„The Power of the Fuze“

60th Annual Fuze Conference
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Overview

- History, the large Calibre Fuzes
- Requirements
- Challenges
- Miniaturised Fuze Batteries
- New Test Equipment
- Conclusions
Legacy Fuze Batteries

- PS115 (lead)
- MOFA post launch
- DEP 1400x series

- Requirements
  - Power $1 - 5$ W
  - Energy $200 - 500$ J
  - Life time $< 200$ s
  - Rise time $> 100$ ms
The “Onset”

- In our 2011 presentation ...

we have analysed the requirements ...

... and proposed a small Fuze battery
The Start

- Naively we thought …
  - substitute a 5 – 10 mJ set-back-generator
  - with a 100 mJ fuze battery
  - ¼ the size of the generator

is not a big issue
we used to build Artillery/Mortar-Fuze Batteries with 10,000 times more Capacity

just reduce the diameter by a factor of 3 and
the height by factor of 2.5
Customers Challenge

- Our 2014 presentation …

**Power Supply**

- All new electronic Subsystems are
  - Low voltage 1.7 - 8.5 V
  - Low current 5 - 110 mA
  - Low power 10 - 300 mW

- Typical combinations for medium caliber
  \[ P_{\text{Peak}} = 50 - 500 \text{ mW} \]
  flight times of 10 - 20 sec sum up to \( E = 0.5 - 10 \text{ J} \)

- Sophisticated Power management is required to lower Energy

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supplemented by DoD 2014.1 SBIR

- rise time < 10/100 ms
- current > 2/40 mA
- voltage > 2.9 V

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**our customer survey**

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**Anforderungen/Randbedingungen**

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**Electrical data**

- Voltage: As high as possible to reduce current. We are thinking 3-4 cells in series (if possible).
  - Minimum voltage level TBD

- Energy: Shall 0.5 Joule, Should 1 Joule

- Activation: Should 50 msec, Shall 100 msec (min 300 mJ delivered at this time to capacitor)

- Type of load: DC/DC converter (switching type). Up to 10 W can be consumed by the converter for a short time.
**Bottom Line**

- Requirement “Challenges/Highlights” *
  - Voltage as high as possible
  - Energy hundred’s of mJ
  - Power most of the Energy within ms some W’s
  - Current hundred’s of mA
  - Rise time almost instantaneously \( t_r = \text{close to zero} \)
  - Life time up to 60 s
  - Environment spinning and none spinning

* fortunately not all cumulative
Our first small Battery

- High Acceleration (no/low spin)

DEP 14103 at -46°C
The next small Battery

- DEP14202.01

reflecting new customer requirements

DEP14202.z; -46°C, spin
Early Voltage/Power Capability

- **Load-Test**

![Graph showing load-test results]

**2s Battery**
- \( P \approx 500 \text{ mW/cm}^2 \) \( @ \) 100 ms
- \( E \approx 40 \text{ mJ/cm}^2 \) until 100 ms

**Power** = \( f(t) \)

**Energy** = \( f(t) \)
Load Management

- **Load Profile**

- avoid (delay) high current until battery is sufficiently activated (electrolyte has reached the place where it is supposed to be)

- high capacitive load can be even worse (remember: empty capacitor is a “short circuit”)
New Lab-Test-Equipment
New Lab-Test-Equipment

- External Load Panel (e.g. Maccor) or Customer Breadboard
- Synchronised Load and Data Recording
- Spin Rate up to 18,000 rpm
- Test-Time up to 500 s (actually unlimited)
First Results

- **DEP14202.02**
  = none spinning mod of DEP14202.01
Conclusion

- Lithium Reserve Batteries provide very short Activation Time
  - under high forces
    - Acceleration
    - Spin
  - if properly designed
  - under proper load management
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Lithium Reserve Batteries are able to provide “In-Barrel” Power!
Thank you for your attention!

Questions?

… and don´t forget talk to us about YOUR requirements!
Diehl & Eagle Picher Contact

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