



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

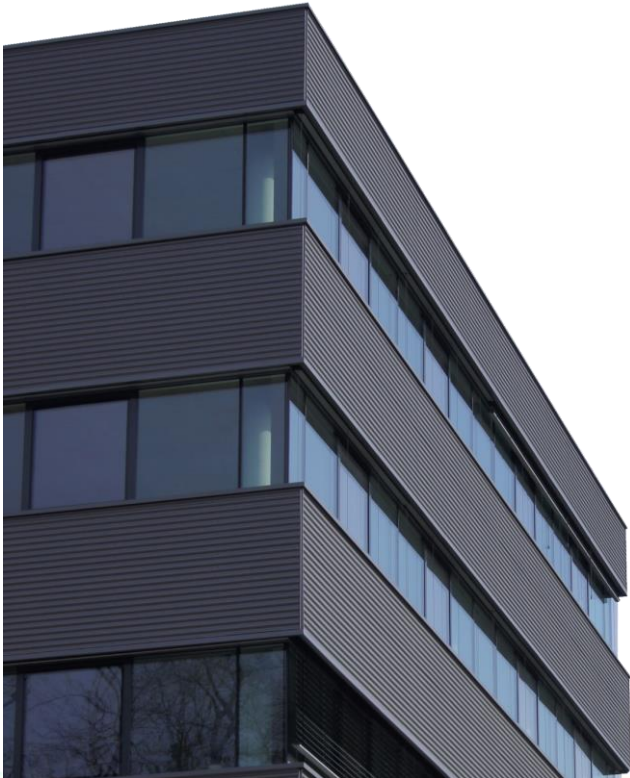


Dr. Adrian Matoi
EMC PARTNER AG, Switzerland



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



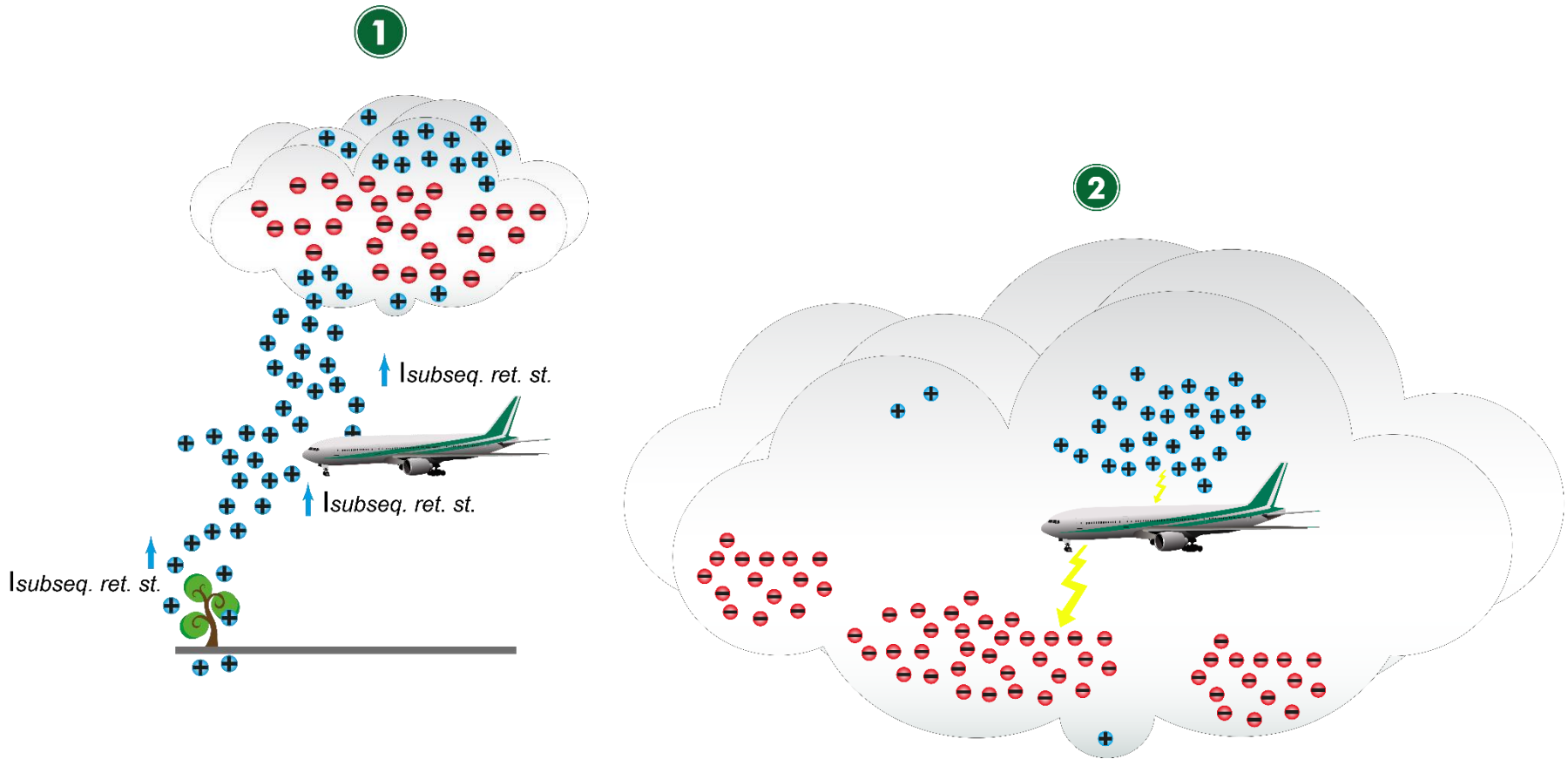
Content

- ✓ 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

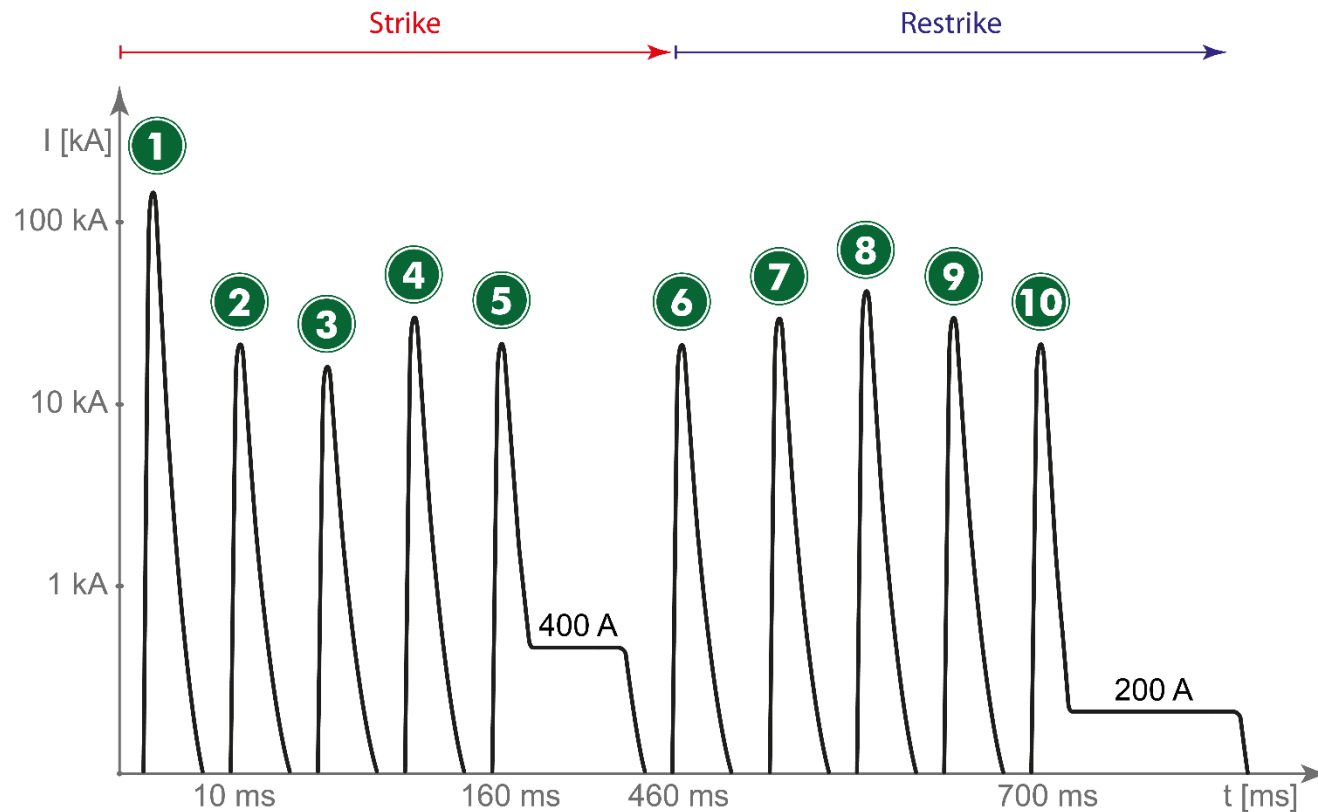


