NEMP Test Systems MIL-STD-461E&F RS105 @ 50 kV/m

System description

Version 1.8/ 14.3.2013

S:\Prospectus\SystemDescriptionDocuments\System_Description_NEMP_RS105_V18.doc

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

montena

1. RS105 test system description

Montena's NEMP test system is designed to perform RS105 tests according MIL-STD 461, both E and F versions.

The test setup comprises following elements.

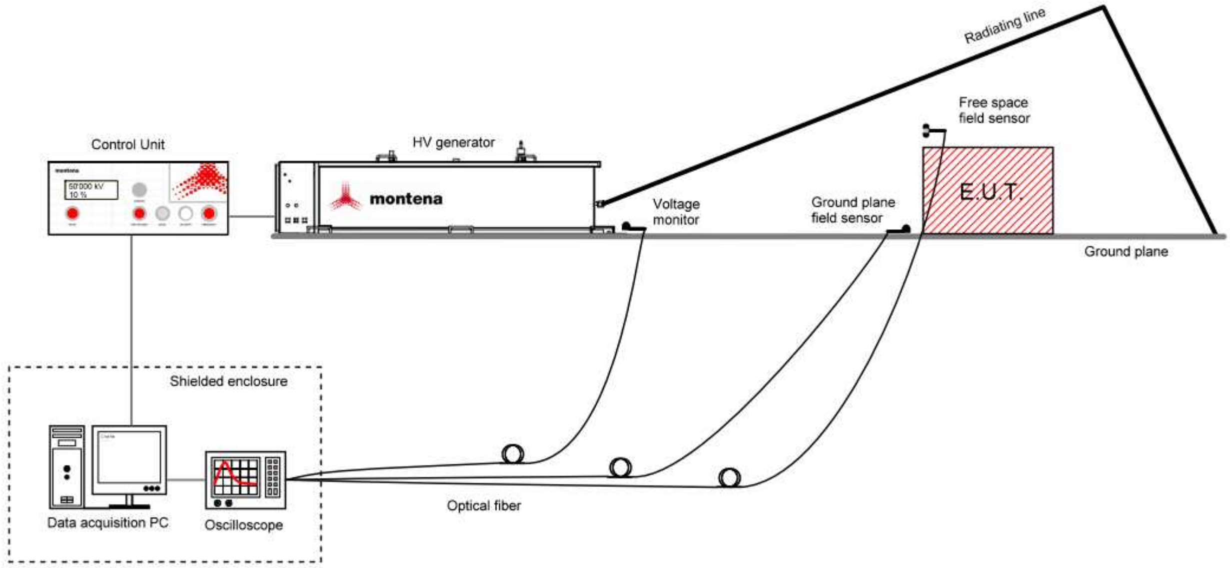


Figure 1 : schematic of a typical RS105 test setup installation

The HV generator delivers the high voltage pulse to a transmission line mounted on a metallic ground floor. The line termination load absorbs the pulse and avoids reflexions. A control unit monitors the HV generator and triggers the pulse generation. Different types of sensors are used to monitor the generated electric & magnetic fields as well as the generator output pulse voltage and shape.

An oscilloscope collects the measurements from the field and voltage sensors for display and eventually storage in the control PC. In order to ensure correct measurement the oscilloscope has to be placed in a shielded enclosure, protecting it from the strong E-field pulse.

Other accessories as LISN or TPDs can be required but are not shown in the above drawing.

The system can be mounted indoor or outdoor. The smallest versions of montena NEMP test systems are not designed to be installed permanently outdoor. However, the installation can stay outside if the weather conditions are good.

Pulse shapes

Montena's NEMP test installation is able to perform RS105 tests according the MIL-STD 461, both E and F versions.

