IEEE TC 5: High Power Electromagnetics (HPEM) Technical Committee
On the web at https://www.emcs.org/tc-5-high-power-electromagnetics.html

Minutes of Glasgow Virtual Meeting by WEBEX
Wednesday, 28 July 2021 (10:00 a.m. – Noon Central U.S. Time)

Confirmed Minutes

1) **Opening of the meeting and approval of the agenda – Bill Radasky, Chairman**

Chairman Dr. William (Bill) Radasky brought the virtual meeting to order at 10:00 a.m. Central U.S. Time. Both the Chairman, Bill Radasky, and the Vice Chairman, Mike McInerney were present. The Secretary, Pina Dall' Armi-Stoks, was not present due to the time difference in Australia. Radasky welcomed the attendees, reviewed the agenda and asked for suggested changes; none were offered. Radasky made a motion to approve the agenda. Motion Seconded and Carried (MSC).

2) **Review and approval of minutes of previous TC 5 meeting – Bill Radasky, Chairman**

The unconfirmed minutes from the virtual TC 5 meeting in Reno on 3 August 2020 were reviewed and approved without any changes.

3) **TC 5 membership list update – All**

The TC 5 membership list over the past 5 years was reviewed. Mike McInerney was able to make several screen shots of the online attendees for this WEBEX meeting; there were 19 unique attendees, which is a reduction from past years. There were a few new members, so the 5-year membership list (including email addresses) will be updated to be used to contact our membership. We do not publish the detailed 5-year list on the website or in the minutes, as there may be private information contained in it. Only the officers' and subcommittee chairs' email addresses are revealed on the website, and this procedure has been approved by the IEEE.

The existing attendance list (before the meeting) was shown at the meeting, and new members will be added to the 5-year list.

4) **Report on the paper review process and sessions for Glasgow – Bill Radasky**

Radasky reviewed the paper review process for Glasgow virtual conference and also the tutorials and special sessions that were presented virtually. There were 26 regular, abstract and special session papers submitted; 22 were accepted. We ended up with 4 technical sessions and 1 special session (ESD). The review process was difficult due to the new software, and a new problem arose this year. For many years the tutorial and special session process had run smoothly, but this year there were several proposals submitted without an indication of support from TC 5. While support is not necessarily required, there should at least be a review from the TC for items within their scope. If a tutorial or special session proposal is not of high quality, we could recommend that the tutorial or special session not be accepted. Discussions with the tutorial chairs at the end of the process were successful in that in the future, "unsupported" tutorial proposals will be sent to TCs which cover the scope of the tutorial. Also a special session did not mark support from TC 5 (one covering ESD), and TC 5 was asked at the last minute to review the papers in the session. This was done successfully, but could have been accomplished more easily if TC 5 was aware of the session.

We had a large contingent of reviewers this year, and they should be recognized for their hard work. The reviewers were: Hayashi, He, Homma, Khazhinsky, Leferink, McInerney, Rachidi, Rubinstein, Sabath, Savage, Thomas, and Willemen.

There was a special session on ESD entitled, "Robust Design for System Level ESD: Device, PCB and System Level," organized by David Pommerenke.

There were also five tutorials presented:

- Modeling of IEMI Scenarios organized by Frank Sabath
- Protection of Critical Infrastructures Against IEMI organized by Michael Suhrke and Martin Schaarschmidt
- HPEM Effects on Electronic Systems organized by Frank Sabath
- Achieving ESD Robustness Through System Efficient ESD Design Simulation organized by David Pommerenke
- Recent Advancements in HEMP, EMP and IEMI Protection – A Global Perspective organized by Joel Kellogg and Dave Giri

During this virtual conference there was a live session scheduled: "Ask the Experts". TC 5 experts contributed to two of the sessions in the areas of lightning and ESD.

In addition to the paper reviews for this Glasgow virtual conference, several TC 5 experts (Hayashi, McInerney, Radasky and Savage) provided reviews for HPEM papers for the APEMC 2021 conference planned for Bali in September 2021.

5) **Report from the Lightning Subcommittee – Marcos Rubinstein and Farhad Rachidi**

A comprehensive report was presented covering lightning conferences and other planned activities, either virtual and/or cancelled for 2021 and those planned for 2022 (10 separate events). Four lightning working groups are actively working in CIGRE Study Committee

C4 and a working group in the IEEE PES is also active. As for 2022, the lightning subcommittee plans to organize a lightning session at the EUROEM/ASIAEM Symposium in Abu Dhabi in 2022, and will support the Spokane IEEE EMC Symposium in 2022 through encouraging technical papers to be submitted. Since this IEEE EMC symposium was held virtually this year, we have decided to attach the charts presented at this WEBEX TC 5 meeting to these minutes. This presentation is found in Attachment 1.

6) **Report from the EM Information Leakage Subcommittee – Yuichi Hayashi**

Yuichi Hayashi provided his report beginning with an overview of the regular session papers (3) presented this year. He has also organized a special session for APEMC to be presented in Bali in September 2021. It is entitled, "Hardware security issues due to EM passive/active attacks on devices complying with EMC standards." He is planning to organize a special session for Spokane in 2022 tentatively entitled, "Hardware security required for the next generation of cryptography and electronic devices". His report is presented in Attachment 2.

7) **Report from the HEMP/IEMI Subcommittee – Mike McInerney**

Mike McInerney presented the HEMP/IEMI report in two parts. For the HEMP aspects, Bill Radasky provided a summary of activities including:

- The U.S. Department of Energy has published an open document to specify recommended HEMP waveforms to use to evaluate the vulnerability of the U.S. infrastructure
- The IEC has taken steps to update IEC 61000-2-9 (HEMP environment)
- The IEEE Power Energy Society is preparing a white paper dealing with the protection of protective relays from HEMP
- CIGRE Study Committee C4 has a working group considering approaches to protect high voltage power control house electronics against HEMP
- Power companies are investigating ways to protect their electronics from HEMP (and IEMI)

With regard to the IEMI aspects Frank Sabath reported on the tutorials scheduled for this conference in the field of IEMI (see the list under item 4 of these minutes). Also an update on the IEC work dealing with IEMI was provided. Frank Sabath mentioned that due to a recent promotion, he will no longer be able to support the HEMP/IEMI subcommittee, but recommends that Sven Fisahn take over this responsibility (Sven provided a presentation dealing with the research from his organization, and this presentation will be discussed under agenda item 11). This recommendation was appreciated and accepted, and we all wish Frank Sabath good luck in his future endeavors. The full report for this subcommittee can be found in Attachment 3.

8) **Report from ESD Subcommittee – Joost Willemen and Misha Khazhinsky**

Joost Willemen presented the report from the ESD subcommittee. He reviewed the paper submission process for regular papers and for the special session on ESD. He also discussed the paper exchange program between ESDA and the IEEE EMC Society. He also reviewed the significant list of ESD standards that have been published in 2021. The details of this presentation are found in Attachment 4.

9) **Coordination with SC-1, Smart Grid – Mike McInerney**

McInerney introduced the activities of Special Committee 1 (Smart Grid), which is a coordinating committee, and he indicated that the SC 1 meeting will be held virtually on 9 August. It is noted that Mike McInerney is the new Chairman of SC 1 and Bill Radasky continues in his role as Vice Chair and Dave Thomas is the Secretary. McInerney commented that TC 5 is keeping track of any issues involving Smart Grid, and both the Chair and the Vice Chair of TC 5 have been attending the SC 1 meetings for many years.

He also mentioned that there is ongoing work in Smart Electric Power Alliance (SEPA) that deals with EMC and high power EM environments. There are several white papers that have been published that deal with the EMC aspects of Smart Grid. Don Heirman was the long-time chairman of the EMC work and after his passing, Bill Radasky has become the new chair.

10) **TC 5 web page – Mike McInerney, Vice Chairman**

McInerney reported on the new process for allowing technical committees to update their web pages. There were a few technical problems with the update process, but Mike was able to update the TC 5 site. He has some remaining cleanup to do to populate the subcommittee pages with regard to open documents, and he looks forward to comments from any members with regard to documents that could be placed on the site. The webpage for TC 5 can be found at: https://www.emcs.org/tc-5-high-power-electromagnetics.html

11) **Review of HPEM activities since last TC 5 meeting in Reno – All**

Radasky opened up discussion on new activities worldwide in our area of work. Sven Fisahn provided a presentation covering the work of his organization in Germany: Bundeswehr Research Institute for Protective Technologies and NBC Protection (WIS). The presentation covered the work underway in HEMP, IEMI and other HPEM areas. The presentation was approved for open distribution and is found in Attachment 5.

A second discussion was led by Dr. Nicholas Mora who is the Director of Electromagnetic Effects at Directed Energy Research Centre within the Technology Innovation Institute in Abu Dhabi, UAE. He indicated that his group is active in organizing virtual workshops in the areas of HEMP and IEMI and that they are building up a simulation capability at their centre.

Another discussion was led by Dr. Andrew Podgorski, concerning the need to standardize threat waveforms for very high level HPEM threats. He did not think that the work in the IEC nor MIL-STD-464 was sufficient for this purpose. It might be a good idea for Andrew to submit a paper describing this need so that we may consider whether there are any actions that TC 5 might consider in the future.

New plans for updating several standards of the IEC for HEMP environments and protection were discussed under item 7 of this agenda, so this information was not repeated here during the discussion.

12) **TC 5 Tutorials/Special Sessions planned at the EMC 2022, Spokane**

Based on the presentations provided at this meeting from the subcommittees, it appears that the following proposals are likely for the 2022 conference in Spokane:

- Special session on "Hardware security required for the next generation of cryptography and electronic devices," from the EM Information Leakage Subcommittee
- Tutorial covering the update of HEMP environments and protection standards in IEC SC 77C
- Lightning and ESD subcommittees plan to promote regular paper submissions

As usual this is the preliminary list, and it is likely that more proposals may be forthcoming near the proposal submission date.

13) **Update on aircraft lightning direct strike standardization - All**

After many years of discussion concerning the need for a new IEEE standard dealing with the effects on electronics when an aircraft is struck by lightning, a new PAR 28.38 has been approved. It is titled, "Aircraft Component Lightning Strike Direct Effects Qualification." Fred Heather reviewed the scope of the project and asked for the support of TC 5 in this work. We continue to recommend to our members that they join this standards committee if they have interest in the subject.

