Indirect lightning test:
The new MIL-STD-461G CS117 vs DO-160G S22

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EMC PARTNER AG, Switzerland
Indirect lightning test equipment supplier ↔ EMC PARTNER

- Founded in 1994
- Swiss private company, headquarters in Laufen
- Largest choice of impulse generators
- Market leader in supplying equipment for ind. light.
- Development, production and testing in house
- Global representative network
Content

- Introduction
- Basic considerations
- Test requirements and test levels compared
- Calibration and test setup examples
- Roundup
- Conclusion
Introduction

Lightning statistics (Boeing, Onera France): 54,900 events in 2013

Aircraft can be involved in a natural occurring lightning or trigger one

$subseq. ret. st.$ – subsequent return stroke current
Introduction

Severe negative real flash to ground:

- Typically between 1 and 11 strokes, average: 3, max. strokes: 24
- Total duration: 20 ms – 1 s, average duration: 200 ms
Introduction

External *idealized* current components (time not to scale):
a very popular diagram in literature
Introduction

Direct lightning effects

- Puncture
- Burning
- Melting, etc.

Indirect lightning effects

Electromagnetic effects:
- Induced currents
- Induced voltages

www.eturbonews.com
Basic considerations

**RTCA DO-160G Section 22**

- Commercial aircraft
- Complete set of tests included
- In place for a long period

**MIL-STD-461G CS117 (new)**

- Military aircraft and surface naval ships
- Complemented by other STDs like 464
- Introduced in 2015, based on DO-160G

**RTCA → Radio Technical Commission for Aeronautics**
Basic considerations

Standardization

SAE AE2 → Experience, Know-how → ARP54xx → RTCA SC 135 → DO-160G S22, S23


DOD → HDBK, SPEC, STD, etc.
Test requirements compared

RTCA DO-160G Section 22

EUT designation
Five test levels

MIL-STD-461G CS117 (new)

No EUT designation
Two test levels

L1: internal eq.
L2: external eq.

L1: below deck
L2: above deck

WF set | Test type | Waveforms
---|---|---
A | PIN | 3, 4
B | PIN | 3, 5A

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www.navy.mil
Test requirements compared: test types

RTCA DO-160G Section 22

- Pin injection
- Cable bundle

MIL-STD-461G CS117

Ø No pin injection requirement

- Cable bundle
Test requirements compared: test types

MIL-STD-461G CS117

Why no pin injection requirement in MIL-STD-461G?

MIL STD-464:

- There are two models, one for direct effects and another for indirect effects
- The model for indirect effects does not include pin injection
Test requirements compared: injection method

**MIL-STD-461G CS117**

Only cable induction (CI) is used as injection method: no direct injection (PIN), no GI

<table>
<thead>
<tr>
<th>S22</th>
<th>Pulse application</th>
<th>CS117</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>Pin injection (PIN)</td>
<td>Ø</td>
</tr>
<tr>
<td>✓</td>
<td>Cable induction (CI)</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>Ground Injection (GI)</td>
<td>Ø</td>
</tr>
</tbody>
</table>
Test requirements compared: signal types

MIL-STD-461G CS117

Only Multiple Stroke (MS) and Multiple Burst (MB): no Single Stroke (SS)

S22

- ✓
- ✓

CS117

- Ø

- ✓

- ✓
Test requirements compared: waveforms

MIL-STD-461G CS117

All waveforms from S22 present, except WF5B

<table>
<thead>
<tr>
<th></th>
<th>WF1</th>
<th></th>
<th>WF2</th>
<th></th>
<th>WF3</th>
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<tr>
<td></td>
<td><img src="image1" alt="Waveform" /></td>
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<td></td>
<td><img src="image4" alt="Waveform" /></td>
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<td></td>
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<td><img src="image14" alt="Waveform" /></td>
<td></td>
<td><img src="image15" alt="Waveform" /></td>
<td></td>
</tr>
</tbody>
</table>

- **WF1**:
  - $t_{0\text{-}10\%} = 6.4\ \mu s$
  - $t_{10\%\text{-}50\%} = 69\ \mu s$

- **WF2**: $t_{0\text{-}100\%} < 340\ \text{ns}$
  - $t_{0\%\text{-}10\%} = 6.4\ \mu s$

- **WF3**:
  - 25% - 75% from largest peak

- **WF4**: $t_{0\text{-}100\%} = 6.4\ \mu s$
  - $t_{10\%\text{-}50\%} = 69\ \mu s$

- **WF5 A/B**:
  - **WF5A**:
    - $t_{0\text{-}10\%} = 40\ \mu s$
    - $t_{10\%\text{-}50\%} = 120\ \mu s$
  - **WF5B**:
    - $t_{0\text{-}100\%} = 50\ \mu s$
    - $t_{10\%\text{-}50\%} = 500\ \mu s$

- **WF6**: $t_{0\text{-}10\%} = 0.25\ \mu s$
  - $t_{10\%\text{-}50\%} = 4\ \mu s$
Test requirements compared: applicability of tests

