Baumer Electric AG.

Fulfilling already many space requirements, this high standard industrial product has been selected as the baseline to be adapted for space applications.

2.1. The MyCom Design

The cutaway view below shows a typical design of a MyCom precision switch. Just three moving parts and high-quality materials guarantee a large number of switching operations with constant repeat accuracy. The low activation forces, the short movements and the compact design guarantee the robustness.

'14th European Space Mechanisms & Tribology Symposium – ESMATS 2011'
Constance, Germany, 28–30 September 2011

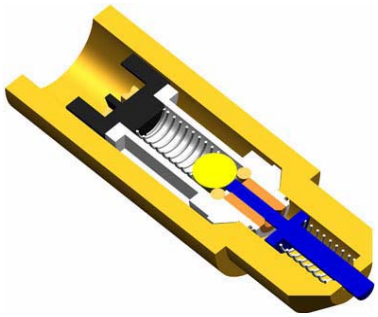

Figure 2. MyCom industrial precision micro switch (cutaway view).

Here, the second spring in the head part of the device is non-standard (custom tailored). While the sensor housing is typically made of brass nickel plated, a variant stainless steel housing can be provided. The activating pin is made of zirconium oxide and as such is sensitive to lateral loads.

2.2. The MyCom Standard Parameters

The Baumer MyCom Typ B precise micro switch is specified with the following parameters.

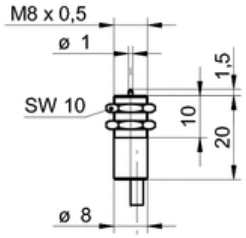

Figure 3. Dimensions MyCom 75/80.

Table 1. Standard Parameters MyCom 75/80.

General Data	
repeat accuracy	< 0.001 mm
activating force	75 cN
mech. pre-run / overrun	- / 1.5 mm approx.
Electrical Data	
DC voltage max.	15 VDC
switch current DC max.	2 mA
AC voltage max.	24VAC
switch. current AC max.	50 mA
output circuit	break function (NC) mechanical
Mechanical Data	
activating pin	zirconium oxide ZrO2
potting resin	PUR-G Wepuran VU4477/31
housing material	brass nickel plated
dimension	8 mm
type	cylindrical threaded
housing length	20 mm
connection types	cable, 80 cm
life cycle (trigger events)	10'000'000
Ambient Conditions	
operating temperature	-20°C to +75°C
protection class	IP 50

3. ADAPTATION FOR SPACE

To adapt and qualify the Baumer micro switch for space applications a close cooperation between Baumer Electric AG and RUAG Space has been initiated. In the frame of this cooperation Baumer provided detailed information of all materials and processes used for manufacturing and assembling of the micro switch. Design details have been discussed and two main domains have been identified to be addressed.

3.1. Material Review and Assessment

In a first step RUAG reviewed the materials used in the standard MyCom switch consulted by the RUAG experts for materials and the future customer.
As a result of this activity the potting resin, solder and harness have been replaced by space qualified components. The potting resin Weburan (PUR) was replaced by a space proven epoxy (Stycast). The solder Sn63Pb37 to be used was specified according to ECSS Q-70-08A and the cabeling to be used was specified according to ESA/SCC 3901/012-02. These modifications were checked and approved in agreement with Baumer Electric AG.

3.2. Process Review and Assessment

Based on the outputs of these reviews and in close interaction with RUAG's customer of the project using this micro switch, only small process modifications were required. These are related to the change in potting resin and the soldering process.
Since Baumer Electric AG is familiar with the use of Stycast on other components, the process was in place and needed only to be referenced in the production documentation accordingly.
In addition, the required harness (ESA/SCC 3901/012-02 AWG 28) will be procured by RUAG Space directly. During the pre-assembly of the sensors, RUAG will provide ESA certified staff for execution of the soldering process.

4. Qualification Testing

4.1. Verification Approach

The qualification of this modified micro switch will be performed in the frame of a running space mechanism project,

- partially on component level and
- partially as an integrated component of the mechanisms in the frame of the space mechanism qualification test program.

Testing will cover the typical mechanism parameters: repeatability, triggering sequences (life time), thermal cycling, operating and non-operating temperatures, as well as vibration testing within the scope of the pilot project needs.
Based on the current development schedule, full qualification is expected by mid of 2012.

4.2. Expected Qualification Status

The micro switch will be space qualified to the pilot project specified levels given in Tab. 2:

Table 2. Pilot Project Qualification Levels.

General Data	
repeat accuracy	< 0.001 mm
activating force	75 cN
mech. pre-run / overrun	- / 1.5 mm approx.
Electrical Data	
DC voltage max.	15 VDC
switch current DC max.	2 mA
AC voltage max.	24VAC
switch. current AC max.	50 mA
output circuit	break function (NC) mechanical
Mechanical Data	
activating pin	zirconium oxide ZrO2
potting resin	Stycast-2651MM
housing material	brass nickel plated
dimension	8 mm
type	cylindrical threaded
housing length	20 mm
connection types	cable, 130 cm
life cycles (trigger events)	800 (space environment)
Ambient Conditions	
operating temperature	-50°C to +70°C
non-operating temperature	-60°C to +90°C
thermal vacuum	< 10^{-5} hPa
thermal cycling	8 cycles incl. bakeout at +80°C
shock environment	Tab. 3
sine & random vibration	Tab. 4 / Fig. 4
protection class	IP 50

Table 3. Pilot Project Shock Loads.