14) **Any other business - All**

Nicholas Mora mentioned that a webinar on Directed Energy was planned for the November/December time frame, and he indicated that information on this webinar would be forthcoming.

Bill Radasky mentioned that one of our active participants in TC 5 was to be presented with an important award at the Awards "Luncheon" which had not yet been held. It was recommended that this award not be mentioned during the meeting, but since these minutes have been written after the award was publicized, we can now congratulate our colleague. A Technical Achievement Award from the IEEE EMC Society was presented to Prof. Yuichi Hayashi "For contribution to threat analysis of EM information security and application of EMC countermeasures against threats." As Chairman of the EM Information Security Subcommittee for TC 5 and an active researcher in the field, this award is richly deserved.

15) **Adjournment**

The WEBEX meeting was adjourned at 12:05 p.m. U.S. Central Time.

TC-5 Meeting, Friday, Jul 28 2021, Virtual

Report on Lightning Activities

M. Rubinstein F. Rachidi

Main Events with Lightning Related Content in 2021

- AMS Annual meeting, ~~New Orleans~~, Jan 10-14 (Virtual)
- IEEE EMC & SIPI, ~~Raleigh, NC, Apr 30- May 6~~ and International Symposium on EMC and EMC Europe, ~~Glasgow, Scotland, Jul 30 – Aug 6~~ (Combined virtual, Jul 26-Aug 20)
- APEMC & EMC ~~25-28 May,~~ Bali, Indonesia (Sep 27-30)*
- GROUND & LPE conference, ~~Jun 2 to 5, 2021, Belo Horizonte, Brazil~~ (Virtual, Jun 2-4)
- ICLP/SIPDA, ~~Colombo~~ (Virtual, Sep 20-26)
- EUROEM/ASIAEM~~, Abu Dhabi, 2020~~ (Postponed to early 2022)
- URSI GASS, Rome, Italy (On-site with provision for on-line, Aug 28-Sep 4)
- AGU Fall Meeting Dec 13-17, New Orleans (Online and in-person)

*The APEMC 2021 conference is still planned to be in-person, with the possibility of pre-recorded presentations for those people who are not able to attend the conference in-person. All sessions will also be recorded and made available for registered participants after the conference.

Main Events with Lightning Related Content in 2022

- Int. Conf. on Atm. Electricity, Jun 19-24, Tel Aviv, Israel
- EUROEM/ASIAEM, early 2022 (no dates yet)
- ICLP, South Africa (Oct 2-7)
- ILDC/ILMC (neither dates nor venue announced at this time)
- APEMC, Beijing, China (May 8-11)
- GROUND & LPE conference (neither venue nor dates announced yet)
- IEEE EMC & SIPI, Aug 1–5, Spokane, Washington
- EUROEM(ASIAEM, Abu Dhabi (no dates yet)
- EMC Europe, Rome, Italy (To be held virtually September 23-25)
- CIGRE 2022 Technical Exhibition, Paris, Aug 29-Sep 2.

Approved CIGRE Working Groups on Lightning (2020 - 2022)

- WG C4.59, “Real-time Lightning Protection of the Electricity Supply Systems of the Future”, Chair: Chong Tong (China)
- WG C4.61, “Lightning transient sensing, monitoring and application in electric power systems”, Chair: Jingliang He (China)
- WG 4.66. “New concept for analysis of multiphase back-flashover phenomena of overhead transmission lines due to lightning”, Megumu Miki (Japan)
- WG4.67, Lightning Protection of Hybrid Overhead Lines, Alexandre Piantini, Brazil.

Other Working Groups

- IEEE PES Lightning Performance of Overhead Lines Working Group
  - Annual meeting will be held this year in conjunction with Virtual 2021 IEEE PES GM (which will be held from Jul 26-29).
  - In 2022, the meeting will be held July 17 - 21, Denver.

This year's activities

- Organized a Lightning: Organized together with Bob Davis an “Ask the Experts Discussion” on Aug 7
- Papers submitted to the ICLP/SIPDA conference in Colombo, September

Proposed work for 2022

- Lightning session at EUROEM/ASIAEM 2022
- Promoting lightning-related papers for IEEE EMC 2022
- Several contributions to ICLP 2022 in Cape Town, South Africa

28 July 2021

Activity Report

IEEE EMC Society TC5 Subcommittee: Electromagnetic Information Leakage

Yuichi Hayashi

Regular Session in IEEE EMC + SIPI 2021

TP-THU-5A • Sponsored by TC-5

Co-Chairs: William Radasky (Metatech Corporation, Goleta, CA, USA),
Yuichi Hayashi (Nara Institute Science and Technology, Japan) ,

The number of papers: 3 papers (Related to EM information leakage)

1. Multiple and Reproducible Fault Models on Micro-controller using Electromagnetic Fault Injection
2. Machine Learning Voice Synthesis for Intention Electromagnetic Interference Injection in Smart Speaker Devices
3. The Application Of The Duffing Oscillator To Detect Electromagnetic Leakage Emitted By HDMI Cables

Special Sessions in APEMC 2021

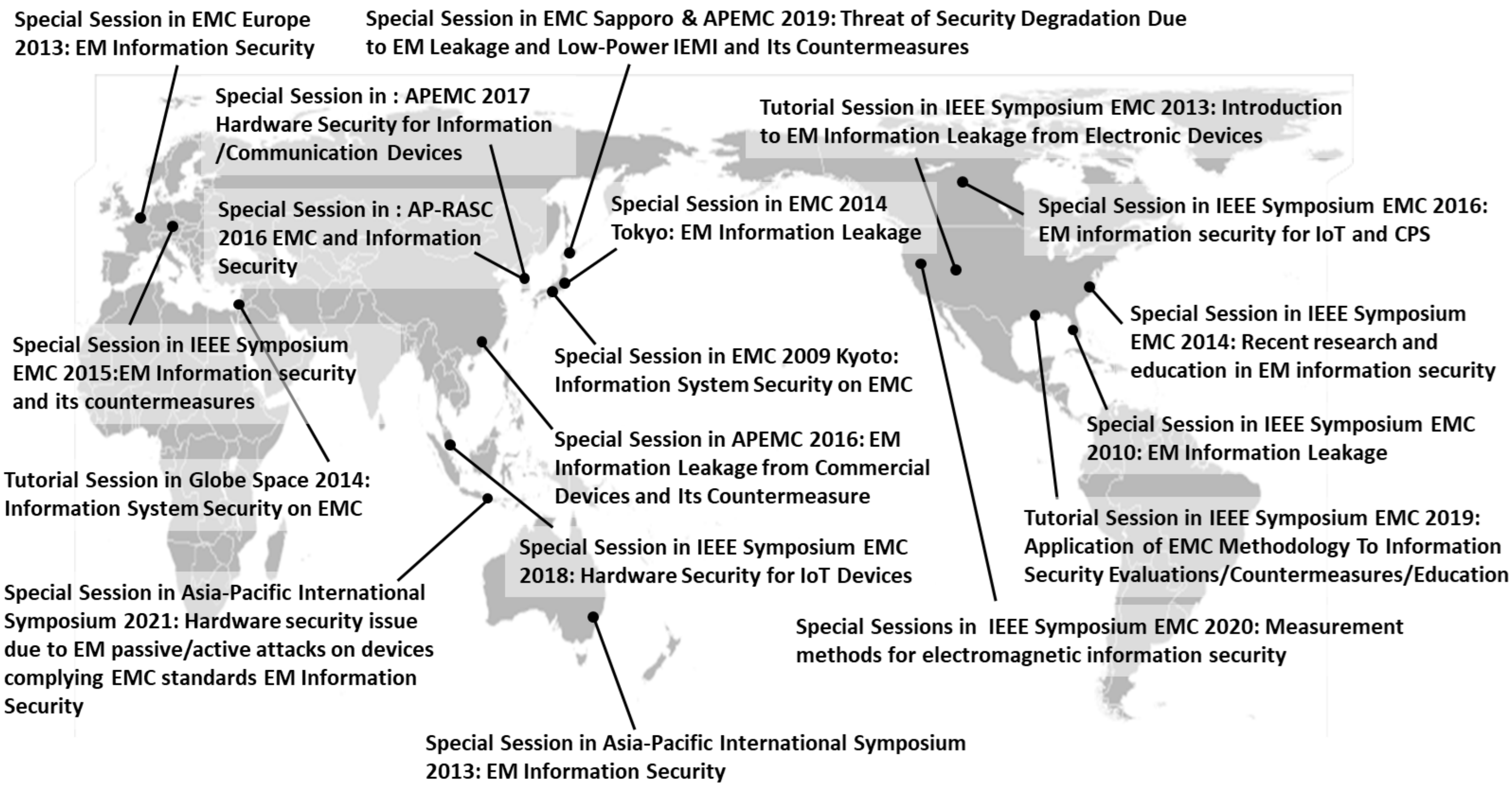
Hardware security issue due to EM passive/active attacks on devices complying EMC standards

Co-Chairs: Yuichi Hayashi (Nara Institute Science and Technology, Japan) , William Radasky (Metatech Corporation, Goleta, CA, USA)

The number of papers: 10 papers

1. Board-Level Hardware Trojan Detection Using Sensing Function of On-Board ICs in IT Devices
2. Information Leakage Through Emissions Standards for Commercial Equipment
3. A Scheme to Improve SNR of Received EMI Signal from Information Display Device
4. Investigation of the Effect of Temperature on Fault Injection Using Intentional Electromagnetic Interference
5. A Study for Low Calculation Cost Side-Channel Resistance Prediction Based on Transfer Impedance of Leakage Path
6. Analysis of Electromagnetic Information Leakage from Overdesigned Power Delivery Network of Cryptographic Devices
7. A Fundamental Evaluation of EM Information Leakage Induced by IEMI for a Device with Differential Signaling
8. A Study on Output Bit Tampering of True Random Number Generators Using Time-Varying EM Waves
9. Study on Measurement Resolution of Side-Channel Waveform in Correlation Power Analysis
10. Fundamental Study on Evaluating Immunity of RO-Based TRNGs Against Frequency Injection Attack

Research activity of EM information security in commercial devices (since 2009)



Outreach activity in future

To promote the field of information leakage, we would like to have workshop/special sessions in future EMC symposiums.