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

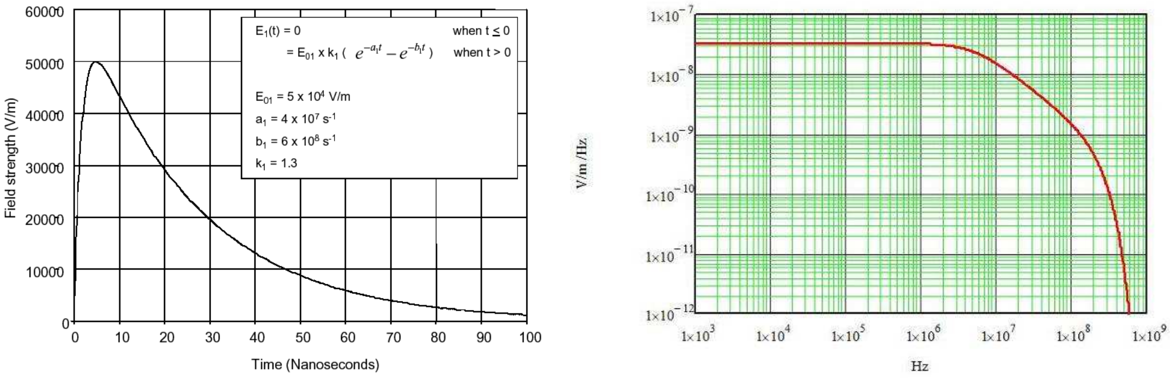


Figure 2 : MIL-STD-461E&F RS105 pulse shape and spectrum

- The rise time is between 1.8 ns and 2.8 ns. The electric field must be continuously increasing during this part of the pulse.
- The full width half maximum (FWHM) pulse width must be between 18 and 28 ns.

Note: the generator delivers a pulse with positive polarity. A negative polarity field pulse can be simulated by placing the EUT upside down. Optionally montena can build customized generators for both positive and negative polarities.

Clearing distances

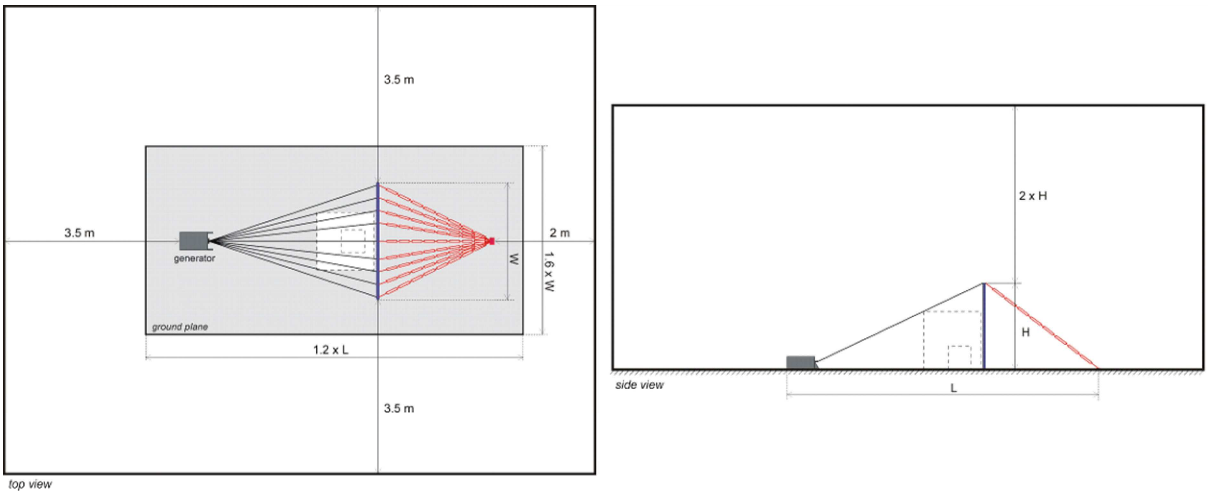


Figure 3 : minimum recommended clearance distances

The transmission line can be influenced by metallic structures placed in the vicinity. A shielded room, a metallic room or electrical cables are concerned. An anechoic room covered with absorbers can also add distortion on the pulse inside the transmission line. This is due to the fact that the lowest resonance frequencies of an anechoic chamber are lower than the low frequency limit of efficiency of the absorbers. As an example for a 14 x 9 x 6 meter anechoic chamber, the lowest frequency resonance is about 20 MHz. At this frequency the absorbers are completely transparent and the chamber is fully resonant.

As the pulse can be more or less distorted by reflection due to metallic structures in the vicinity the best solutions are to install the transmission line either in a wooden building or on an open area test site.

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

2. Radiating line

The transmission line radiates the field on the equipment under test (EUT). The line must be optimised for good waveform fidelity and therefore must have low reflection at the end of the structure formed by a resistive load adapted to the generator impedance.

The radiating line is made of multiple copper wires terminated with distributed load resistances. The lines are hold mounted on plastic poles. The radiating line has to be installed on the floor, on a metallic ground plane.