$I_{subseq. ret. st.}$ – subsequent return stroke current

Introduction

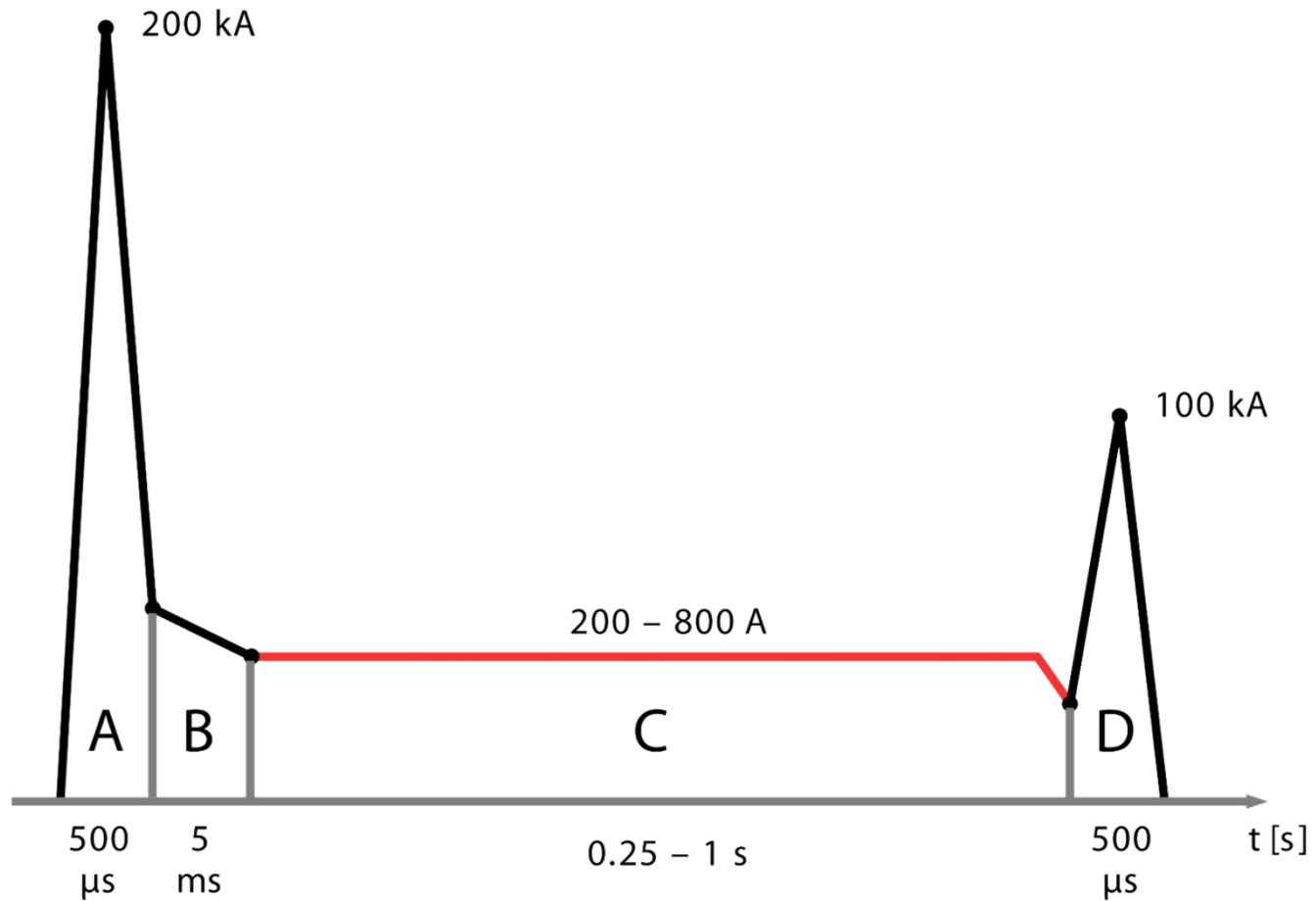
Severe negative **real** flash to ground:

- ✓ 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

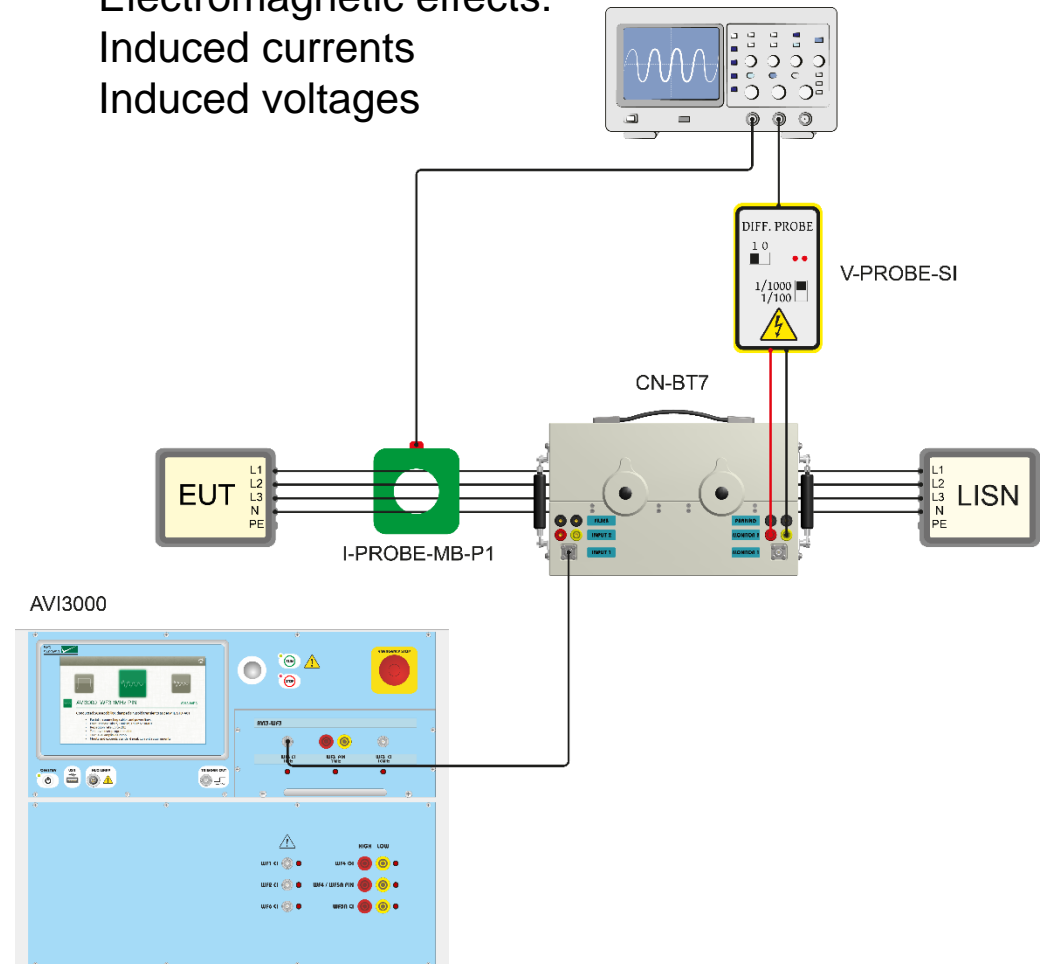
Direct lightning effects

Puncture
Burning
Melting, etc.