Special session in IEEE EMC + SIPI 2022
Topic: Hardware security required for the next generation of cryptography and electronic devices (tentative)

HEMP/IEMI Subcommittee Report to TC 5 (HPEM)

Mike McInerney

28 July 2021

TC5 HEMP / IEMI Subcommittee

- Created in 2020 to improve the organization of the website and ease subcommittee reporting
  - HEMP information had been placed under meeting minutes, while other subcommittees placed relevant information on their respective sub-pages
  - Since parts of HEMP and IEMI have similar fast rising time waveforms and are high power EM, they are associated
  - HEMP (and IEMI) literature is now listed on the HEMP / IEMI web page
  - Mike McInerney volunteered to be the General POC for the new HEMP / IEMI subcommittee
  - Bill Radasky volunteered to be the POC for the new HEMP subcommittee
  - Frank Sabath retained role as POC for IEMI subcommittee
  - Frank Sabath is retiring from his role as POC for IEMI subcommittee
  - Have opening for new IEMI POC

TC5 HEMP / IEMI Subcommittee

- We encourage TC5 committee members to submit information on TC5 related activities to subcommittee POCs
  - Lightning
  - EM (Information) Leakage
  - HEMP / IEMI
  - ESD

TC5

Recent HEMP Activities

- Several important HEMP activities have occurred since our last virtual conference and TC5 meeting
  1. The U.S. Department of Energy has published an open document to specify recommended HEMP waveforms to use to evaluate the vulnerability of the U.S. infrastructure
  2. The IEC has taken steps to update IEC 61000-2-9 (HEMP environment)
  3. The IEEE Power Energy Society is preparing a white paper dealing with the protection of protective relays from HEMP
  4. CIGRE Study Committee C4 has a working group considering approaches to protect high voltage power control house electronics against HEMP
  5. Power companies are investigating ways to protect their electronics from HEMP (and IEMI)
- Items 1 and 2 are discussed in more detail in the following two charts

U.S. DOE HEMP Environments

- On January 11, 2021, the U.S. Department of Energy Released a set of HEMP environments to be used for assessing the susceptibilities of the critical infrastructure
  - This was required by the HEMP Executive Order released under President Trump in March 2019
  - The waveforms recommended for E1 and E2 HEMP are identical to those published in IEC 61000-2-9
  - The waveforms for E3 Blast Wave and E3 Heave are higher than those recommended by IEC 61000-2-9
  - All of the waveforms are presented graphically and with analytic formulas
  - TC5 will place the public memo on the TC5 website
- Link: https://www.energy.gov/sites/default/files/2021/01/f82/FINAL%20HEMP%20MEMO_1.12.21_508.pdf

TC5

IEC 61000-2-9 Update Plans - 1

- IEC Subcommittee 77C has been planning to start new work and maintenance on its body of IEMI and HEMP publications
  - Several HEMP and IEMI publications will be updated
- For the HEMP radiated environment, there are several areas of IEC 61000-2-9 that have been discussed for more than 1 year to improve the standard
- The maintenance work for IEC 61000-2-9 has been recently approved
  - Project Leader: Dr. William Radasky
  - Summary of improvements are on the next chart

IEC 61000-2-9 Update Plans - 2

- Key improvements to be considered
  - Provide information for the variation of the E1 and E3 HEMP fields as a function of position. This could include sample ground contour plots and/or range dependent variations for the peak values and even the pulse shapes.
  - Consider adding a few additional analytic E1 HEMP waveforms with different rise times and pulse widths.
  - Provide a new E3 HEMP waveform (both B- and E-fields) based on new openly published information.
  - Provide information on how to compute the E3 field from the incident B-field and provide a few ground conductivity profiles for those calculations.
  - Provide an annex that shows an equivalent QEXP (Quotient of Exponentials) waveform that is more accurate above 100 MHz for the E1 HEMP waveform. This will help those who try to extend the DEXP (Difference of Exponentials) waveform in the frequency domain to frequencies well above 1 GHz.
  - Explain in another annex why the E1 HEMP waveform in time does not require a “zero area”. This has caused a great deal of confusion regarding the way the E1 HEMP waveform is specified.
  - Provide (in an annex) a simple explanation of the high-frequency approximation (HFA) so the use of the “1-D” numerical solution is not misunderstood. A comprehensive list of references could also be provided to underscore the accuracy of the HFA.

Recent IEMI Activities - 1

- Much of the activity in IEMI from 2020 – 2021 is occurring through the combined 2021 IEEE EMC/EMC Europe Symposium with 4 different tutorials dealing with IEMI being presented beginning next week
  - WT-Mon-3: Monday, 2 August 2021
    - Modeling of IEMI Scenarios
    - Organizer: Frank Sabath
  - WT-Tues-4: Tuesday, 3 August 2021
    - Protection of Critical Infrastructures Against IEMI
    - Organizers: Michael Suhrke, Martin Schaarschmidt
  - WT-Thurs-3: Thursday, 5 August 2021
    - HPEM Effects on Electronic Systems
    - Organizer: Frank Sabath
  - WT-Fri-3: Friday, 6 August 2021
    - Recent Advancements in HEMP, EMP and IEMI Protection – A Global Perspective
    - Organizers: Joel Kellogg, Dave Giri

Recent IEMI Activities - 2

- IEC SC 77C has approved maintenance on IEC/TR 61000-5-6 titled, "Electromagnetic compatibility (EMC) - Part 5-6: Installation and mitigation guidelines - Mitigation of external EM influences"
  - Dr. Richard Hoad is the project leader
- The improvements include:
  - Update the whole document to include other HPEM environments including **Intentional Electromagnetic Interference (IEMI)**
  - Add to the Scope new clauses with the concept of EM Resilience which includes the new field of HPEM detectors; recovery and restoration
  - Review the rest of the document to improve the consistency of the text with other SC 77C documents produced after this document. This would include any definitions and figures that should be updated.
  - Convert the document to become an International Standard.

ESD Update

Joost Willemen
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Michael Khazhinsky
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Virtual TC-5 (HPEM) Meeting

July 28, 2021

ESD Technical Exchange – 2021 Updates

- ESDA Representatives (Michael Khazhinsky, Joost Willemen) participated in ESD paper review
  - 5 regular paper submissions
  - 4 special sessions submissions (Special session organizer: D. Pommerenke)
- Joost Willemen chairs TC-5 sponsored ESD session: TP-THU-5-B ESD: "ESD and Smart Grid IEMI" (Thursday, Aug 12, 2021), with Michael McInerney as co-chair
  - Only 1 paper in this session, all other papers have been reassigned to a special session
- The 2021 ESD Symposium again has a special focus on EMC and System Level related topics
  - Session with 2 invited papers
  - 2 seminars
  - "Ask the experts" session
- Paper exchange program between IEEE EMC&SIPI Symposium and ESDA continues in 2021
  - 1 paper and 1 tutorial from 2020 EMC&SIPI Symposium are presented as invited papers at the 2021 ESD Symposium
  - This year no invited papers from the 2020 ESD Symposium at the EMC&SIPI Symposium

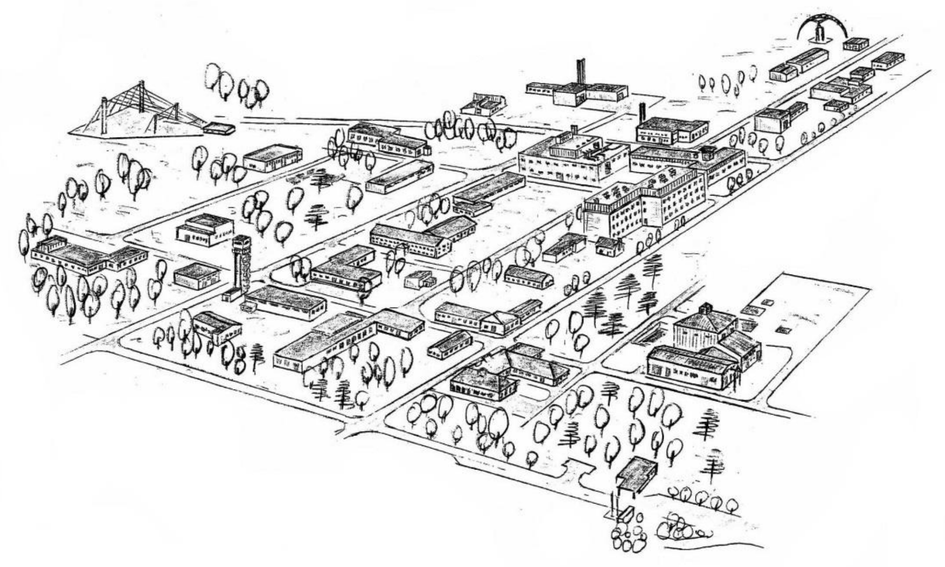
ESD Standards – 2021 Updates

- Mil Std 1686 and Mil HBK 263 were withdrawn, and military is now using ANSI/ESD S20.20 and ESD TR20.20 for ESD control program requirements.
- Published an update to the Technology Roadmap in October 2020.
- John Kinnear is the IEC TC101 chairman as of January 1, 2021.
- 10 ESD standard documents have been published in 2021:
  - ANSI/ESD SP3.5 - Test Methods for Air Assist Bar Ionizers, Soft X-Ray (Photon) Ionizers, Room Ionization Alternatives, and Non-Airflow Alpha Ionizers
  - ANSI/ESD STM7.1 - Flooring Systems - Resistive Characterization
  - ANSI/ESD S8.1 – Symbols
  - ANSI/ESD STM11.11 - Surface Resistance Measurement of Planar Materials
  - ANSI/ESD STM11.12 - Volume Resistance Measurement of Planar Materials
  - ANSI/ESD SP14.5 – Near Field Immunity Scanning - Component/Module/PCB Level
  - ANSI/ESD SP17.1 - Process Assessment Techniques
  - ESD TR5.5-05-20 - Transmission Line Pulse (TLP) – Transient Response Evaluation
  - ESD TR18.0-02-20 - Latch-up Electronic Design Automation (EDA)
  - ESD TR23.0-01-20 - Electrical Overstress in Manufacturing and Test
- Upcoming document releases:
  - ANSI/ESD S20.20 – ESD Control Program Requirements
  - ESD TR53-01 – Compliance Verification Test Methods
  - ANSI/ESD S1.1 – Wrist Straps
  - ANSI/ESD STM11.13 – Two Point Resistance Measurement
  - ANSI/ESDA/JEDEC JS-002 – Charged Device Model (CDM)
  - ESD JTR002-01 – User Guide for ANSI/ESDA/JEDEC JS-002