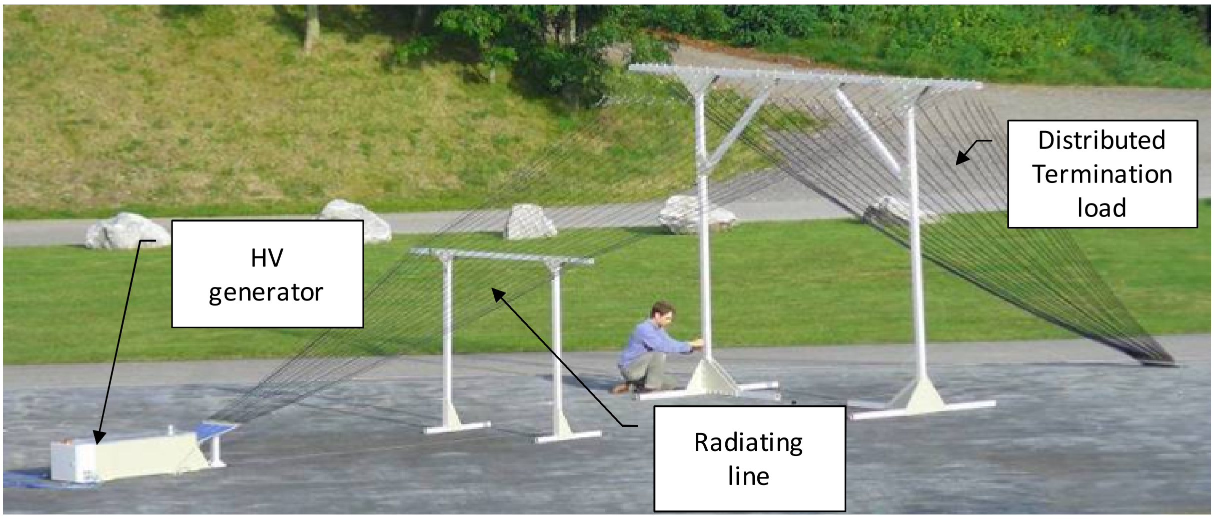


Figure 4 : example of a transmission line for an EUT of max. 0.75 x 0.75 x 1.5 m (W x H x L)

Triangular transmission line vs. parallel plate structure

The standard RS105 proposes a transmission line that is a parallel plate structure. After having done simulations and experiments we have found that a triangular radiation line provides better pulse shape with fewer distortions generated from the different reflexions.

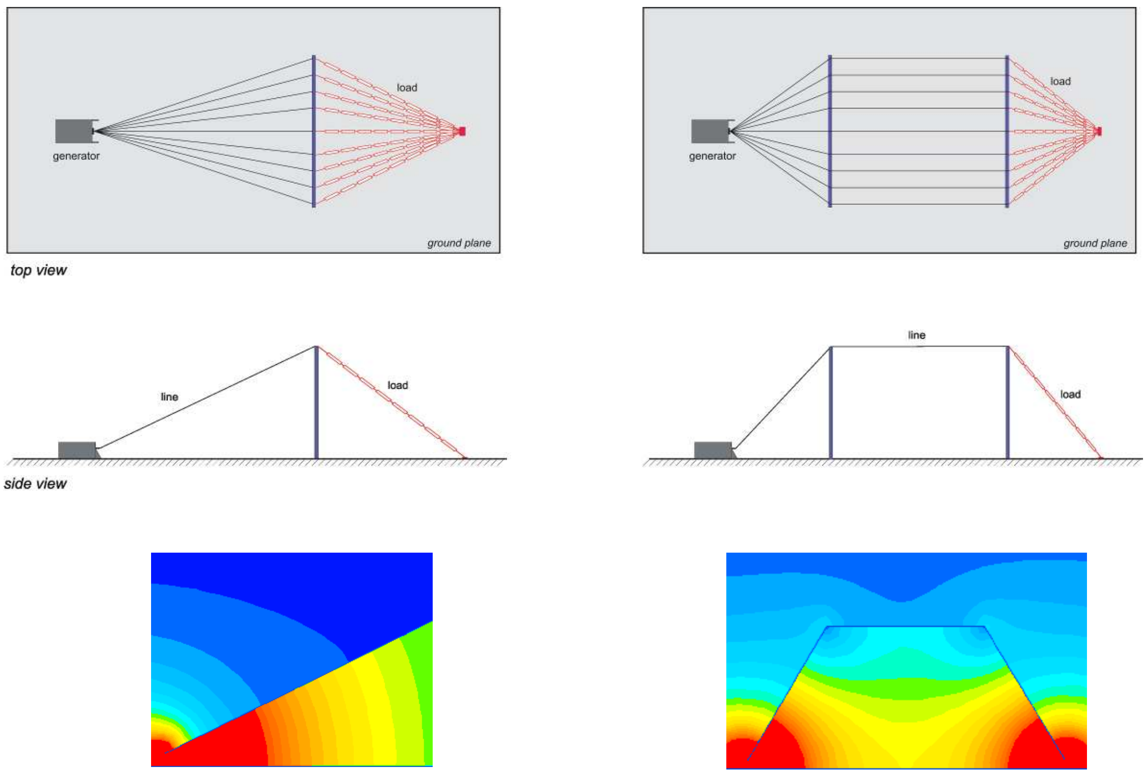
In the triangular radiation line, the pulse produced by the HV generator is transformed into a TEM[1] electromagnetic field travelling in the direction of the load. Because there is no discontinuity along the line, no other electromagnetic modes than TEM are exited. Only the construction of the load induces some reflections. In the parallel plate, the wave is travelling up to the transition placed between the slope (triangular part) and the flat part. In this region other modes than TEM are produced that induce reflections and field distortions. The process is repeated at the end of the flat part, and finally the termination load influences also the reflection.