→ Indirect lightning effects

Electromagnetic effects:
Induced currents
Induced voltages



Basic considerations

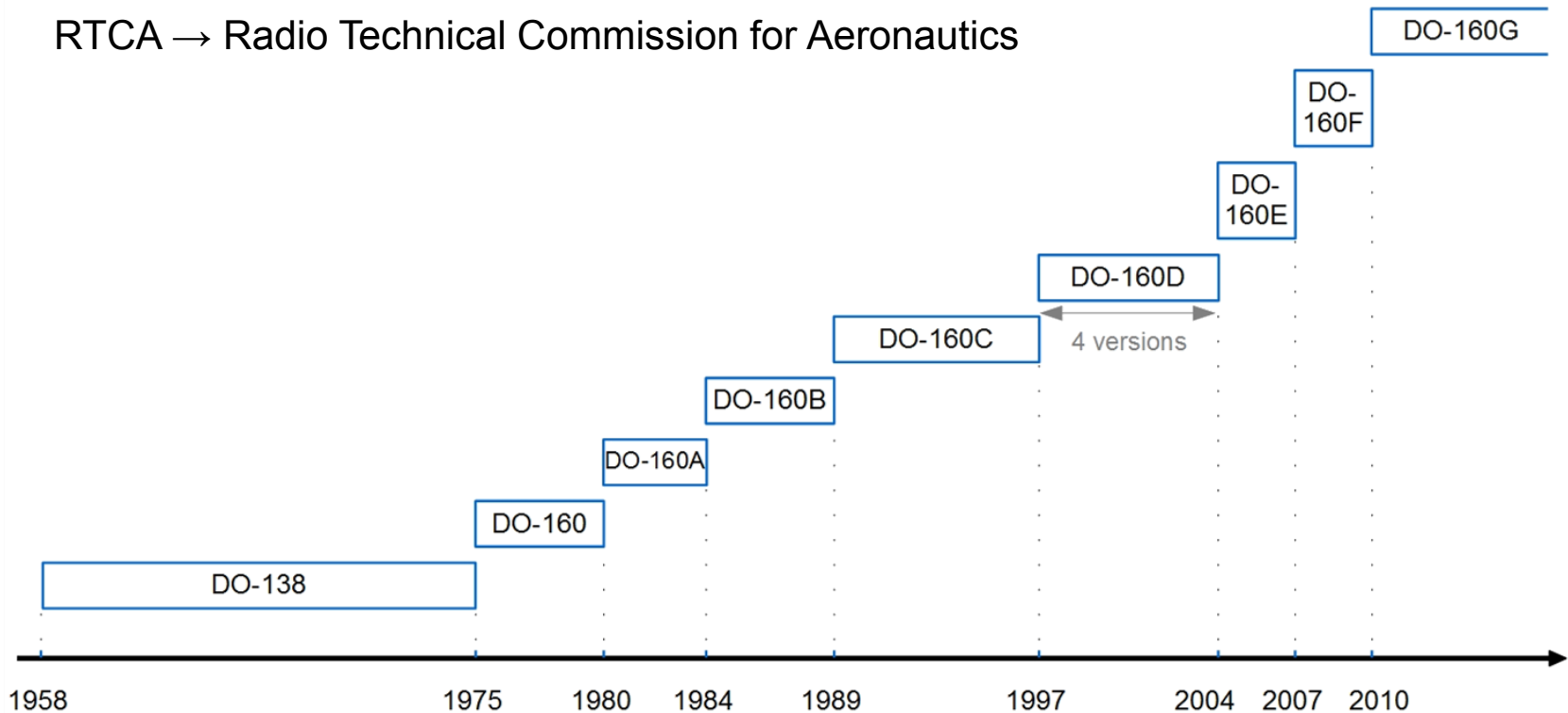
RTCA DO-160G Section 22

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

MIL-STD-461G CS117 (new)

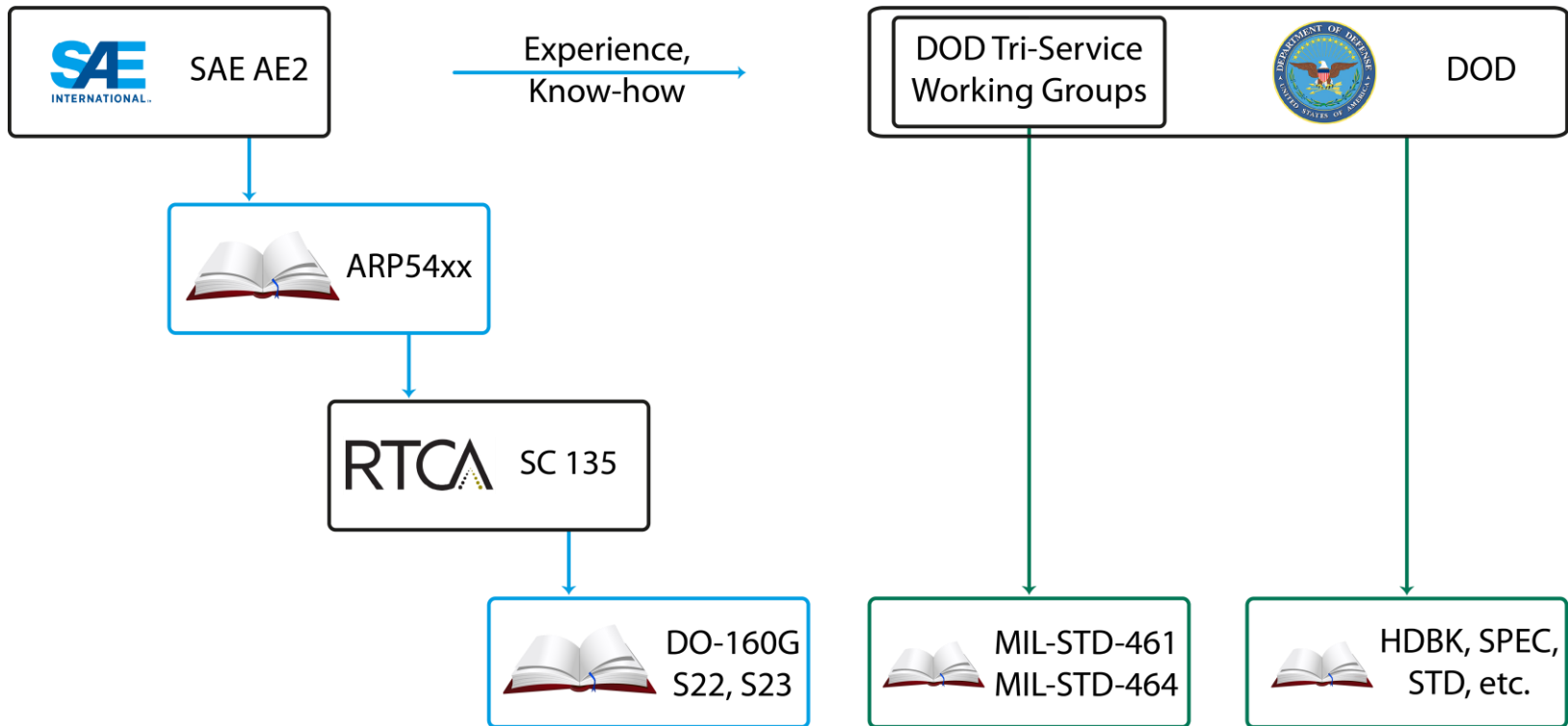
Military aircraft and surface naval ships
Complemented by other STDs like 464
Introduced in 2015, based on DO-160G

RTCA → Radio Technical Commission for Aeronautics



Basic considerations

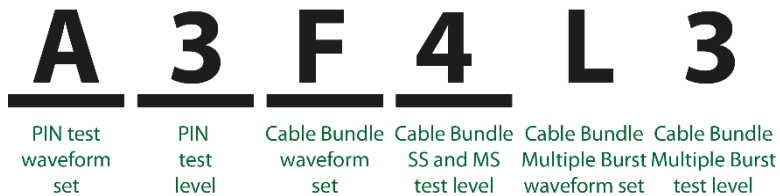
Standardization



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 |

www.navy.mil

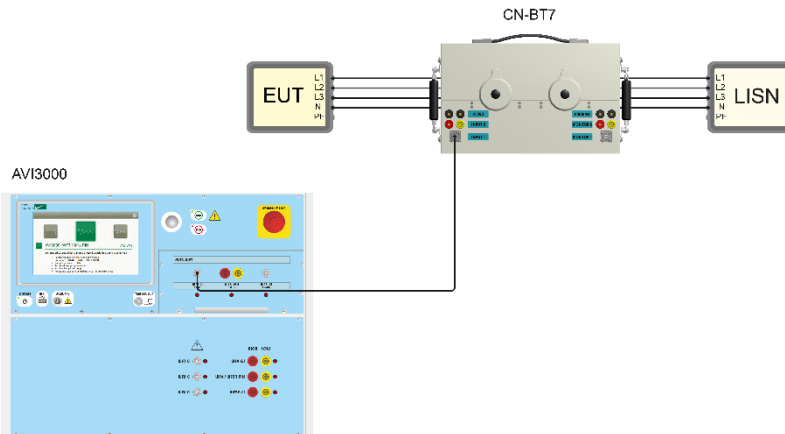
Test requirements compared: test types

RTCA DO-160G Section 22

✓ Pin injection



✓ Cable bundle

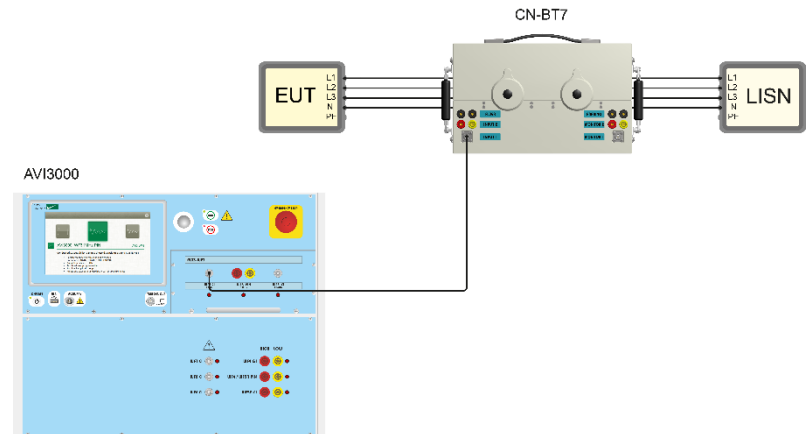


MIL-STD-461G CS117

∅ No pin injection requirement



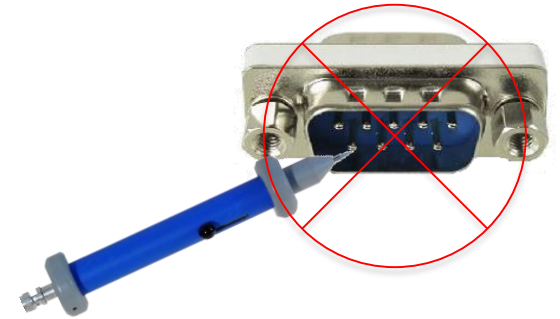
✓ Cable bundle



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

| S22 | Pulse application | CS117 |
|-----|-----------------------|-------|
| ✓ | Pin injection (PIN) | ∅ |
| ✓ | Cable induction (CI) | ✓ |
| ✓ | Ground Injection (GI) | ∅ |