Attachment 5
28 July 2021

Bundeswehr Research Institute for Protective Technologies and NBC Protection (WIS)

Branch 320
Electromagnetic Effects
and HPEM



Branch Head 320:

Dr. Martin Schaarschmidt

TOC

- Introduction WIS
- High-Power Electromagnetics (HPEM)
- Equipment & Facilities
- R&D Projects

General information about the WIS

German Research Map:
Federal Research Institutions

Sven Fisahn

Bundeswehr Research Institute for Protective Technologies and NBC Protection (WIS)

Branch 320
Electromagnetic Effects and HPEM

Mission:
Research, Testing and Advice on Electromagnetic Effects and HPEM

Organization WIS

Director
DirProf Dr. Sabath

Staff
- R&T–Coordination
- Controlling
- Quality Management
- Occupational Safety
- Public Relations

Technical–Operational Service
***

- Biological Laboratory
- Chemical Laboratory, Hazardous Materials–Evaluation Team
- Workshops

Directorate **Detection**
***

- RN – Detection ZESAM
- B – Detection
- C – Detection
- Verification

Directorate **NucWeapons Effects HPEM Fire Protection**
Dr. Rambousky

- Effects of Nuclear Weapons, Ionizing Radiation
- Electromagnetic Effects and HPEM
- Scientific Computing and IT
- Fire Protection Technology

Directorate **NBC–Protective Equipm Decontamination Water Purification**
***

- Individual– and Collective Protection
- Decontamination
- Water Purification

Economic–Administrative Service
***

- Organization
- Budget, Procurement, Contracts
- Materials Logistics, Internal Service
- Security
- Library

Mission GF 320 – Electromagnetic Effects and HPEM

Research

- Research & Technology (R&T) Projects on HPEM
  - Interaction mechanisms of HPEM with electronic components and systems
  - Protection measures against HPEM effects

Testing

- Qualification testing to ensure HPEM hardess of military equipment and other security relevant systems and facilities
- Assessment of potential HPEM weapons and their effects
- Participation in standardization working groups (national, international, military, civil)

Advice

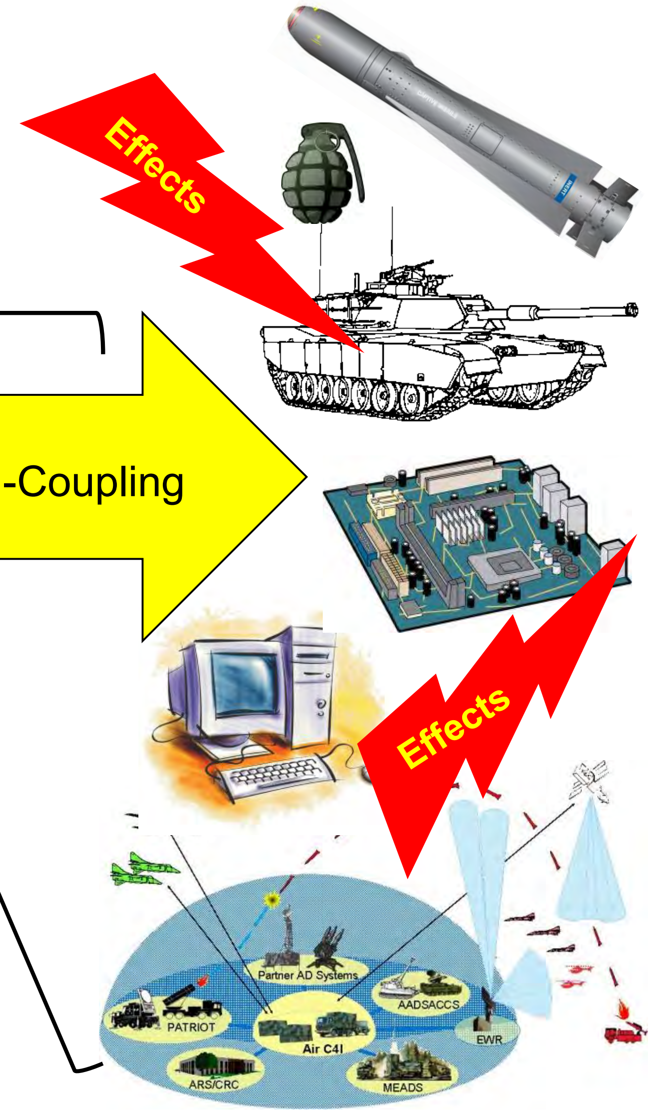
- Guidance to the Armaments Directorate (MoD) concerning protection of military equipment against HPEM attacks
- Support of the Armaments Directorate (MoD) concerning HF personnel safety by scientific assessment and measurements

Research & Technology (R&T) – Context / Focus

Numerical EM-Field Simulation
CEM (PROTHEUS)

EM-Fields
wave propagation

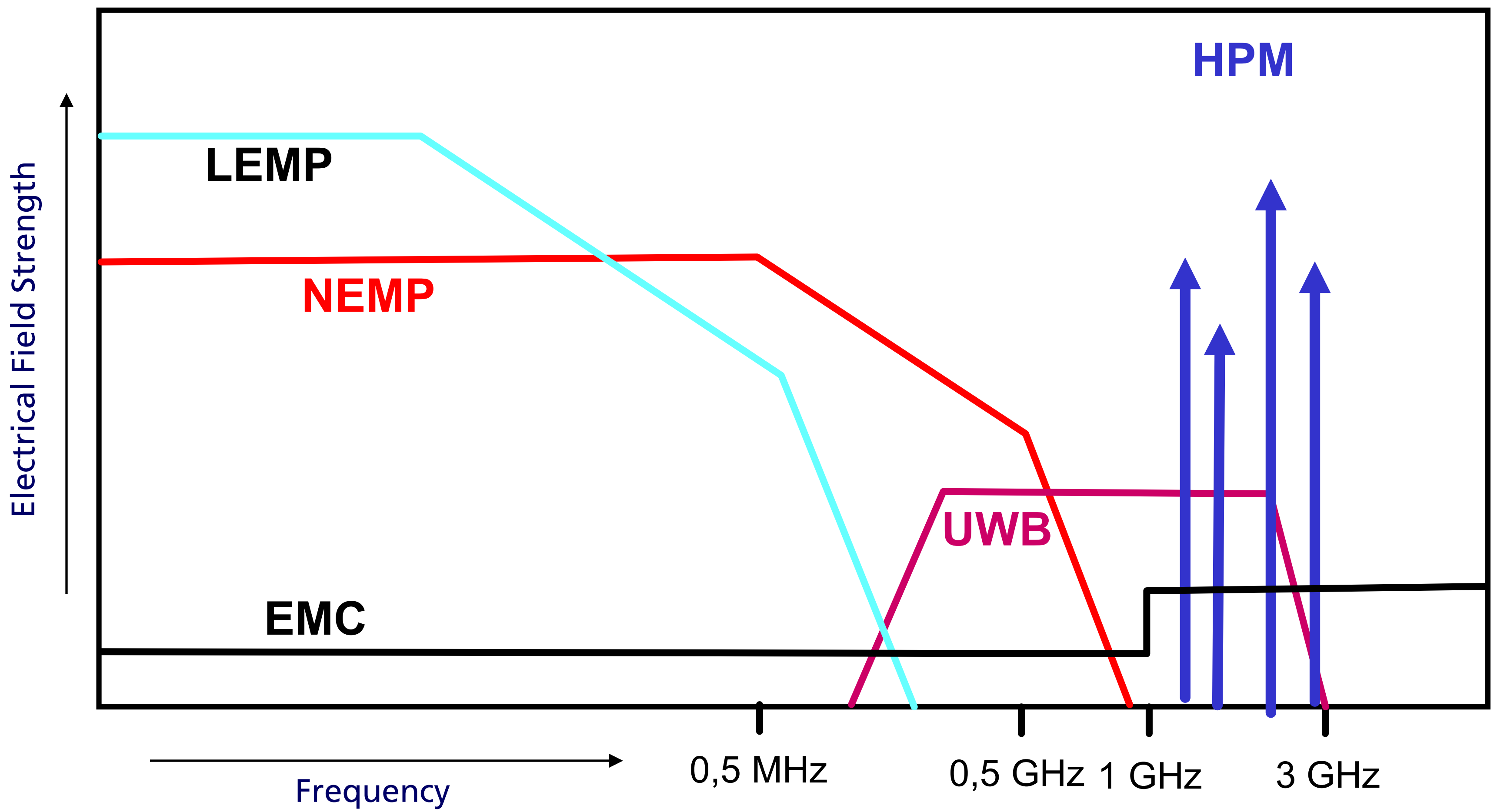
EM-Coupling



HPEM-Effector

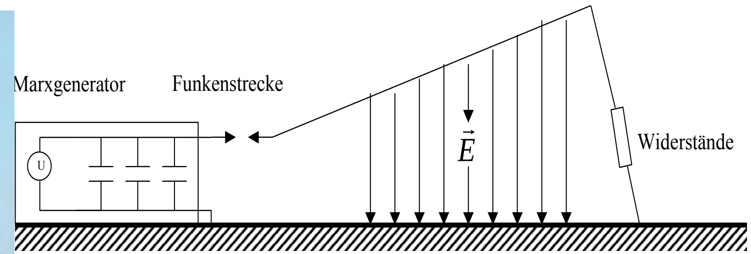
HPEM-Interaction
HPEM-Protection
HPEM-Qualification Testing
HPEM-Standardization

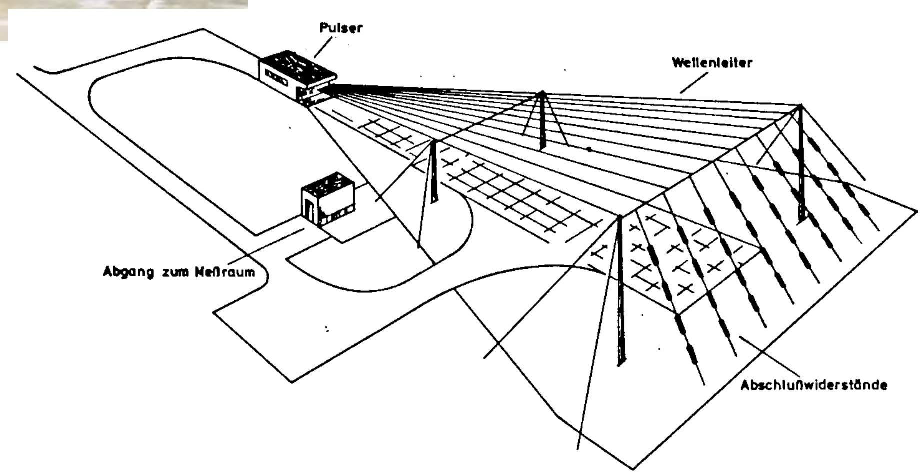
Frequency ranges of electromagnetic effects