The field homogeneity is theoretically better for the parallel plate antenna. But with a good design the field homogeneity given in the RS105 standard can be fulfilled without problem.

[1] TEM: Transverse ElectroMagnetic

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com



Radiation line (triangular line) *Parallel plate structure*

Figure 5 : triangular line vs. parallel plate structure

The design of the overall shape of the line is a compromise between the low reflection and the compactness.

Field uniformity

The electric field is mainly vertically polarized. The field distribution under the line is shown in the figure below.

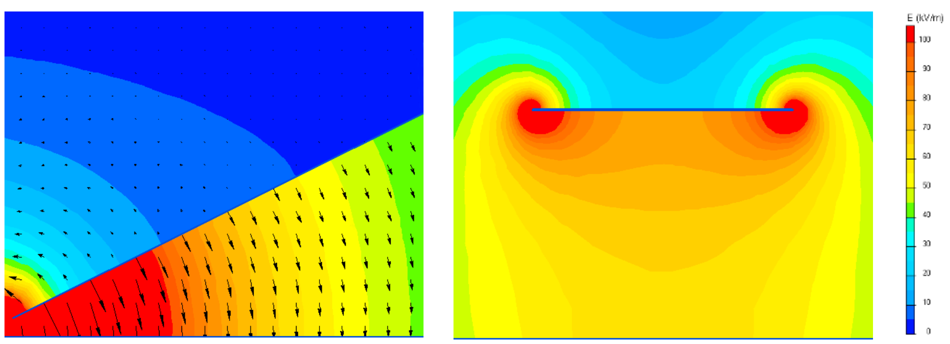


Figure 6 : triangular line vs. parallel plate structure

montena

3. HV generator and control unit

3.1 HV generator

Most of montena's HV NEMP generators are built around a Marx generator and the triggering is made by controlling the Nitrogen pressure in sparking gaps. A peaking circuit is possibly used to ensure a very short pulse rise time.

Figure 7 : example of a 360 kV HV generator

3.2 Control unit

The remote control unit is connected to the HV generator and provide following features:

- Indication and setting of the HV charging voltage
- Indication and setting of the nitrogen pressures controlling the pulse triggering
- Interlock circuit allowing the connection of external safety features (as door switches)
- Provide an RS232 and USB interface for remote control

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

4. System monitoring

Different field monitors are required or can optionally be used to measure the electromagnetic pulse.

4.1 Ground plane field monitors

Ground plane field monitors are made of derivative field sensors directly placed on the ground plane and are connected to the oscilloscope through coaxial cables and passive integrators. Even though a measurement with a numerical integration is also possible, we recommend using the provided passive integrator.

For distance above 15 m, a fibre optic link is required (see other accessories below).