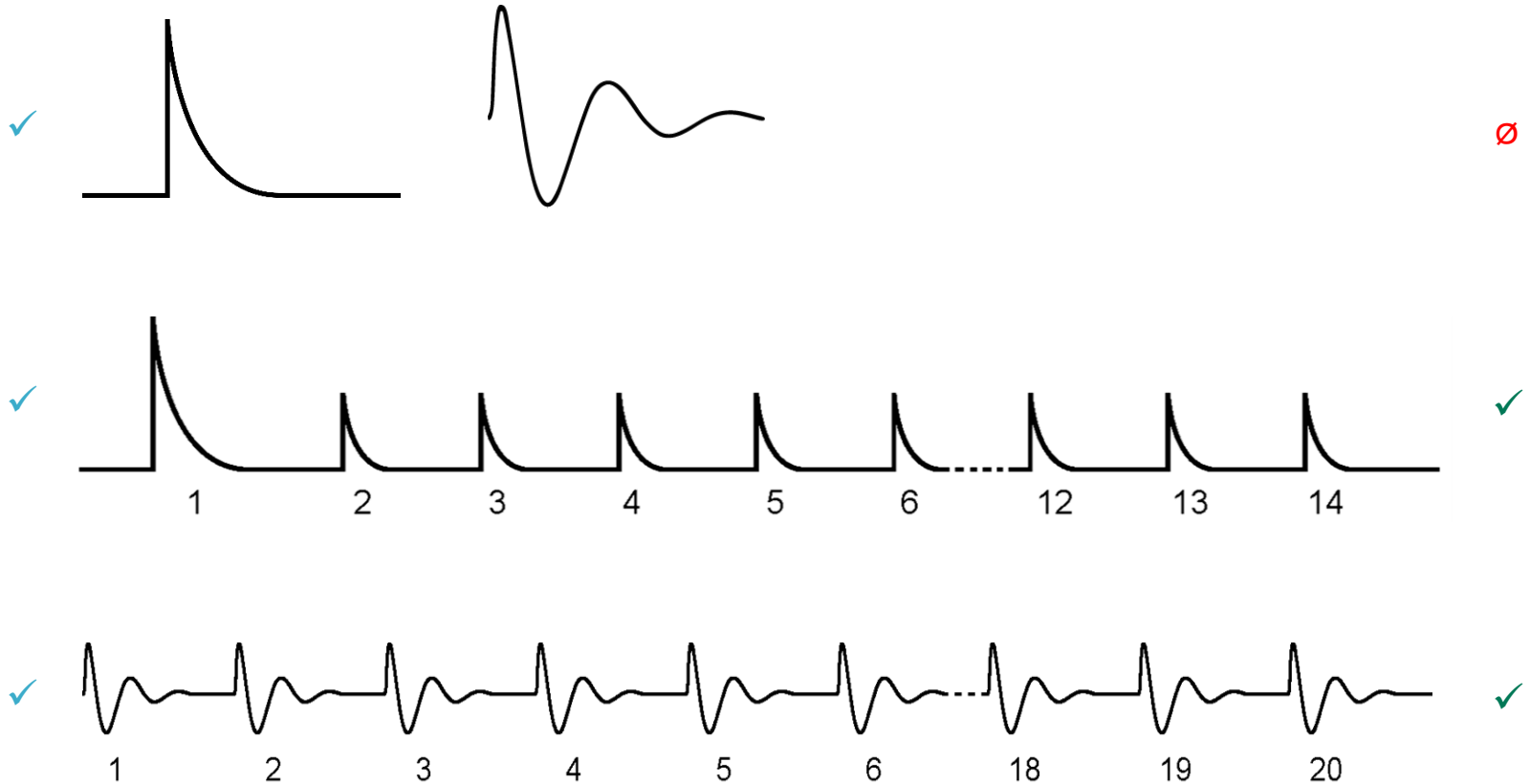
Test requirements compared: signal types

MIL-STD-461G CS117

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

S22

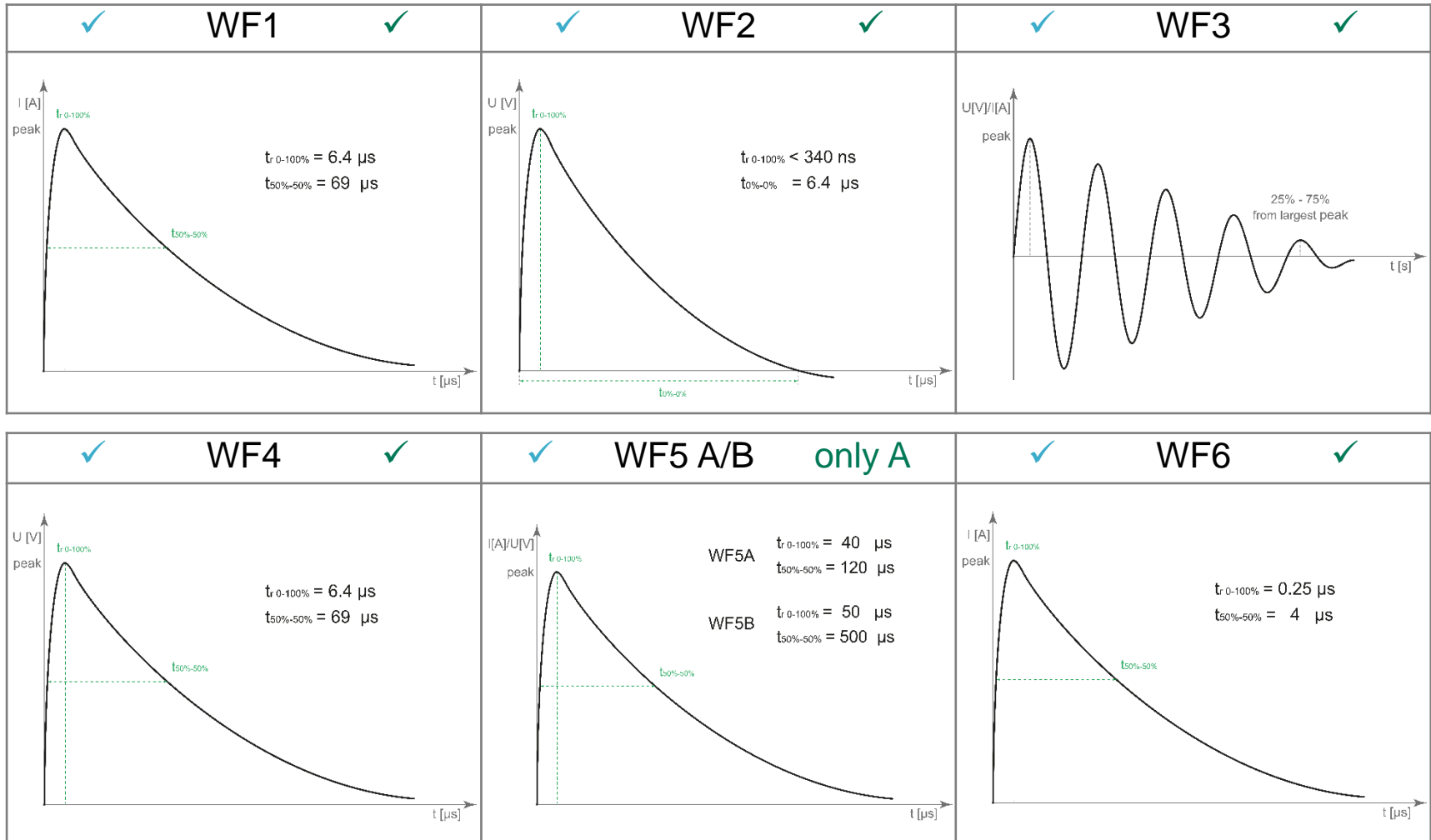
CS117



Test requirements compared: waveforms

MIL-STD-461G CS117

All waveforms from S22 present, except WF5B



Test requirements compared: applicability of tests

MIL-STD-461G CS117

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

| S22 | Type | Signal | WF1 | WF2 | WF3 | WF4 | WF5A/B | WF6 | CS117 |
|-----|------|--------|----------------|--------|-----|--------|--------|--------|-------|
| ✓ | PIN | SS | no req | no req | yes | yes | WF5A | no req | ∅ |
| n/a | | MS | no requirement | | | | | | n/a |
| | | MB | no requirement | | | | | | n/a |
| ✓ | CB | SS | yes | yes | yes | yes | WF5A | no req | ∅ |
| ✓ | | MS | yes | yes | yes | yes | WF5A | no req | ✓ |
| ✓ | | MB | no req | no req | yes | no req | no req | yes | ✓ |