- Introduction WIS
- High-Power Electromagnetics (HPEM)
- Equipment & Facilities
- R&D Projects

NEMP Simulators – TEM-Waveguide DIESES





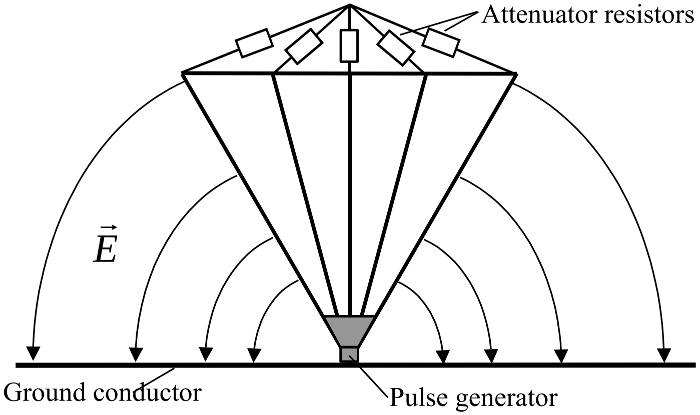
TEM-Waveguide

Rise time:	1.0 - 2.5 ns
Pulse duration:	25 - 50 ns
Amplitude:	1 kV/m - 100 kV/m
Test volume:	10 m x 10 m x 10 m

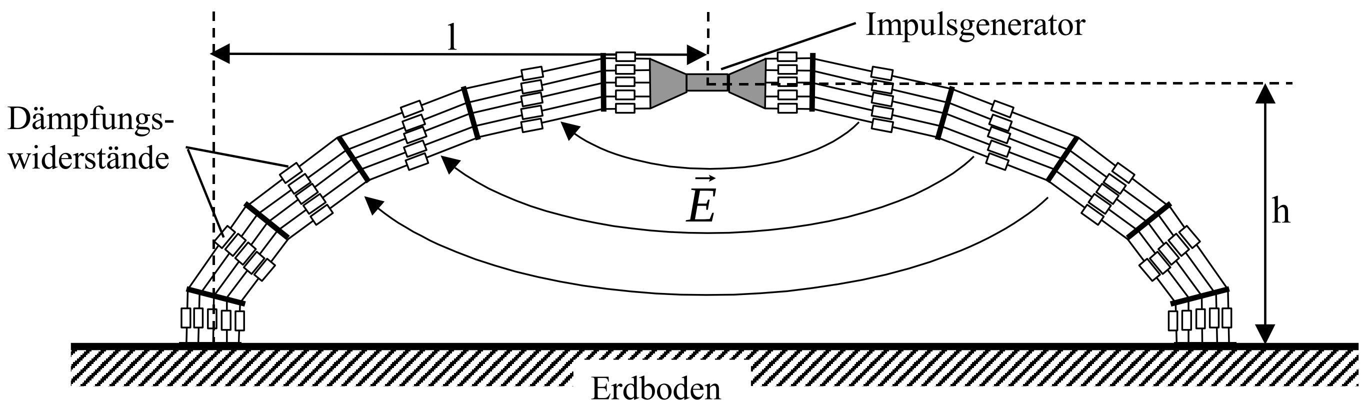
NEMP Simulators – VPD

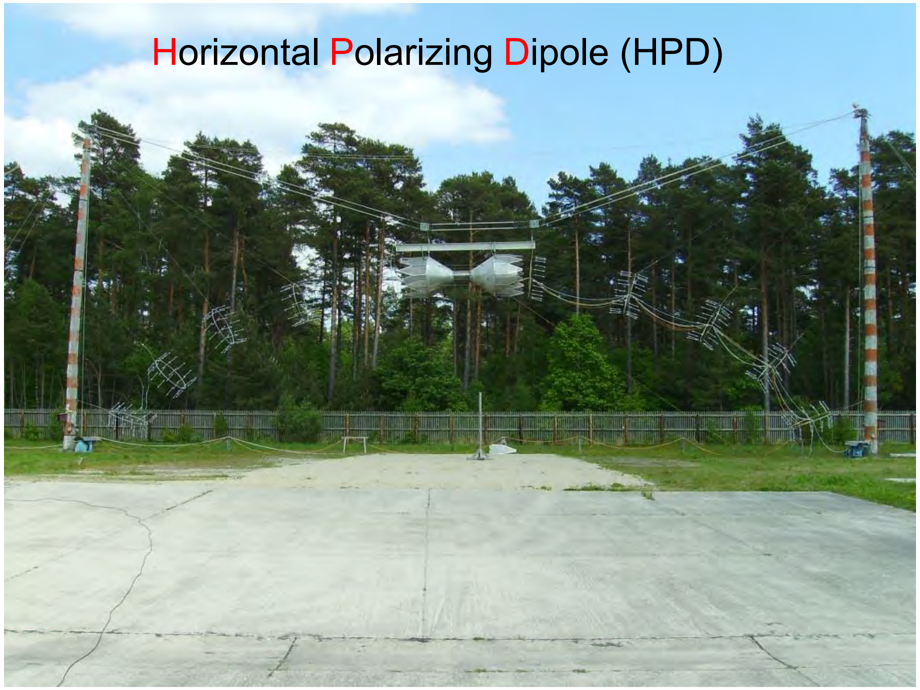
Vertical Polarizing Dipole (VPD)

Rise time:	2.5 ns
Pulse duration:	25 ns
Amplitude:	1 kV/m - 15 kV/m
Test volume:	10 m x 10 m x 6 m



NEMP Simulators – HPD

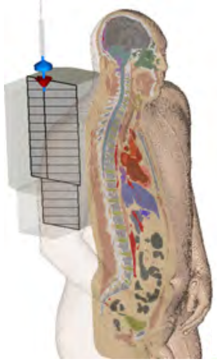


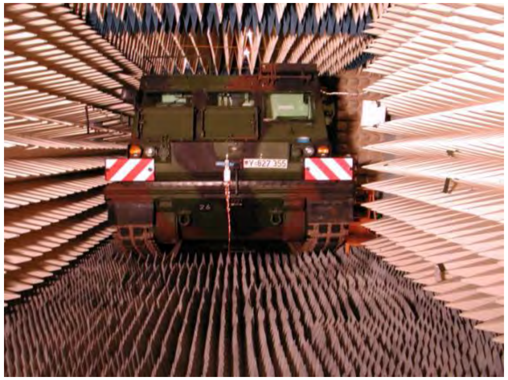


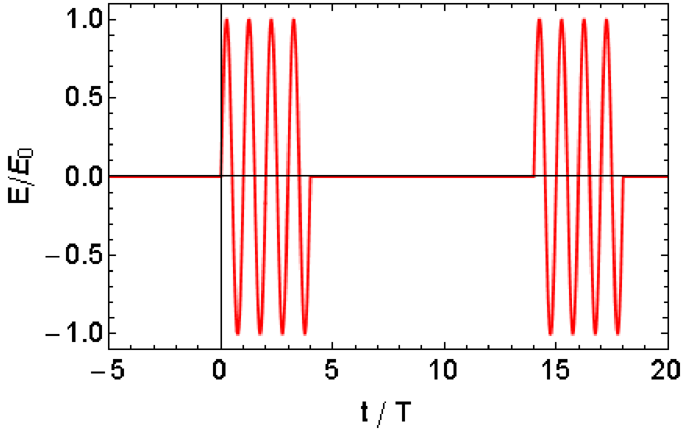
Rise time:	1 ns - 3 ns
Pulse duration:	10 ns - 20 ns
Amplitude:	1 kV/m - 50 kV/m
Test volume:	10 m x 10 m x 6 m

High-Power Microwave Facility – SUPRA

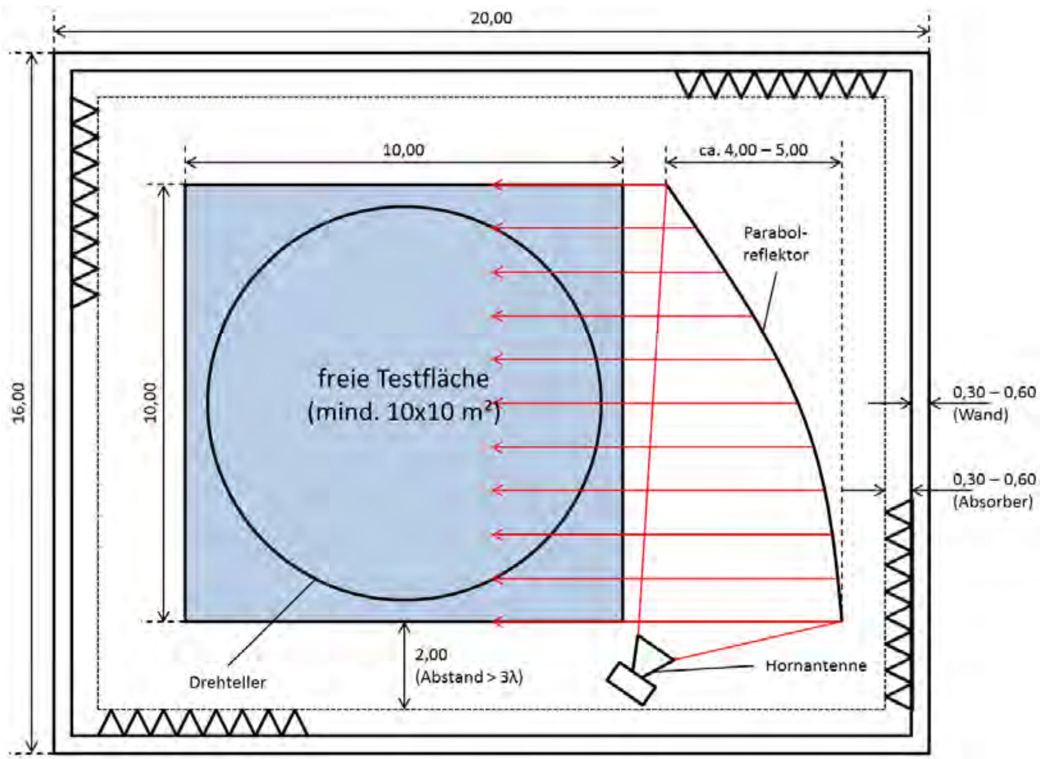
- 8x super reltrons
- frequency range: 685 MHz – 3 GHz
- mean power: 100 MW bis 500 MW
- effektive field in 15 m distance: >50 kV/m
- illumination area in 15 m distance: 4 m x 3 m
- pulse duration: > 300 cycles
- Pulse repetition frequency: up to 10 Hz
- Pulses per Burst: <100