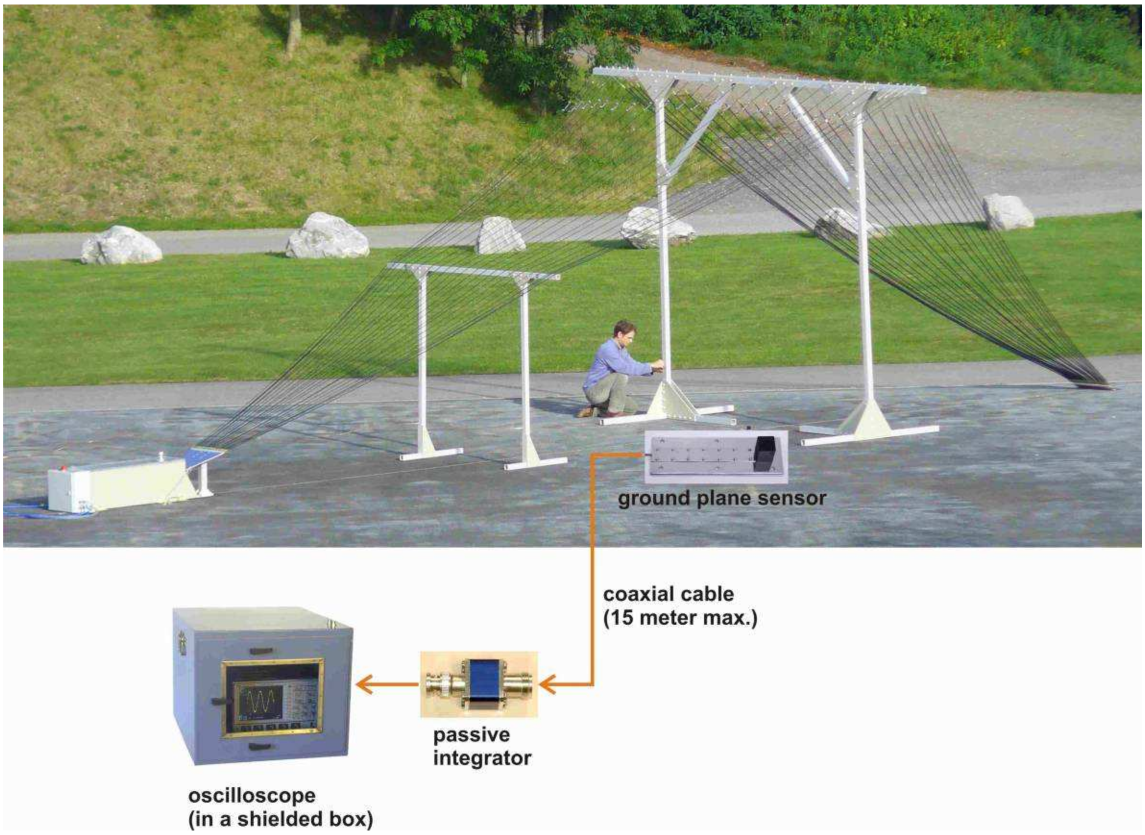


Figure 8 : Ground plane field sensor setup

Ground plane electrical field monitor

The ground plane E-field monitor is used for the measurement of the electric component of the electromagnetic field. The proposed E-field monitors comprise:

- An derivative E-field sensor (type "D-dot")
- A passive integrator
- A 10 meters semi rigid coaxial cable.

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

Ground plane magnetic field monitor

The ground plane B-field monitor is used for the measurement of the magnetic component of the electromagnetic field. The proposed B-field monitors comprise:

- An derivative B-field sensor (type "B-dot")
- A passive integrator
- A 10 meters semi rigid coaxial cable.

The magnetic field can be calculated from the electric field by dividing it by the impedance of the vacuum (377 ohm) because the structure propagates in a TEM mode. If the reflection at the end of the line is limited, the waveform of the magnetic field is the same than the waveform of the electric field. Additionally the standard does not require any waveform of the magnetic component. Therefore only an electric field sensor could be sufficient for an installation for which the budget is limited.

4.2 Free field monitors

Free field monitors are made of derivative free field sensors which can be place anywhere under the transmission line and are connected to the oscilloscope through optical fibres and passive integrators. We recommend using the provided passive integrator, but a measurement with a numerical integration is also possible.

Unlike to the ground plane sensors where the coaxial cable is directly laid on the ground floor, the free field sensor has to be connected using a fibre optic link.