Test levels compared: multiple stroke MS

| S22 test level | | Waveforms | | | | |
|-------------------|------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| | | 2 / 1 | 2 / 1 | 3 / 3 | 4 / 1 | 4 / 5A |
| | | V _L / I _T [V/A] | V _T / I _L [V/A] | V _T / I _L [V/A] | V _T / I _L [V/A] | V _L / I _T [V/A] |
| L1 | FS | 50 / 50 | 50 / 50 | 100 / 20 | 25 / 50 | 20 / 60 |
| | Sub. | 25 / 25 | 25 / 25 | 50 / 10 | 12.5 / 25 | 10 / 30 |
| L2 | FS | 125 / 125 | 125 / 125 | 250 / 50 | 62.5 / 125 | 50 / 160 |
| | Sub. | 62.5 / 62.5 | 62.5 / 62.5 | 125 / 25 | 31.25 / 62.5 | 25 / 80 |
| L3 | FS | 300 / 300 | 300 / 300 | 600 / 120 | 150 / 300 | 120 / 400 |
| | Sub. | 150 / 150 | 150 / 150 | 300 / 60 | 75 / 150 | 60 / 200 |
| L4 | FS | 750 / 750 | 750 / 750 | 1500 / 300 | 375 / 750 | 300 / 800 |
| | Sub. | 375 / 375 | 375 / 375 | 750 / 150 | 187.5 / 375 | 150 / 400 |
| L5 | FS | 1600 / 1600 | 1600 / 1600 | 3200 / 640 | 800 / 1600 | 640 / 2000 |
| | Sub. | 800 / 800 | 800 / 800 | 1600 / 320 | 400 / 800 | 320 / 1000 |

| CS117 | | 2 / 1 | 2 / 1 | 3 / 3 | 4 / 1 | 4 / 5A |
|-------|------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| | | V _L / I _T [V/A] | V _T / I _L [V/A] | V _T / I _L [V/A] | V _T / I _L [V/A] | V _L / I _T [V/A] |
| L1 | FS | 300 / 600 | ∅ | 600 / 120 | ∅ | 300 / 1000 |
| | Sub. | 150 / 150 | ∅ | 300 / 60 | ∅ | 75 / 200 |
| L2 | FS | 750 / 1500 | ∅ | 1500 / 300 | ∅ | 750 / 2000 |
| | Sub. | 375 / 375 | ∅ | 750 / 150 | ∅ | 187.5 / 400 |

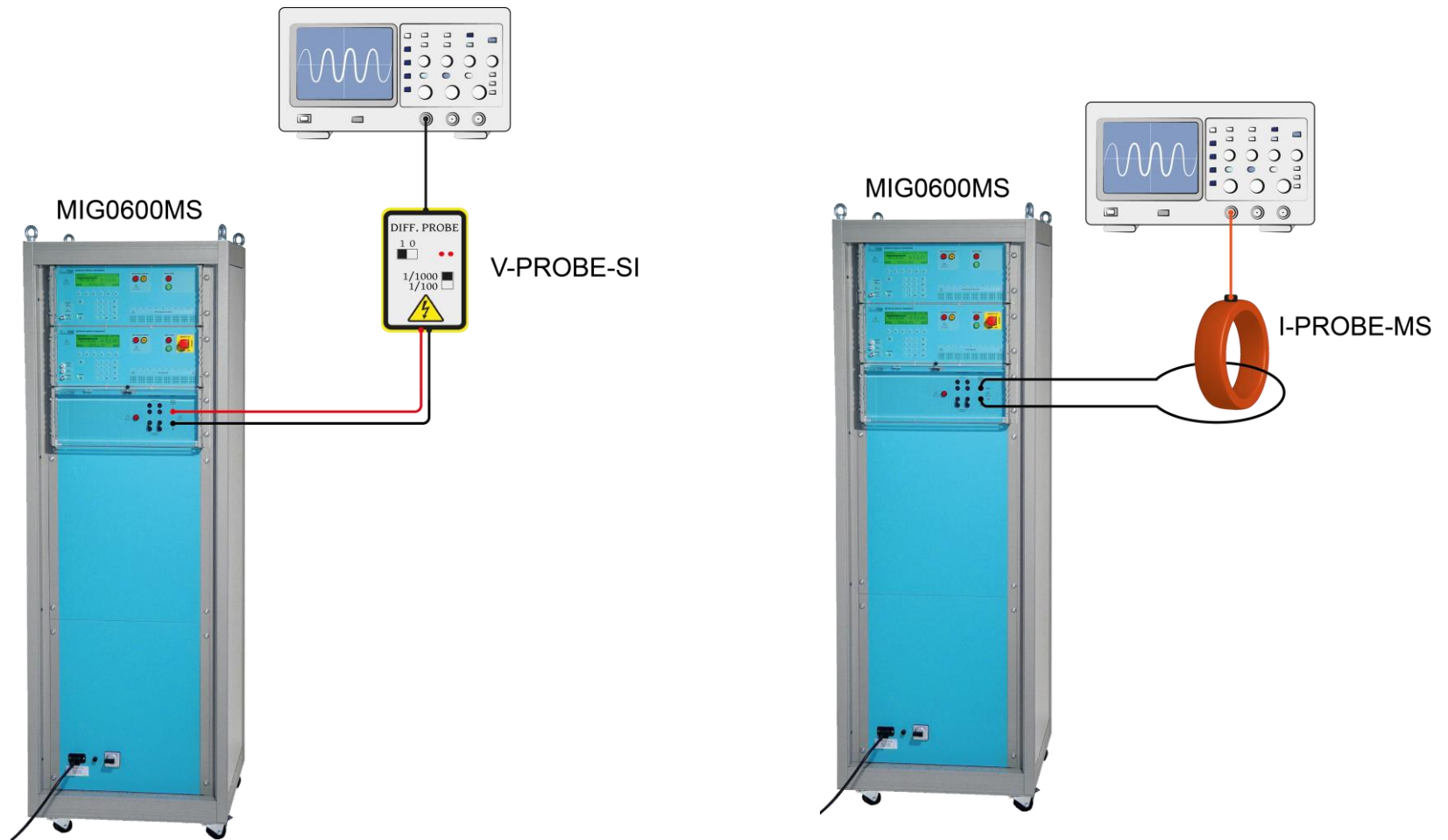
Test levels compared: multiple burst MB

| S22 test level | Waveforms | |
|-------------------|-------------------|-------------------|
| | 3 / 3 | 6 / 6 |
| | V_T / I_L [V/A] | V_L / I_T [V/A] |
| 1 | 60 / 1 | 100 / 5 |
| 2 | 150 / 2.5 | 250 / 12.5 |
| 3 | 360 / 6 | 600 / 30 |
| 4 | 900 / 15 | 1500 / 75 |
| 5 | 1920 / 32 | 3200 / 160 |

| CS117 | 3 / 3 | 6 / 6 |
|-------|-------------------|-------------------|
| | V_T / I_L [V/A] | V_L / I_T [V/A] |
| | 1 | 360 / 6 |
| 2 | 900 / 15 | 1500 / 75 |