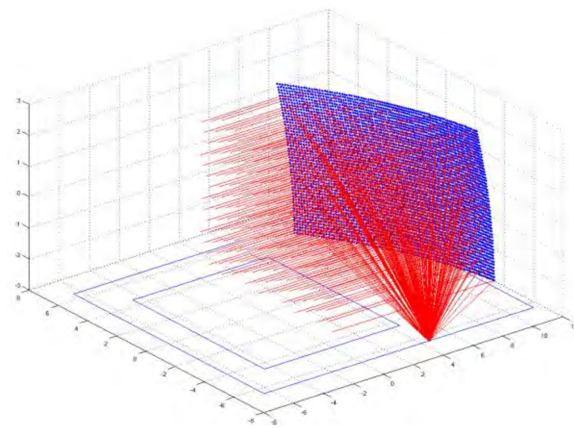






High-Power Microwave Facility – SUPRA – Projected Extension





GTEM-Cell

- Dimensions: (7,8 x 2,8 x 4,1) m
- Frquency range: 0 Hz – 18 GHz
- Input for pulsed signals up to 50 kV (e.g. NEMP pulse)

HPEM-Laboratory – Open TEM Waveguide

- obere Grenzfrequenz: 8 GHz
- max. Eingangsspannung: 50 kV
- integrierte Feldsensoren (E-Feld)
- Testvolumen: 1 m x 1 m x 1 m

Mobile HPM-Source

HPEM-Laboratory –UWB Generator

PBG3:

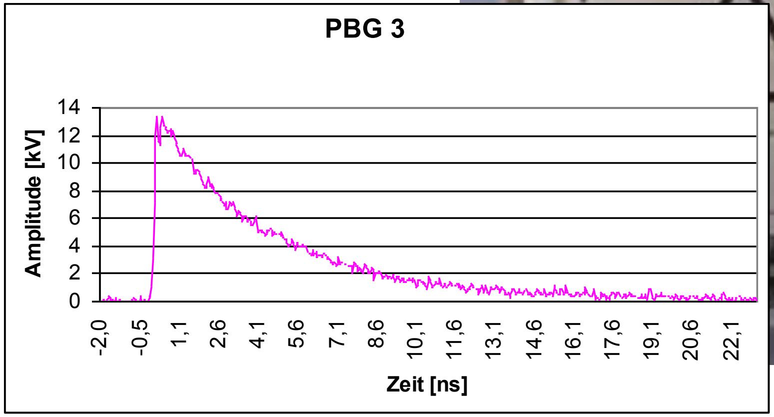
- Multifunktionaler UWB-Pulsgenerator auf Halbleiterbasis
- Ausgangsspannung: 12 kV
- Ansteigszeit: 100 ps
- Pulsdauer: 5 ns
- Wiederholrate: 100 Hz

PBG7:

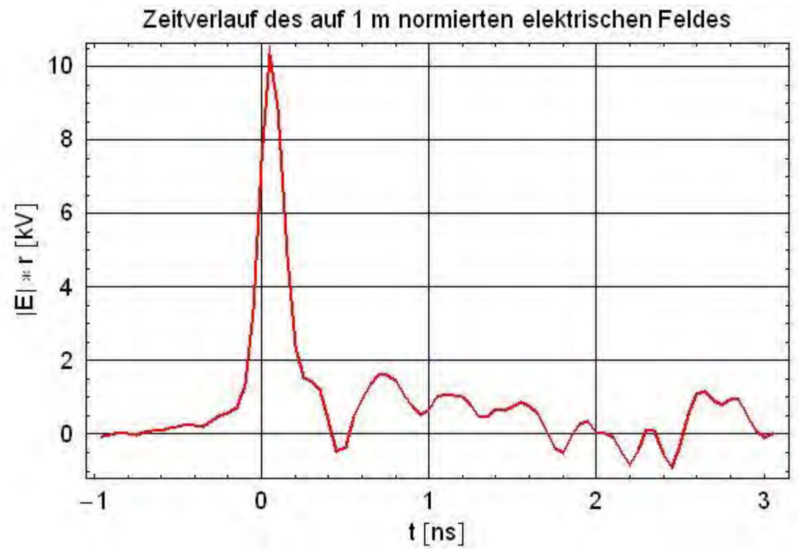
- Multifunktionaler UWB-Pulsgenerator auf Halbleiterbasis
- 4 Ausgänge je 12 kV, t_{rise} = 100 ps (für Phased-Array-Systeme)
- oder ein Ausgang 45 kV, t_{rise} = 150 ps, Pulsdauer 3 ns
- Wiederholrate: 500 Hz

Verwendbare Antennensysteme:

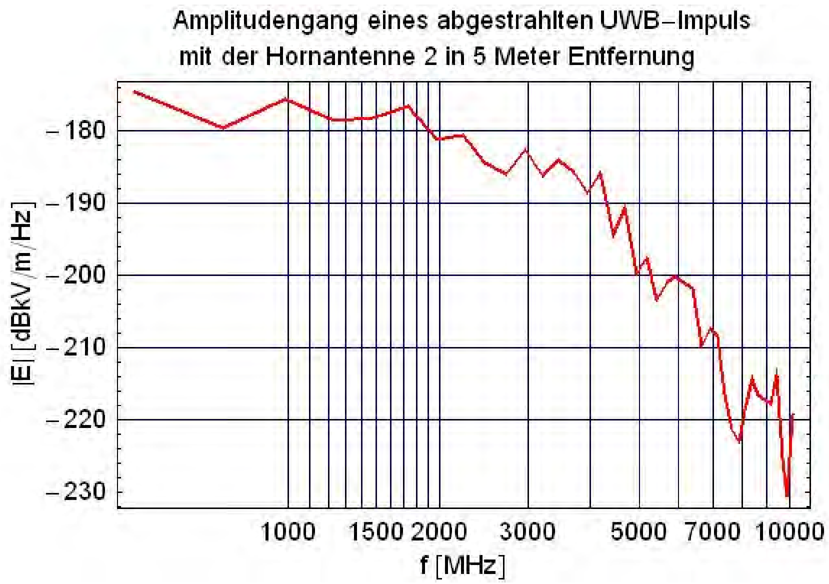
- Impuls Radiating Antenna (IRA)
- Half Impuls Radiating Antenna (HIRA)
- Hornantennen
- TEM-Wellenleiter

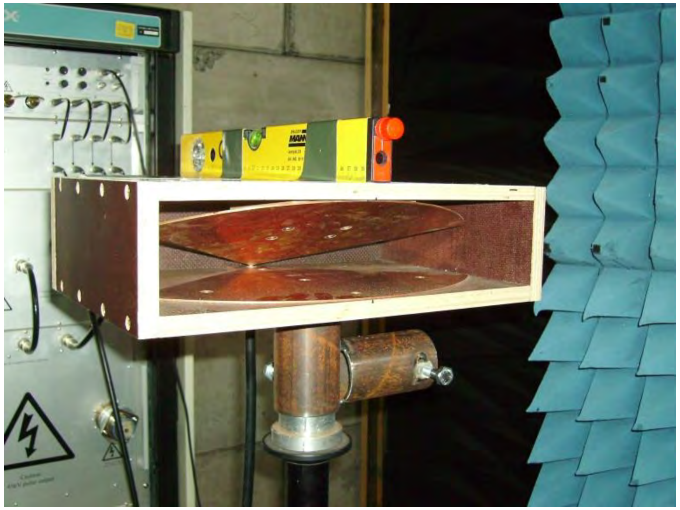


HPEM-Laboratory – Horn Antennas



- obere Grenzfrequenz: 4,5 GHz
- max. Eingangsspannung: 13 kV
- 4 Antennen vorhanden



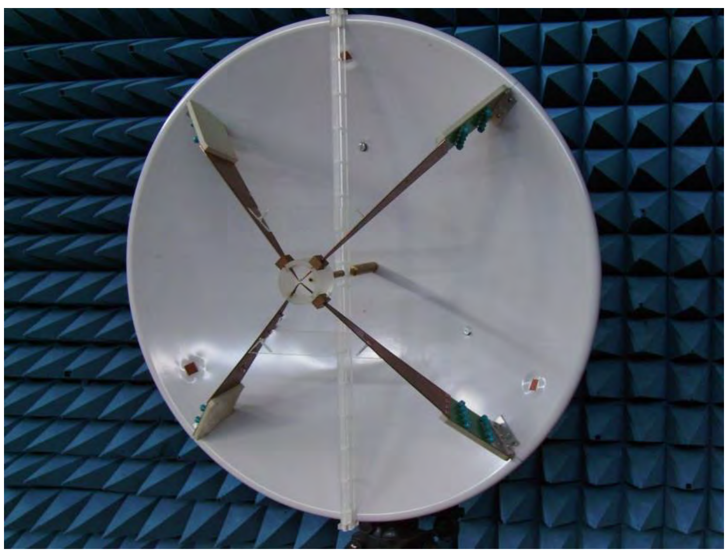


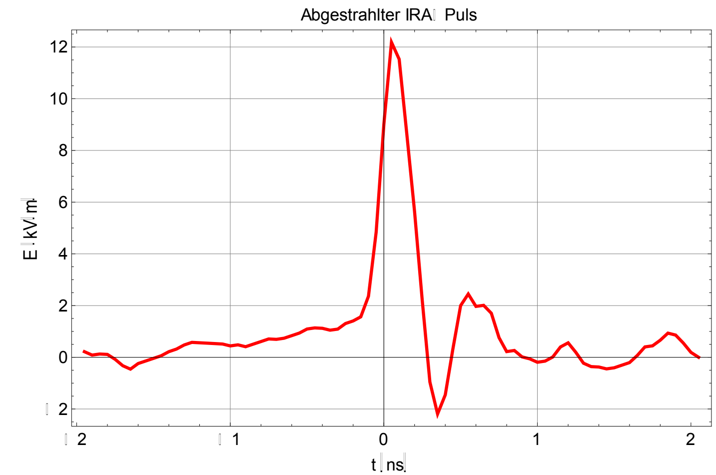
HPEM-Laboratory – Impulse Radiating Antenna (IRA)