Frequency band (Hz)	Shock spectrum (Q=10) (g)
30 – 50	5 – 10
50 – 100	10 – 80
100 – 700	80 – 1000
700 – 1000	1000 – 2000
1000 – 1500	2000 – 2800
1500 – 4000	2800 – 4000
4000 – 5000	4000
5000 – 10000	4000 – 2000

Table 4. Sinusoidal Qualification Levels.

Frequency (Hz)	Level	Remark
5 – 21	11 mm (*) (0 – peak)	No notching
21 – 60	20 g (0 – peak)	
60 – 100	6 g (0 – peak)	
(*) If the maximum hub is lower than 11 mm, the maximum hub shall apply.		

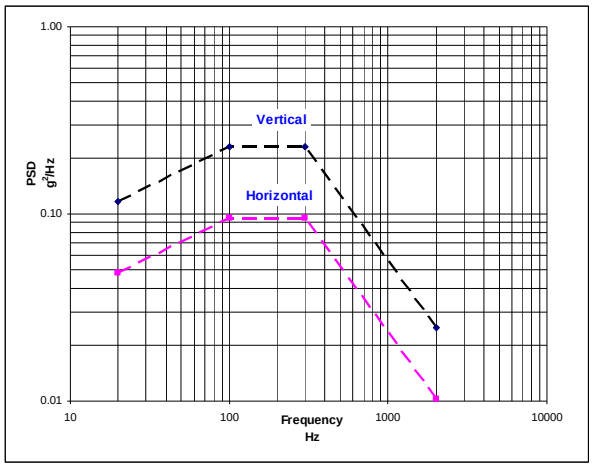

Figure 4.Random Vibration Spectrum (Pilot Project).

4.3. Future Qualification Potential

With reference to industrial applications, the micro switch is able to sustain more then 10 mio trigger events [2]. In addition the micro switch also has heritage [3] in cryogenic applications operating in liquid nitrogen (4K).
With industrial heritage demonstrating that the micro switch is capable of operating at low temperatures with nearly unlimited life expectancy and shock, random and sine vibration effects will be covered by the qualification tests of the pilot project, it is assumed that further low temperature and extended life tests in space simulated environments may easily widen the qualification spectrum of the micro switches.

5. APPLICATIONS

5.1. End-Position Sensor for Hatch Axis

For hatch mechanisms, the detection of the open and closed positions is of critical importance. Therefore the high end micro switches have been used in the assembly shown in Fig. 5.
The attachment nuts of the end switches provide adjustability within < 1mm range. When the end switch is triggered, a signal is given to the system level drive electronics (not scope of RUAG) to command a motor power off.
The sensors are placed next to the hatch axis on the outer housing of the mechanism. Two little bridges connected to the pivot trigger the sensor. Fig. 5 shows the integrated open and close sensors (each position as main and redundant).

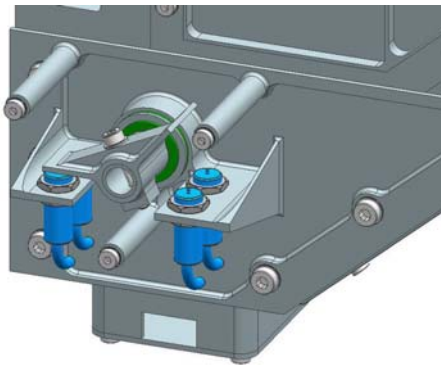

Figure 5. Hatch axis with end-switches assembly.

5.2. Release Sensor with Crash Pad

For the detection of the HDRM release a special release mechanism has been designe d. It consists of two high end m icro switches (main and r edundant) which are held down by a rel ease bar. The release bar is attached to a crash pa d which is going to be compressed in case of the bolt having broken.
The symmetric arrangement of the micro switches and the fixation of the release bar to the crash pad ensure the release bar to heave up straight triggering both release switches.
The crash pad has been designed in order to transform the kinetic energy of the loose part of the fastener into deformation energy.

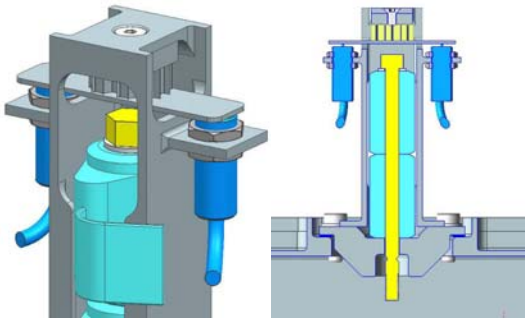

Figure 6. Release Sensor with Crash Pad.

6. NOTES

This paper will be prese nted at the poster session of ESMATS 2011 in Constance.

7. REFERENCES

1. ESA Publications. (2002). Space Engineering Testing, ECSS-E-10-03A.
2. Baumer Electric AG. (2002). Comets for Beginners, Cambridge University Press, Cambridge, UK, pp103-106.
3. Zago, L. (2006). Optomechanical Technologies for Astronomy (Proceedings Volume 6273), The EMIR detector translation unit: a cryogenic high-precision 3-DoF parallel mechanism, proceedings paper, p 4.