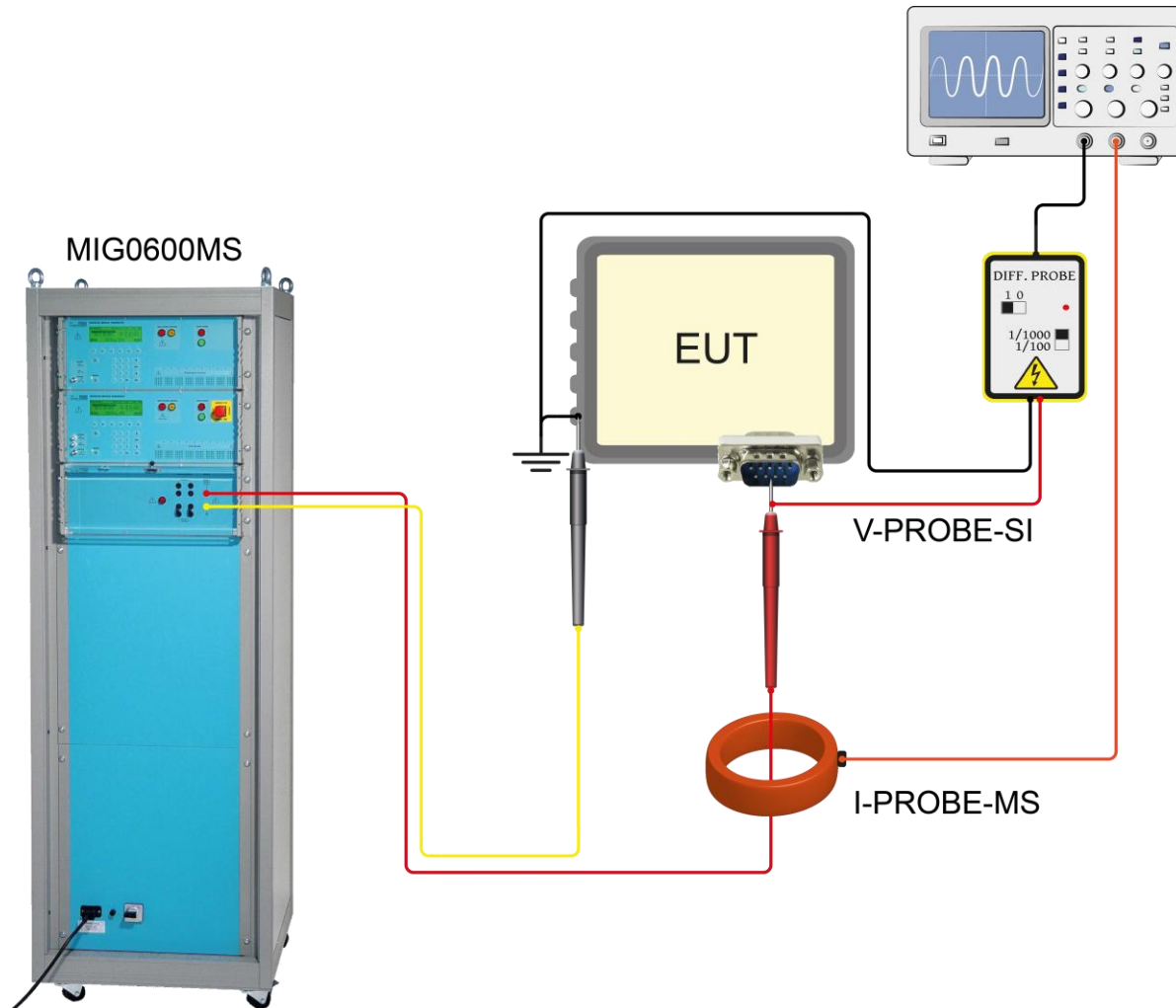
Calibration and test setup examples

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



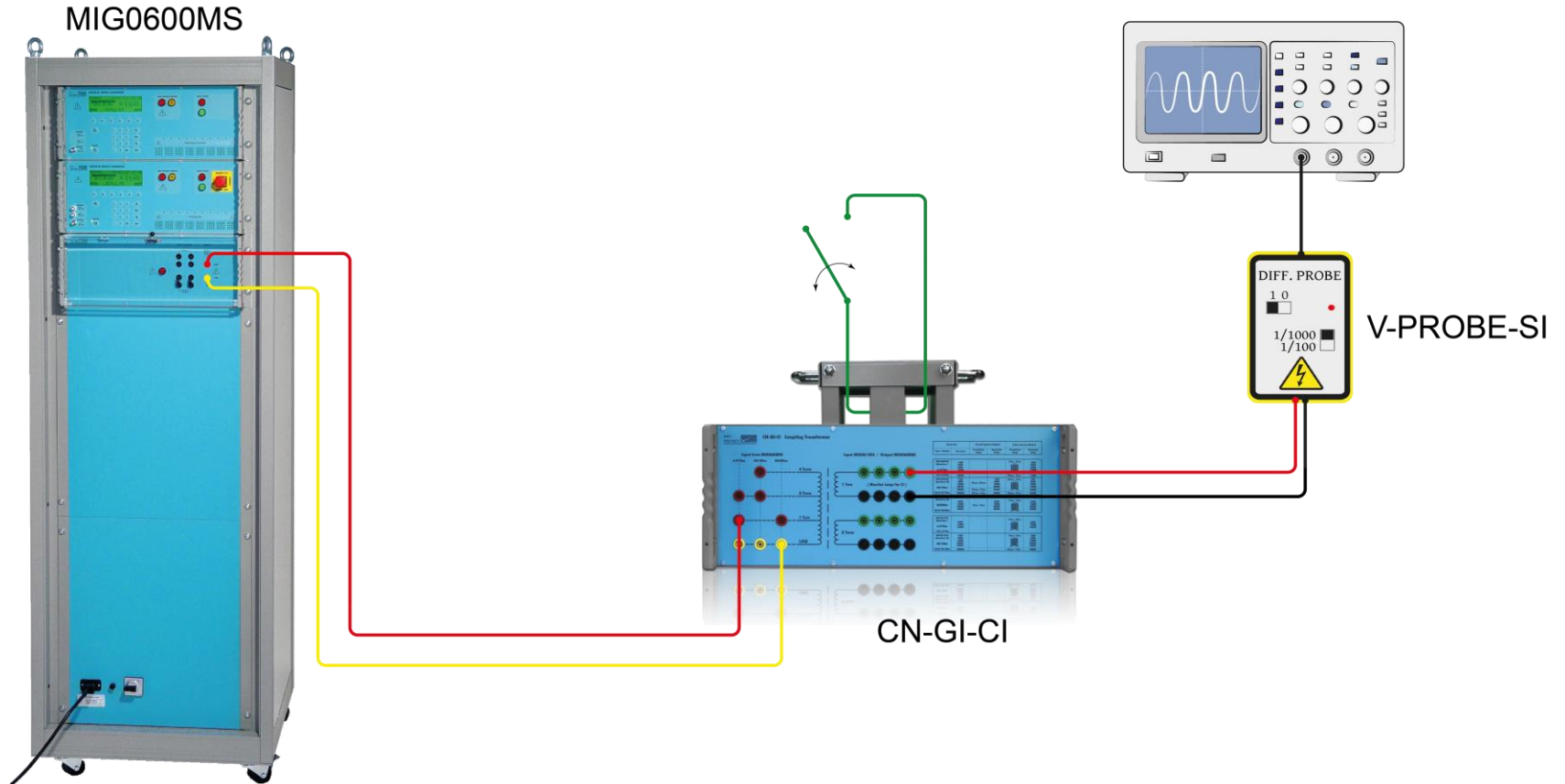
Calibration and test setup examples

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



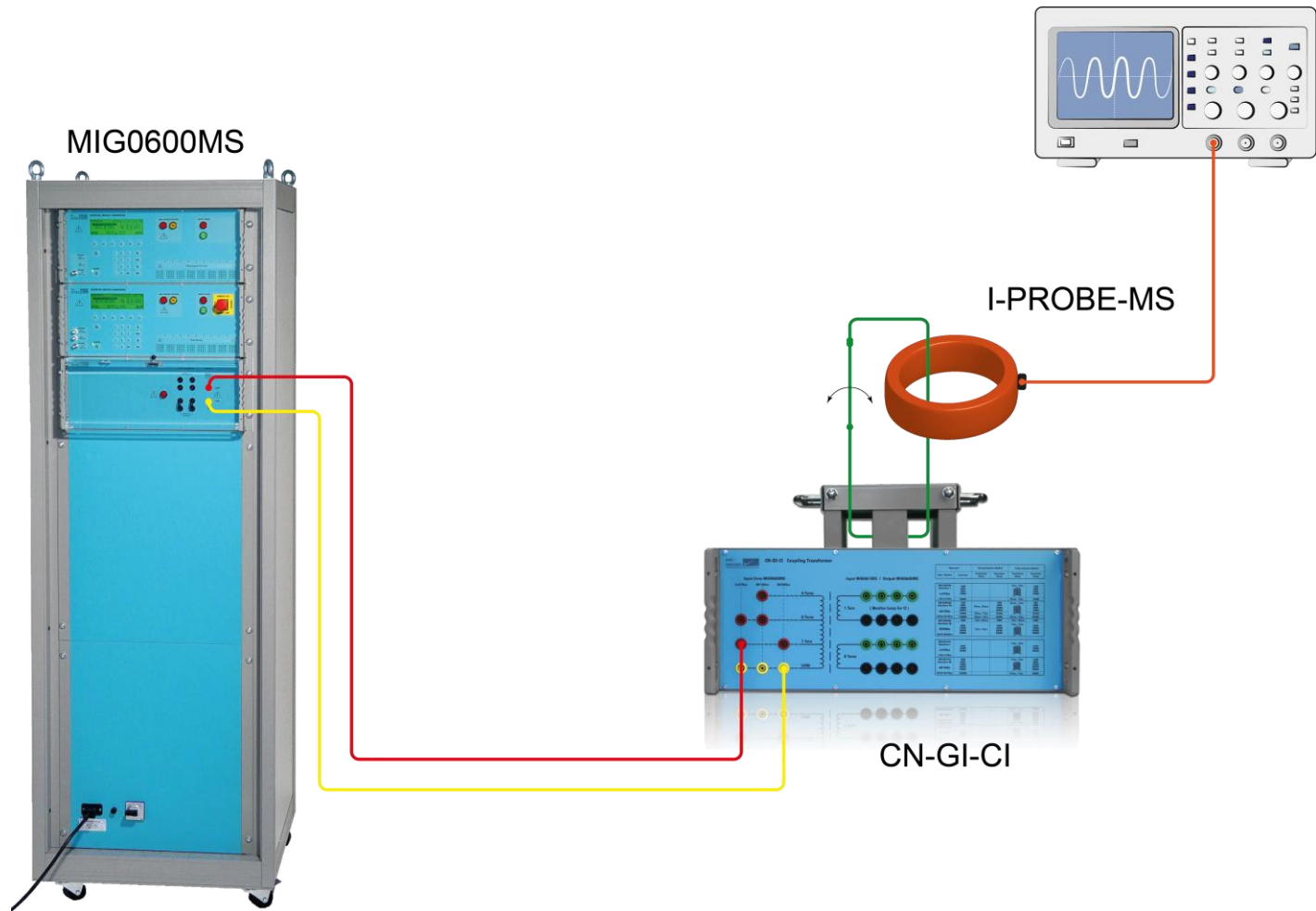
Calibration and test setup examples