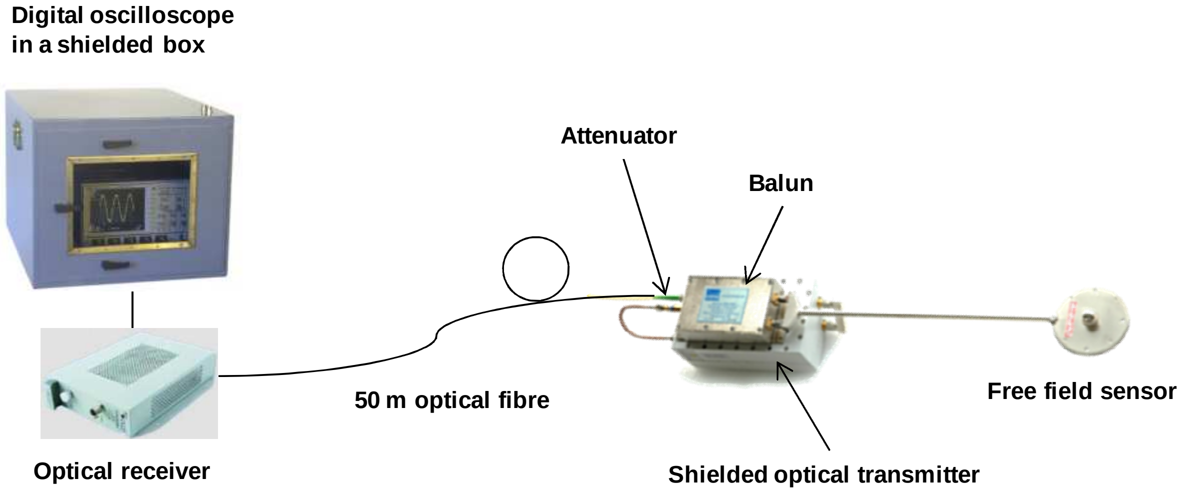


Figure 9 : free field sensor setup

The MIL-STD 461 requires multiple field measurement positions in the test volume it is assumed that a free field sensor is needed. Actually the field waveform is the same in the whole test volume. Additionally the distribution of the field can be well calculated. Therefore only a ground plane sensor could be sufficient for an installation for which the budget is limited

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

Free field electrical field monitor

The free field E-field monitor is used for the measurement of the electric component of the electromagnetic field. The proposed E-field monitors comprise:

- An derivative E-field sensor (type "D-dot")
- A balun with an attenuator
- An optical transmission link.

Free field magnetic field monitor

The free field B-field monitor is used for the measurement of the magnetic component of the electromagnetic field. The proposed B-field monitors comprise:

- An derivative B-field sensor (type "B-dot")
- A balun with an attenuator
- An optical transmission link.

The magnetic field can be calculated from the electric field by dividing it by the impedance of the vacuum (377 ohm) because the structure propagates in a TEM mode. If the reflection at the end of the line is limited, the waveform of the magnetic field is the same than the waveform of the electric field. Additionally the standard does not require any waveform of the magnetic component. Therefore only an electric field sensor could be sufficient for an installation for which the budget is limited.

4.3 Voltage monitor

The high voltage probe is intended to measure the pulse produced at the output of the generator. No resistive voltage probe with sufficient RF performances is available from the market. High speed capacitive dividers are used instead of them.

The voltage monitor is placed at the output of the HV generator and allows precise measurement of the pulse voltage and shape, independently of the EUT placed under the radiating line.

The voltage monitor comprises a derivative voltage sensor, a passive integrator and a coaxial cable.

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

5. Other measurement systems & accessories

5.1 Oscilloscope and shielded enclosure

The oscilloscope is used to measure the voltage and the field produced by the test installation. The requirement of a minimum 500 MHz bandwidth is well adapted to this type of pulse and we recommend a sampling rate of min. 5 Gsa/s.

The passive integrators of the field probes require high impedance oscilloscope inputs. The quality of the high impedance input must be carefully analysed before purchasing the oscilloscope.

See also paragraph 11 of the technical note TN07-11.

To ensure a correct measurement, the oscilloscope has to be placed in a shielded enclosure, or shielded room.

The SB3G shielded enclosure is intended for the protection of the oscilloscope and accessories in the frequency range of 10 kHz to 3 GHz.

The dimensions of the SB3G shielded enclosure are: 61 x 52 x 73 cm.

5.2 Optical link

An optical link is required for to connect the free field sensors to the passive integrator and oscilloscope. Characteristics of the proposed optical links are:

- One shielded TX module and one RX module for one analogue channel
- 50 ohm, < 200 Hz - > 3.2 GHz
- 50 m fibre optic length.

5.3 LISN

The LISNs (Line Impedance Stabilisation Network) are used to provide standardised impedance in common mode to the lines connected to the EUT. This allows a better reproducibility of the tests.