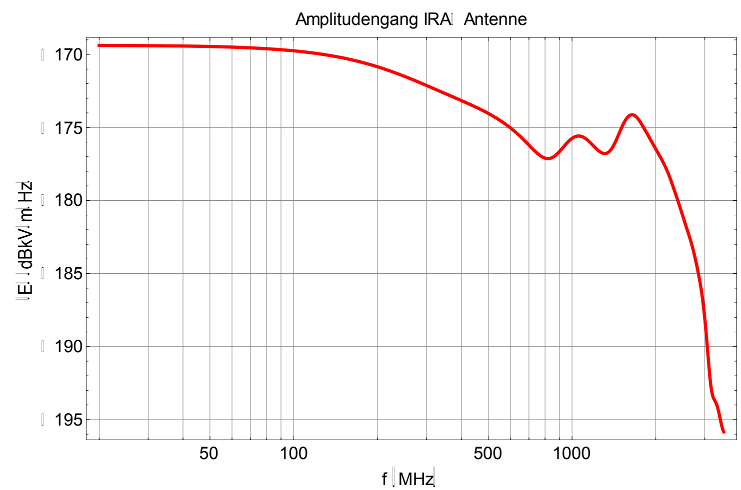
Impulsabstrahlende Reflektorantennen

Durchmesser Apertur:	0,9 m	1,8 m
Max. Spannung:	12,5 kV	50 kV
Obere Grenzfrequenz:	2,5 GHz	n.n
Bandbreite:	1,5 GHz	n.n
r E:	10 kV	n.n

Impuls Radiating Antenna (IRA)





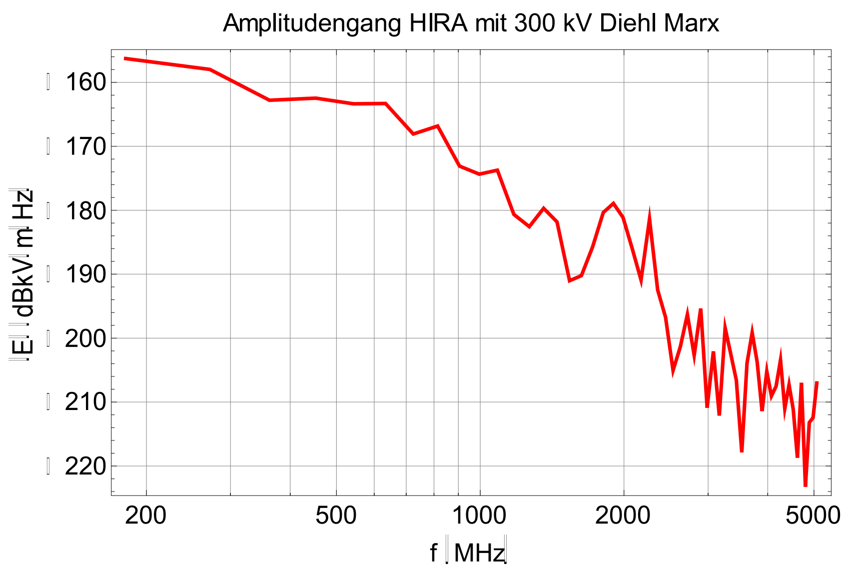


HPEM-Laboratory – Half Impulse Radiating Antenna (HIRA)

Impulsabstrahlende Reflektor-Halbantenne

Durchmesser Apertur:	1,8 m
Max. Spannung:	600 kV
Obere Grenzfrequenz:	2,2 GHz
Bandbreite:	1 GHz
r E:	790 kV

Adaption an verschiedenste Impulsquellen des WIS (Marxgeneratoren, pulserzeugende Netzwerke)

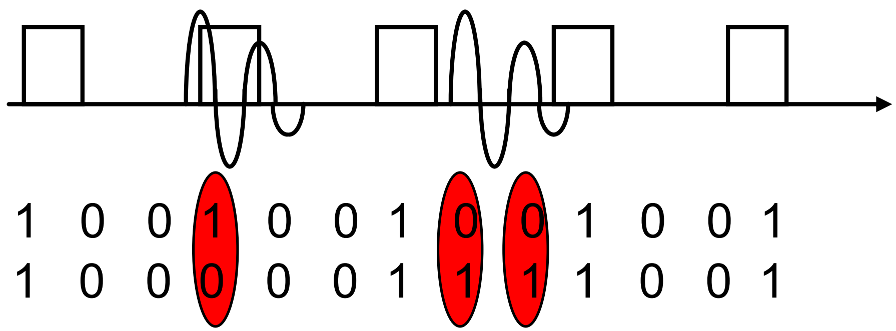


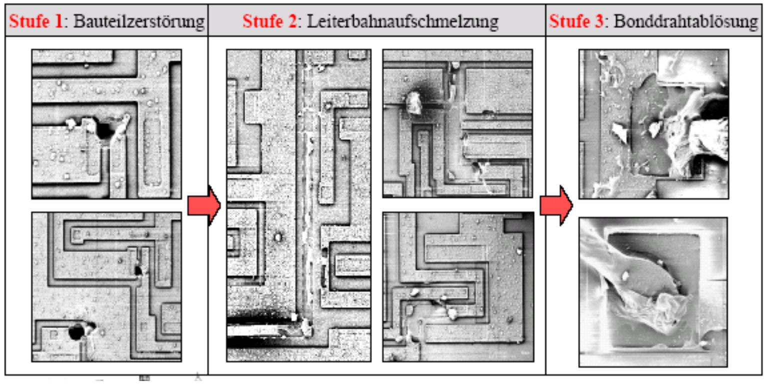
Half Impuls Radiating Antenna (HIRA)

- Introduction WIS
- High-Power Electromagnetics (HPEM)
- Equipment & Facilities
- R&D Projects

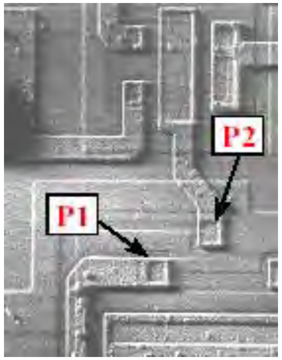
Physical Effects

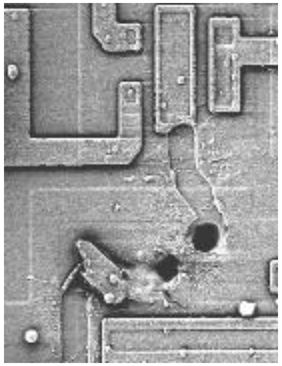
Bit-Flip



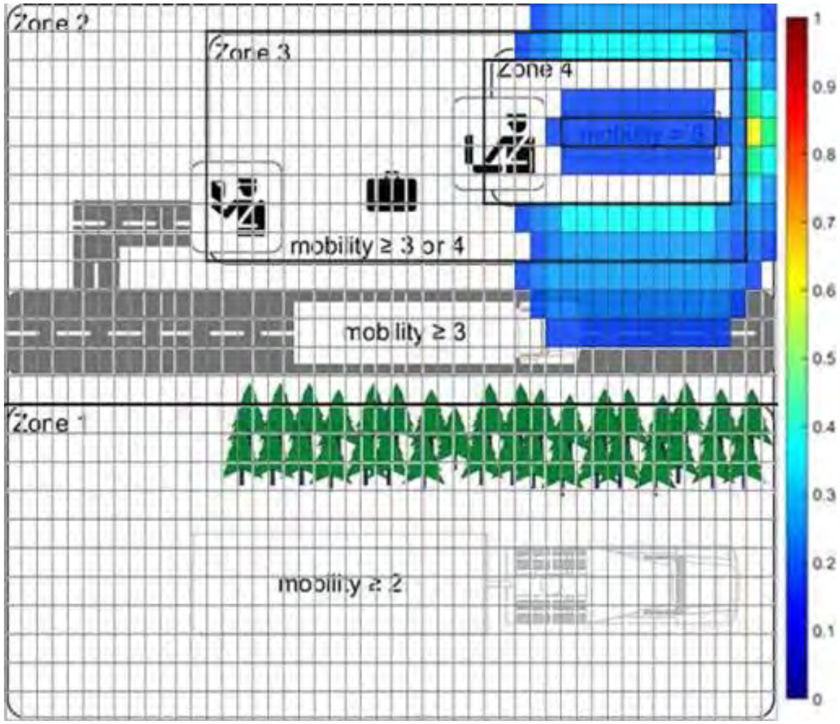


Physical Destruction





Risc Analysis

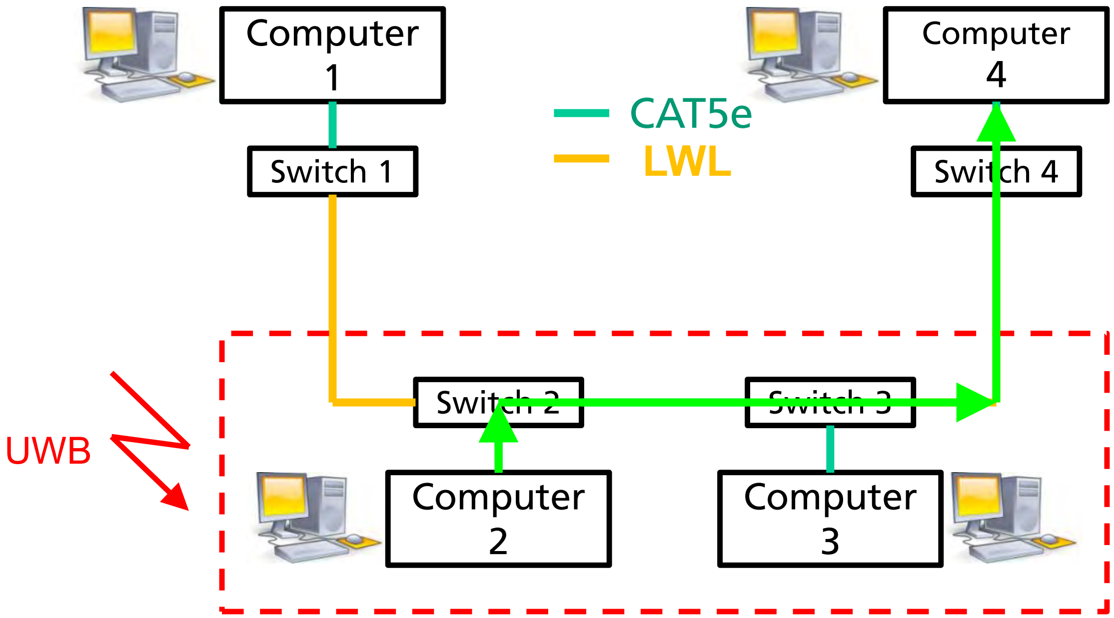


Example: Airport Check-In

- **Fuzzy-Logic based**
- **Nontechnical parameters**
- **Expert knowledge**
- **Information deficit**