RTCA DO-160G Section 22: Cable induction WF1, L5, MS, voltage calibration



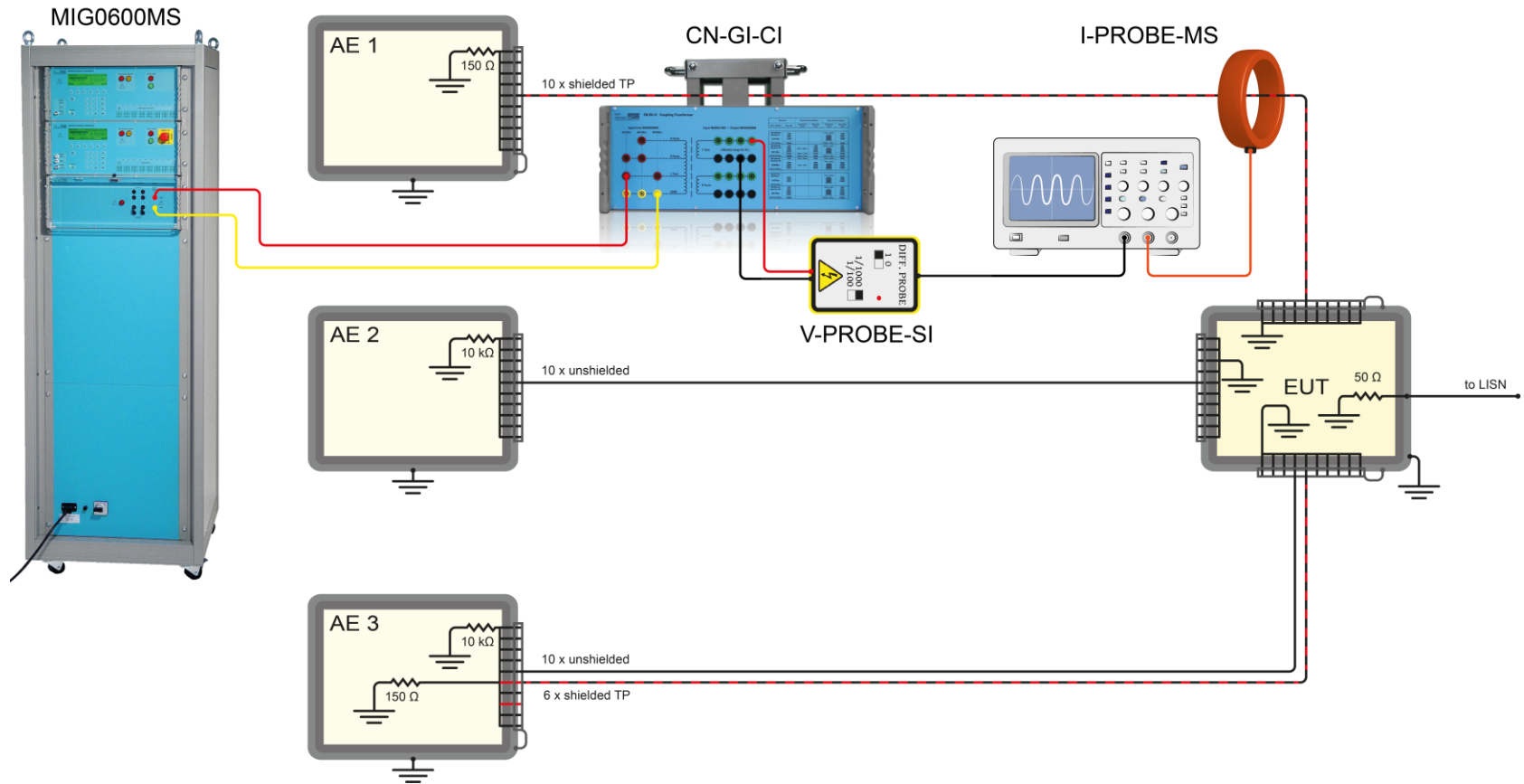
Calibration and test setup examples

RTCA DO-160G Section 22: Cable induction WF1, L5, MS, current calibration



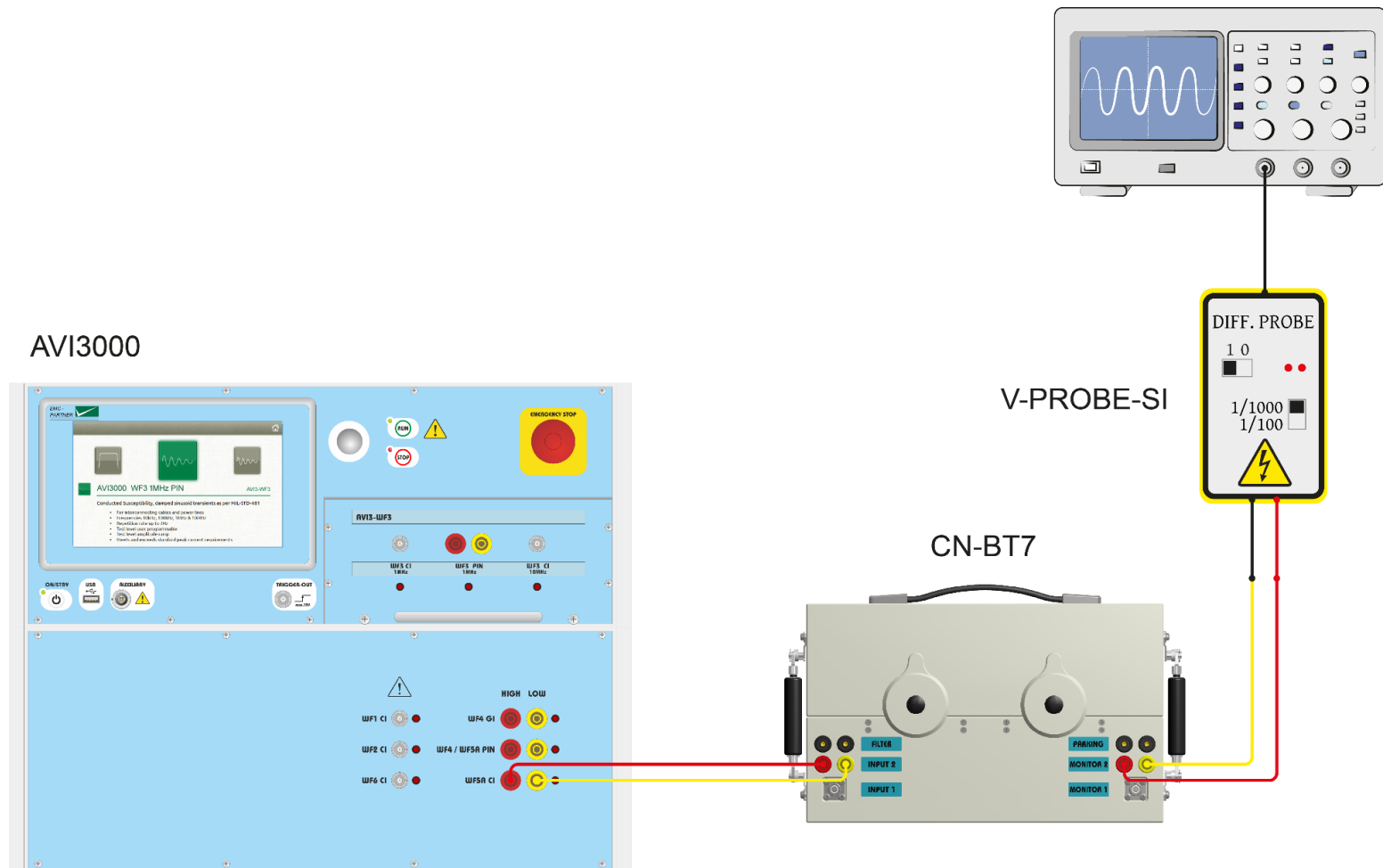
Calibration and test setup examples

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



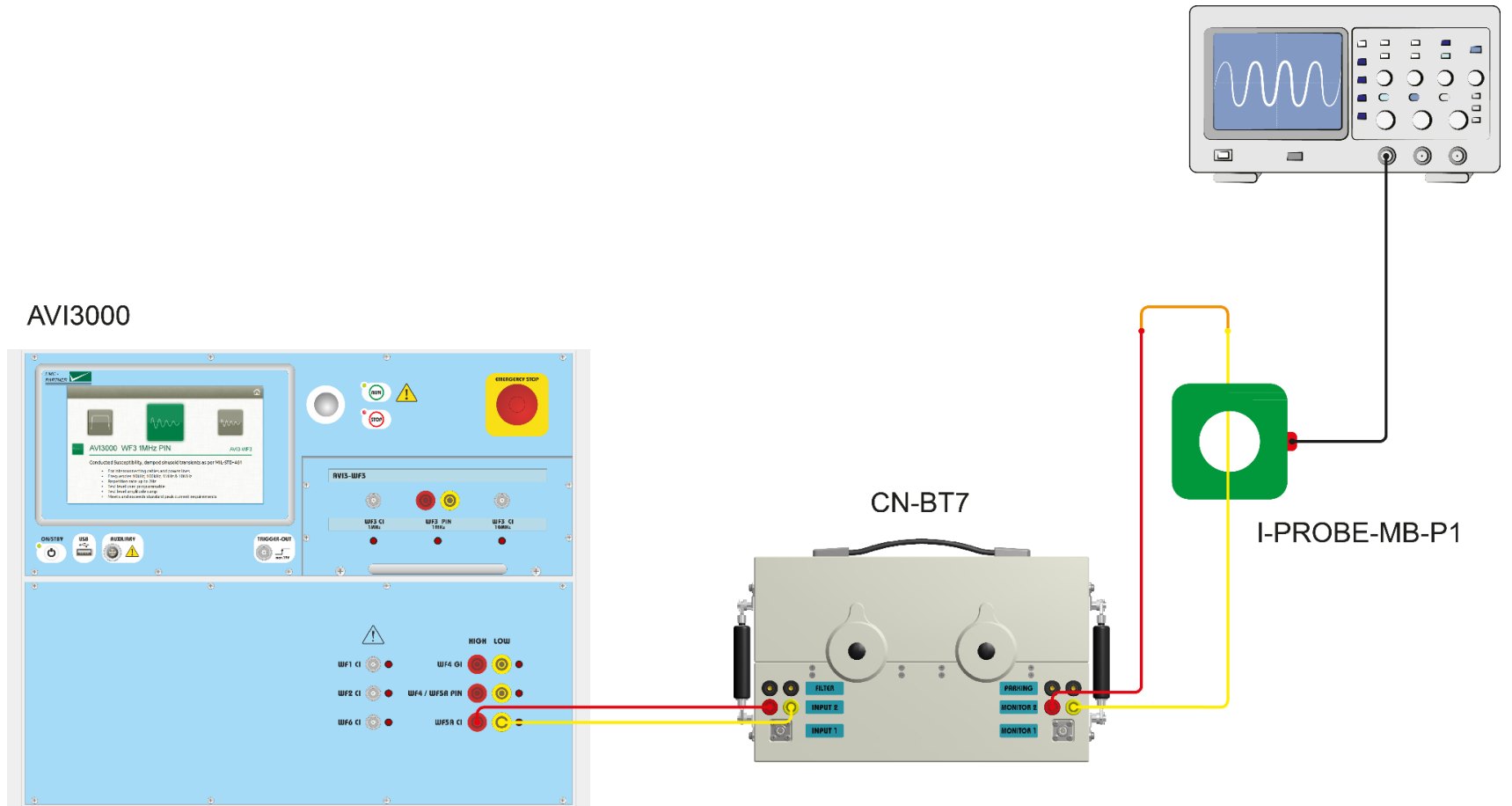