The LISN50-25 fulfils the MIL-STD 461 D,E and F requirements

- 50 Ω // 50 µH
- 1 x 25 A
- 230 Vac (50/60 Hz) - 115 Vac (400 Hz)

5.4 Terminal protection devices (TPD)

The cabling of the EUT going outside the test installation could drive disturbance at quite long distance. Therefore the installation of the terminal protection devices (TPD) is recommended. This device is intended to block the disturbance. It consists of a filter generally built with a capacitance to ground. The internal construction must be adapted to the type of signal or power to filter.

We suggest combined devices which integrate LISNs and TPDs in the same box allowing an easier connection

The LISN - TPD100 fulfils the MIL-STD 461 D,E and F requirements. Is consists of LISN 100 A / 270 Vac 50/60 Hz with a TPD (terminal protection device) of 100 A integrated inside the LISN and with a 20 meter shielded cable 3 x 100 A.

- 50 Ω // 50 µH
- 1 x 25 A
- 230 Vac (50/60 Hz) - 115 Vac (400 Hz).

5.5 Additional housing with heating

An optional insulating box can be placed on the generator housing without needing to dismount it. The heating will be regulated with an adjustable thermostat and a safety thermostat is also included in the circuit. The power is 110-230 V / 300 W.

The housing can be easily removed from the generator in summer. No electronic circuit is present in the insulating box to avoid disturbances..

5.6 Material for the ground plane

If the site does not include a metallic ground plane, a special metallic mesh and the related assembly material can be proposed to build the ground floor.

6. Services

6.1 Onsite installation and training

Montena provides onsite installation and training performed by either an engineer from montena or by a local authorized representative support engineer with help of skilled and unskilled workmen provided by the customer.

Usually site preparation works have to be organized by the customer in coordination with montena. This site preparation work must be of good quality, must fulfil montena's requirements, and must be completely finished before the beginning of the installation by montena.

A training session is usually given directly after installation. This training includes the both the test system operation and maintenance.

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

6.2 System acceptance

The RS105 test setup acceptance procedure is performed with a verification of the generated field based on:

- A typical calibration of a similar test setup made at factory,
- A measurement of the generated field pulse at ground level (with ground field sensor)
- A comparison with the typical calibration results at ground level.

6.3 Onsite calibration

Optionally montena can provide an onsite calibration of the installed RS105 test setup. This calibration measures and validates the generated field pulse according to the definition of the MIL-Std 461, RS105.

A calibration report is delivered.

6.4 Maintenance

No periodical maintenance is required other than calibration of the measurement equipment.

On customer request montena can offer this calibration service with support of montena's authorized local representative.

7. Safety

7.1 High voltage

The control unit provides an input to connect safety equipment as door switches, etc.

Additionally the generator and the control unit have emergency security buttons.

7.2 Electromagnetic emissions

The note 5 of table 6 of the ICNIRP[2] guidelines indicates a limit for the permanent exposure to pulsed electromagnetic fields of about 2 kV/m. The example given below shows the distribution of the field in the vicinity of a 1.8m high transmission line in open area test site conditions. The 2 kV/m limit is reached at around 7 meters away from the line centre. The calculation of the safe distance for other heights of the line can be made linearly from this example.

---

[2] *ICNIRP: International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).*