statistical-theoretical evaluation
Functional description

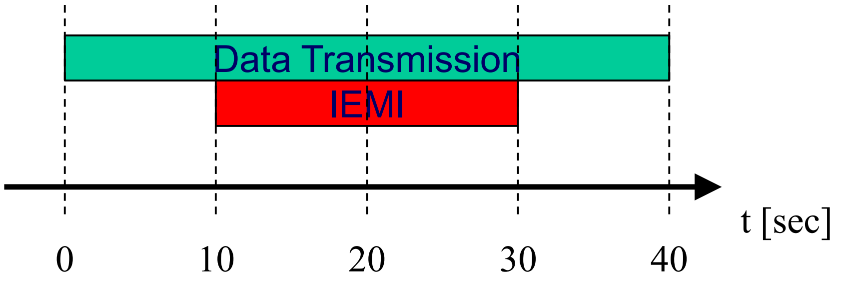
Intelligent Network Protection



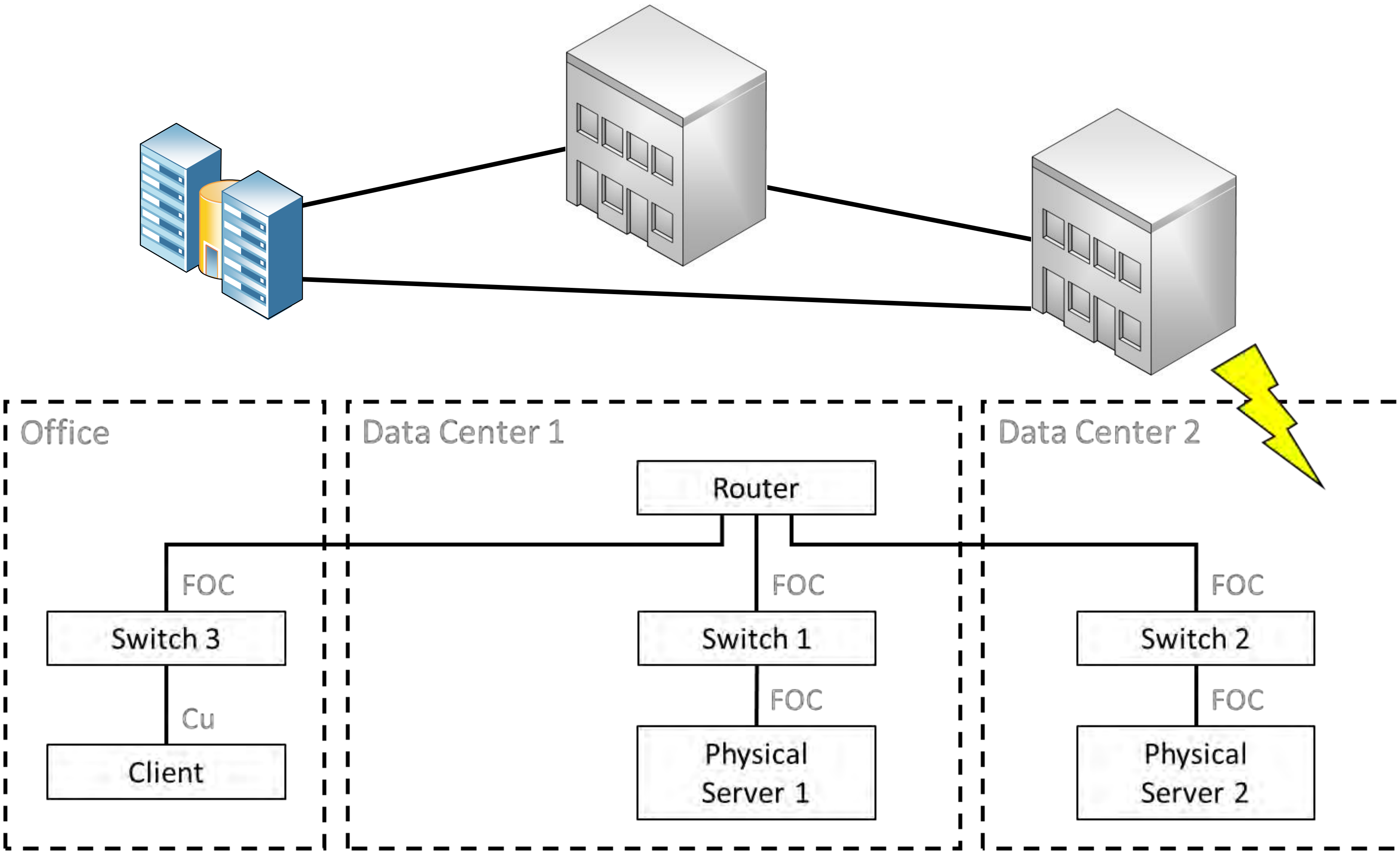
Parameters

- 7,5 kV/m vertikal
- Rep-Rate: 0, 10, 50, 100, 200,…, 800 Hz
- transmission: 40 sec
- Interruption: 20 sec

Resilience of Redundant Server Infrastructure



Resilience of Redundant IT Infrastructure



Defence against UAV/UAS

UAV = unmanned aerial vehicle
UAS = unmanned aerial system

HPEM capabilities

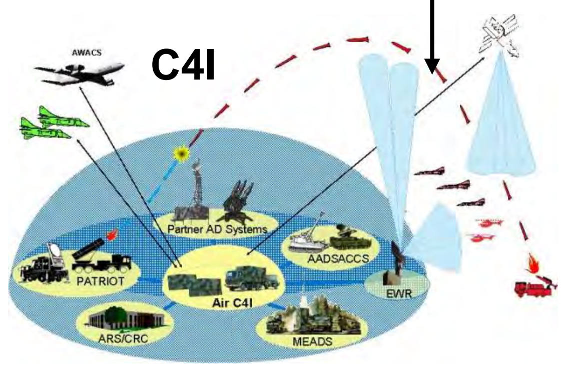
- jamming
- Sensor interruption
- Processing interruption

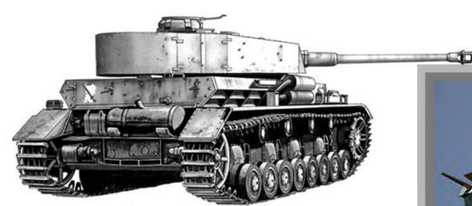
Spiegel-Online vom 16.09.2013

CotS UAV					
Merkmal	Reely 650 ARF	GAUI 500X-S	Flame Wheel	Phantom	Multicopter 800 S
Beschaffung	DEU	DEU	NATO	NATO	NATO
Anzahl	1	1	4	4	2
Steuerung	35 MHz	2,4 GHz	2,4 GHz	2,4 GHz	2,4 GHz
GPS	nein	ja, externes Modul	ja	ja	ja
Autonomes Landen (Coming Home)	nein	ja	ja	ja	ja
Autonomer Flug (Wegpunktnavigation)	nein	ja	nein	nein	ja
Größe (Linie Motor – Motor entlang der Arme)	66 cm	50 cm	56 cm	35 cm	80 cm
Flugzeit	20 min	20 min	20 min	20 min	15 min
Nutzlast	800 g	1400 g	300 g	150 g	2000 g
Einstufung	Modellbau/ Hobby	Modellbau/ Hobby mit MIKADO vergleichbar	Modellbau/ Hobby	Semiprofessionell	Professionell mit MIKADO vergleichbar

Standardization

NEMP	UWB / DS	HPM
Nat.: VG Normen Intern.: AECTP 250/500	Nat.: - Intern.: AECTP 250/500	Nat.: - Intern.: AECTP 250/500
<u>Test facilities:</u> Waveguide „DIESES“ HPD, VPD	<u>Test facilities</u> UWB Pulser + Antenna DS Pulser UWB/DS TEM-Waveguide	<u>Test facilities</u> HPM facility „SUPRA“ Extended anechoic chamber
<u>R&D Activities:</u> Interconnected IT-Systems / TEM-Waveguide (AF119)	<u>R&D Activities:</u> NATO RTO SCI-250 Joint Systems (CF149)	<u>R&D Activities:</u> HPM Testprocedures (CF162) Mobile Source (FF027)





- EMC+SIPI 2021 Virtual:
  - **Tutorial** by Frank Sabath: Modeling of Intentional Electromagnetic Interference (IEMI) Scenarios
  - **Workshop** by Frank Sabath, Dave Giri and Richard Hoad: HPEM Effects on Electronic Systems
  - **Workshop** by Martin Schaarschmidt and Michael Suhrke: Protection of Critical Infrastructure against Intentional Electromagnetic Interference
  - **Technical Session** by Mike McInerney and Frank Sabath: IEMI Generators and Modeling
  - **Technical Session** by Frank Sabath and Mike McInerney: Intentional EMI and HEMP
  - **Technical Session** by Tim Claeys: Risk-based EMC
    ➔ MSCA-ITN „PETER“

- MSCA ITN "PETER - Pan-European Training, Research & Education Network on Electromagnetic Risk Management”
  ➔ https://etn-peter.eu/

- Kleinheubacher Tagung 2021(German forum of the URSI)
  - **Plenary Session** by Frank Sabath: EMI Risk Management
  - **Special Session by Sven Fisahn:** Risk Analysis and German activities within MSCA ITN "PETER - Pan-European Training, Research & Education Network on Electromagnetic Risk Management”

Thank you for your attention!

Questions ?