Calibration and test setup examples

MIL-STD-461G CS117: Cable induction WF5A, MS , internal equipment, voltage calibration



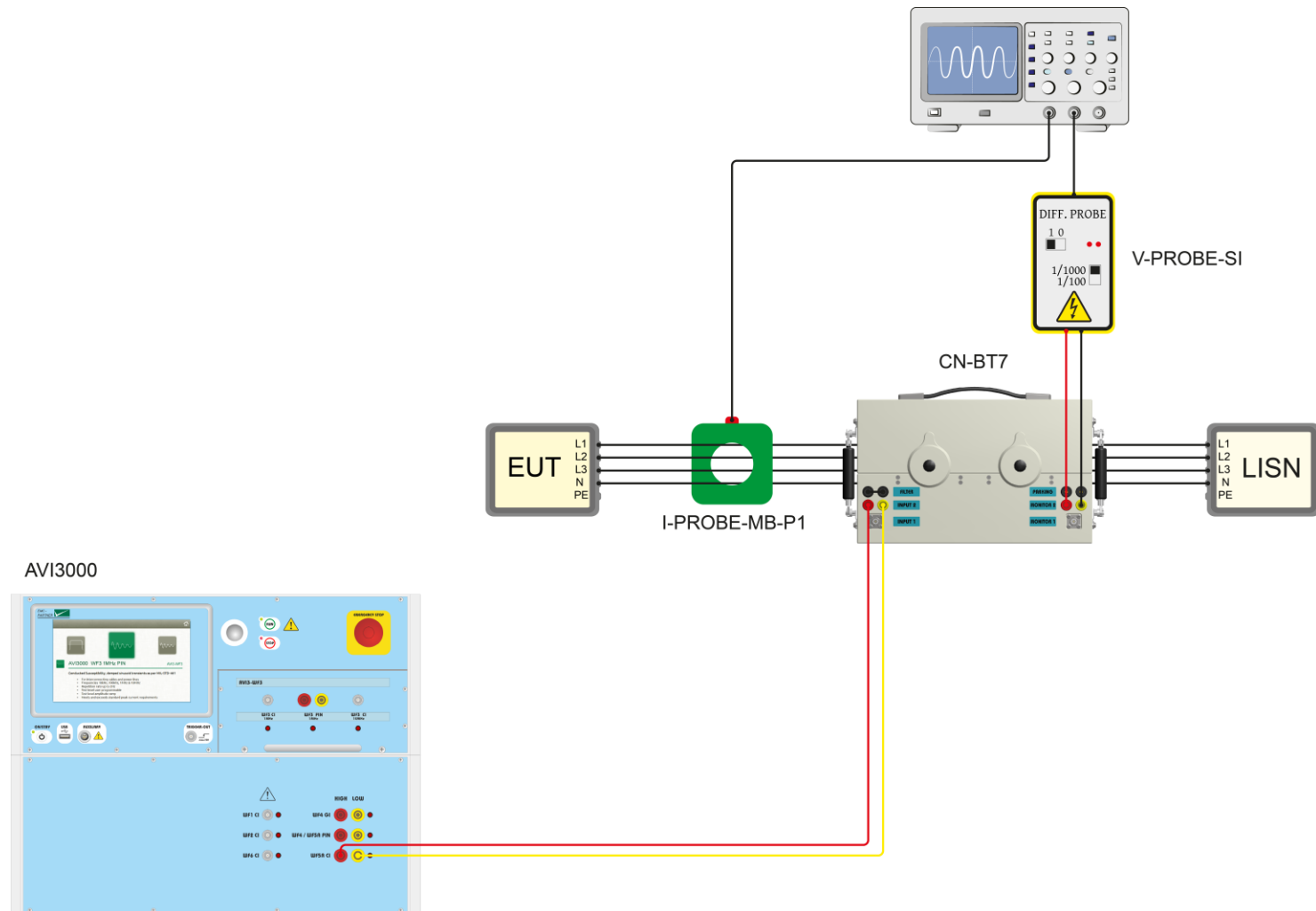
Calibration and test setup examples

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.



EMC LIVE[®] 2016

Thanks for attending!

www.emclive2016.com

© Copyright EMC Partner AG