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

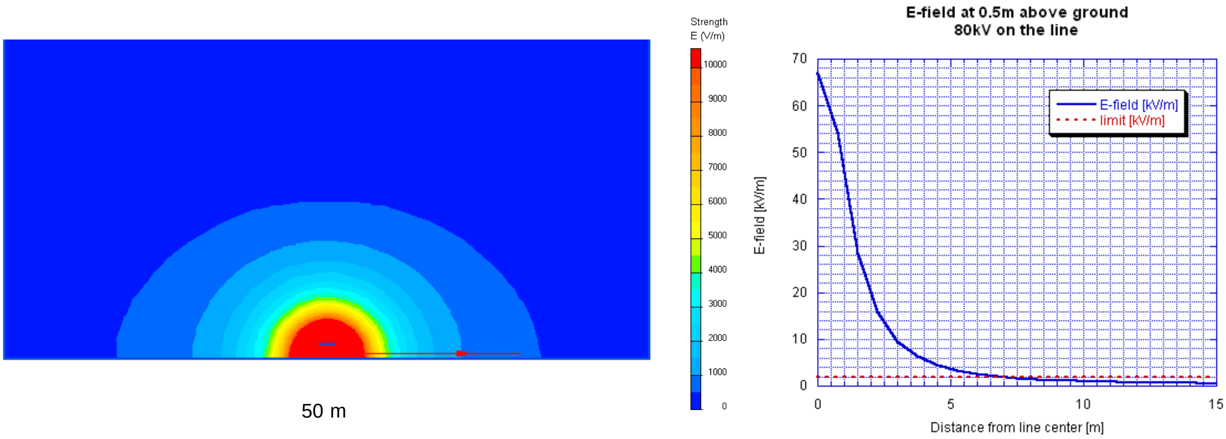


Figure 10 : electromagnetic emissions

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com

montena

8. Montena

Montena has been incorporated in 1903 as a capacitor manufacturing company.

In 1978, the montena EMC division was created to address the arising EMC related problems. Since then montena has earned a worldwide reputation for its leading-edge skills in the fields of high voltage, high frequency and electromagnetic fields.

Montena can count on highly specialized know-how in the field of the electromagnetic compatibility. These skills are put to good use in the development and construction of various kinds of equipment, especially EMC test equipment and fast electrical pulse generator.

Montena designs, builds and markets equipment and accessories for EMC tests. The range of products includes antennas, TEM cells, striplines, field sensors, all kind of pulse generators, test benches, etc.

Montena's high voltage pulse generators are mainly used for EMC tests, high speed imaging and pulsed light decontamination. Montena also builds pulse generators according the custom specific needs.

8.1 MIL STD Systems references

Montena has sold and installed more than 20 NEMP simulators according to MIL STD 461, RS105 worldwide in the last 5 years.

The list below shows some references of test systems according to MIL STD 461, MIL STD 188-125 and other military standards.

Marx pulse generator 320 kV, rise time 5 ns / duration 80 ns with control unit
for NEMP test according to MIL STD 461 / RS105

NEMP test system according to MIL STD 461E - RS105 loading voltage 80 kV
rise time 2.3 ns / duration 23 ns
with 1.8 m high radiation line

NEMP test system according to MIL STD 461E - RS105
Marx pulse generator 120 kV, rise time 2.3 ns / duration 23 ns
with 2.7 m high radiation line

NEMP test system according to MIL STD 461E - RS105
Marx pulse generator 230 kV, rise time 2.3 ns / duration 23 ns
with 3.6 m high radiation line

NEMP test radiation for tests according to MIL STD 461E - RS105
Marx pulse generator 800 kV, rise time 2.3 ns / duration 23 ns
with 9 m high radiation line

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79
www.montena.com e-mail: products@montena.com

NEMP test system according to MIL STD 461E - RS105

Loading voltage 75 kV

rise time 2.3 ns / duration 23 ns

connected to a GTEM, 1m septum height

HV pulse generator 12kV, rise time 5 ns / duration 200 ns

High voltage pulse generator 80kV, rise time 5 ns / duration 500 ns

for Pulse Current Injection (PCI) test according to MIL STD 188/125, appendix B (short pulse)

Marx pulse generator 350 kV, rise time 5 ns / duration 500 ns with control unit

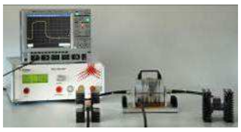
for Pulse Current Injection according to MIL STD 188/125, short pulse

Pulse generator 3 kV, rise time 0.6 µs / duration 3.4 ms

for Pulse Current Injection according to MIL STD 188/125, intermediate pulse

Variable pulse length generator 25 kV, rise time < 5 ns

for Pulse Current Injection test according to MIL STD 188/125

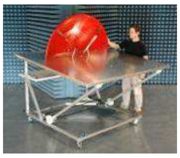


Square pulse generator

for immunity test according to MIL STD 461 / CS115

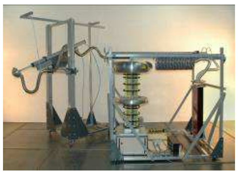
Damped Sinusoidal pulse generator

for immunity test according to MIL STD 461 / CS116



HIRA antenna

Half impulse radiating antenna for the generation UWB E-field pulses (Ultra Wide Band pulses with sub nanosecond pulse duration)



ESD 300kV and P-static test system for helicopter and airborne systems

montena technology sa - 1728 Rossens - Switzerland - phone +41 26 411 84 84 - fax +41 26 411 17 79

www.montena.com e-mail: products@montena.com