MIL-STD-461G CS117

Only MS and MB applicable: No CB single stroke (SS), no PIN tests

<table>
<thead>
<tr>
<th>S22</th>
<th>Type</th>
<th>Signal</th>
<th>WF1</th>
<th>WF2</th>
<th>WF3</th>
<th>WF4</th>
<th>WF5A/B</th>
<th>WF6</th>
<th>CS117</th>
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<tbody>
<tr>
<td>✓</td>
<td>PIN</td>
<td>SS</td>
<td>no req</td>
<td>no req</td>
<td>yes</td>
<td>yes</td>
<td>WF5A</td>
<td>no req</td>
<td>Ø</td>
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<tr>
<td>n/a</td>
<td>PIN</td>
<td>MS</td>
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<td></td>
<td></td>
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<tr>
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<td>CB</td>
<td>SS</td>
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<td>yes</td>
<td>yes</td>
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<td>WF5A</td>
<td>no req</td>
<td>Ø</td>
</tr>
<tr>
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<td>CB</td>
<td>MS</td>
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<td>yes</td>
<td>yes</td>
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<td>WF5A</td>
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<td>CB</td>
<td>MB</td>
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<td>yes</td>
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<td>no req</td>
<td>yes</td>
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</table>
## Test levels compared: multiple stroke MS

<table>
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<tr>
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<th>Waveforms</th>
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<tr>
<td></td>
<td>2 / 1</td>
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<tr>
<td>L1</td>
<td>FS</td>
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<tr>
<td></td>
<td>Sub.</td>
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<td>L2</td>
<td>FS</td>
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<tr>
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<td>Sub.</td>
</tr>
<tr>
<td>L3</td>
<td>FS</td>
</tr>
<tr>
<td></td>
<td>Sub.</td>
</tr>
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<td>FS</td>
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<tr>
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<td>Sub.</td>
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<tr>
<td>L5</td>
<td>FS</td>
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## CS117

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<tr>
<td>L1</td>
<td>FS</td>
</tr>
<tr>
<td></td>
<td>Sub.</td>
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<tr>
<td>L2</td>
<td>FS</td>
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<tr>
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<td>Sub.</td>
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Test levels compared: multiple burst MB

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<td>3 / 3</td>
</tr>
<tr>
<td></td>
<td>VT / IL [V/A]</td>
</tr>
<tr>
<td>1</td>
<td>60 / 1</td>
</tr>
<tr>
<td>2</td>
<td>150 / 2.5</td>
</tr>
<tr>
<td>3</td>
<td>360 / 6</td>
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<tr>
<td>4</td>
<td>900 / 15</td>
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<tr>
<td>5</td>
<td>1920 / 32</td>
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<td></td>
<td>6 / 6</td>
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<tr>
<td></td>
<td>VL / IT [V/A]</td>
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<tr>
<td>1</td>
<td>100 / 5</td>
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<tr>
<td>2</td>
<td>250 / 12.5</td>
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<tr>
<td>3</td>
<td>600 / 30</td>
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<td>4</td>
<td>1500 / 75</td>
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<tr>
<td>5</td>
<td>3200 / 160</td>
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<thead>
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<td>1</td>
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<tr>
<td>2</td>
<td>1500 / 75</td>
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</table>
Calibration and test setup examples

RTCA DO-160G Section 22: Pin injection WF4, L5, SS, voltage and current calibration
Calibration and test setup examples

RTCA DO-160G Section 22: Pin injection WF4, L5, SS, test setup
Calibration and test setup examples

RTCA DO-160G Section 22: Cable induction WF1, L5, MS, voltage calibration
Calibration and test setup examples

RTCA DO-160G Section 22: Cable induction WF1, L5, MS, current calibration
Calibration and test setup examples

RTCA DO-160G Section 22: Cable induction WF1, L5, MS, test setup
Calibration and test setup examples

MIL-STD-461G CS117: Cable induction WF5A, MS, internal equipment, voltage calibration
Calibration and test setup examples

MIL-STD-461G CS117: Cable induction WF5A, MS, internal equipment, current calibration
Calibration and test setup examples

MIL-STD-461G CS117: Cable induction WF5A, MS, internal equipment, test setup
Roundup

MIL-STD-461G CS117 test requirements

✓ Represent only a part of DO-160G S22 test requirements

✓ Applies to military aircraft and surface ships

✓ The only injection method is cable induction

✓ No damage tests (pin injection) required

✓ No single stroke tests required
Roundup

MIL-STD-461G CS117 test levels

✔ Only two test levels

✔ MIL test levels are generally between L3 and L5 from S22

✔ Not intended to address physical effects, only disturbance of functionality
Conclusion

RTCA DO-160G Section 22 and MIL-STD-461G CS117

☑ Are the requirements from analyzed standards the same?

Jain!

☑ Are the two standards similar?

Up to a certain extent.
Thanks for attending!

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