VIG 3

Measurement System for the Shielding Effectiveness of Faraday Cages

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General Brochure

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This document has 11 pages.

TABLE OF CONTENTS

1. Introduction to the VIG 3

1.1 What is the VIG 3 ?

The VIG 3 is the name of a principle and a technology for high performance measurement systems for the shielding effectiveness of Faraday cages or shielded enclosures. The VIG 3 can be applied to continuous or periodical monitoring of shielded rooms, or to acceptance tests.

The VIG 3 is protected by a patent applied for by Excem in 1991. The VIG 3 takes advantage of our experience in the design an manufacturing of the VIG 2 during the years 1989-1991. The VIG 3 is very similar to the original VIG 2, but the analog signal processing has been replaced by digital signal processing, thus offering improved selectivity and accuracy, and also a faster response.

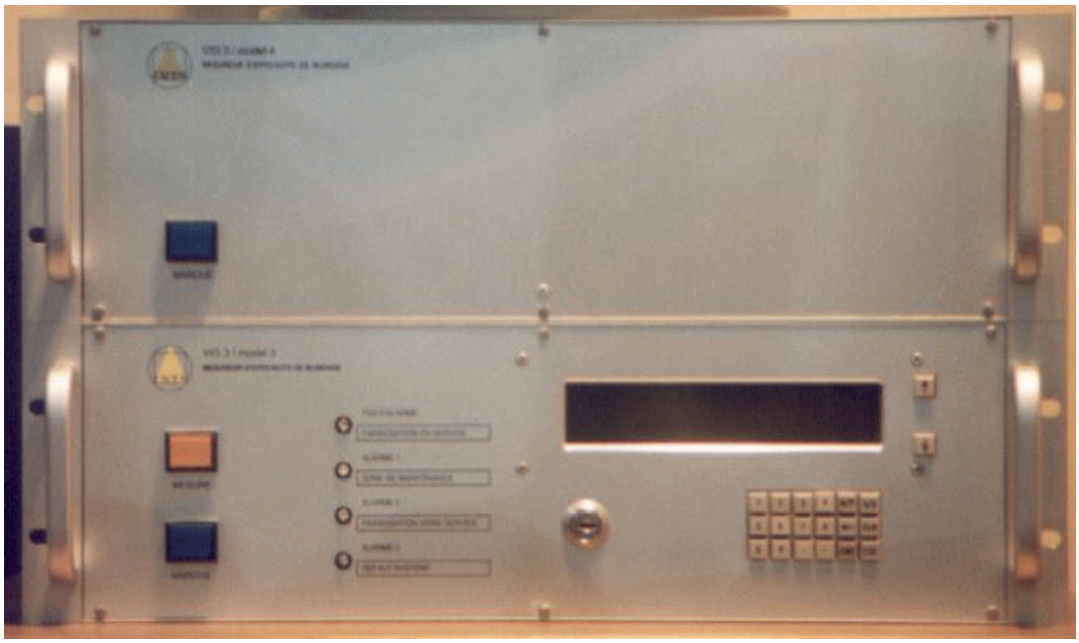

Fig 1: a VIG 3 transmitter (top) and a VIG 3 receiver.

1.2 Applications

Equipments realized according to the VIG 3 technology may be used in all applications requiring acceptance tests or the monitoring of the shielding effectiveness of a Faraday cage. The VIG 3 is the first choice when the measurement should be continuous. Example of possible applications are:

- Acceptance tests and monitoring of rooms for the protection of confidential informations (TEMPEST requirements).
- Acceptance tests and monitoring of equipments for the protection against external electromagnetic threats: high intensity radiated fields (HIRF) due to close powerful transmitter or electromagnetic weapons, LEMP (Lightning ElectroMagnetic Pulse), NEMP (Nuclear Electro-Magnetic Pulse).

- Measurement of very high shielding effectiveness in the laboratory.
- Measurement of shielding effectiveness with very small antennas, and non disturbing electromagnetic fields.
- Measurement of shielding effectiveness with the phase of the transmittance.

1.3 Advantages of the VIG 3 shielding effectiveness measurement systems

The VIG 3 technology features the following capabilities:

- Narrow bandwidth: below 0,01 Hz.
- Spread spectrum emission for a reduced averaged radiated power spectral density.
- Unprecedented sensitivity: the VIG 3 includes a digital vector synchronous detector, and uses several transmission channels on a fiber optic link. This system allows a sensitivity much higher than other existing systems.
- Reduced cost: our VIG 3 technology, though innovative and advanced, makes the manufacturing of the equipment very cheap, because much wider tolerances are allowed on most critical components.
- Simple maintenance.
- Possibility of implementing continuous measurements: thanks to its very high sensitivity, the VIG 3 can be programmed by the user in such a way that it will not significantly disturb the electromagnetic environment. Continuous measurements become therefore possible without risks of interference.

1.4 Available VIG 3 measurement systems

Several types of VIG 2 and VIG 3 systems were delivered during the late 80s and early 90s to various administrations.

However, some of the devices used in these designs are no longer available and the parts we have in stock are for maintenance only. Also, the customers for VIG 2/VIG 3 own the design of some features of the specific equipment they have purchased. Finally each customer had his special specifications for spectrum use and EMC requirement. For these reasons the L2G is not available as a product for new customers at the date of this document.

Today the VIG 3 is available on-demand, not as a off the shelve product. For new orders, it needs to be customized. For this reason this document does not give detailed characteristics of existing equipment such as those shown on fig. 1.

2. Principle of the VIG 3

A shielding effectiveness measurement system implementing the VIG 3 technology (see fig. 2) is made of two separarate sub-systems:

■ A transmitter sub-system (1) + (2):
This sub-system produces narrow-band radiated signals (or wide-band signals in the case of the spread spectrum mode) in at least one frequency band. These signals propagate through the shielded enclosure under test (6), and are detected by the receiver sub-system.

■ A receiver sub-system (3) + (4):
The receiver sub-system is connected to the transmitter sub-system via a fiber optic link (5) with several transmission channels. The amplitude of the radiated signal measured by the receiver sub-system characterises the performances of the screened room under test (6).

On fig. 1 the transmitter sub-system is installed inside the Faraday cage under test, whereas the receiver sub-system stands outside. Of course, the reverse set-up is also possible. The choice of the set-up must be made according to the operational requirements and the electromagnetic environnement. More details on this matter are included in the next clauses.

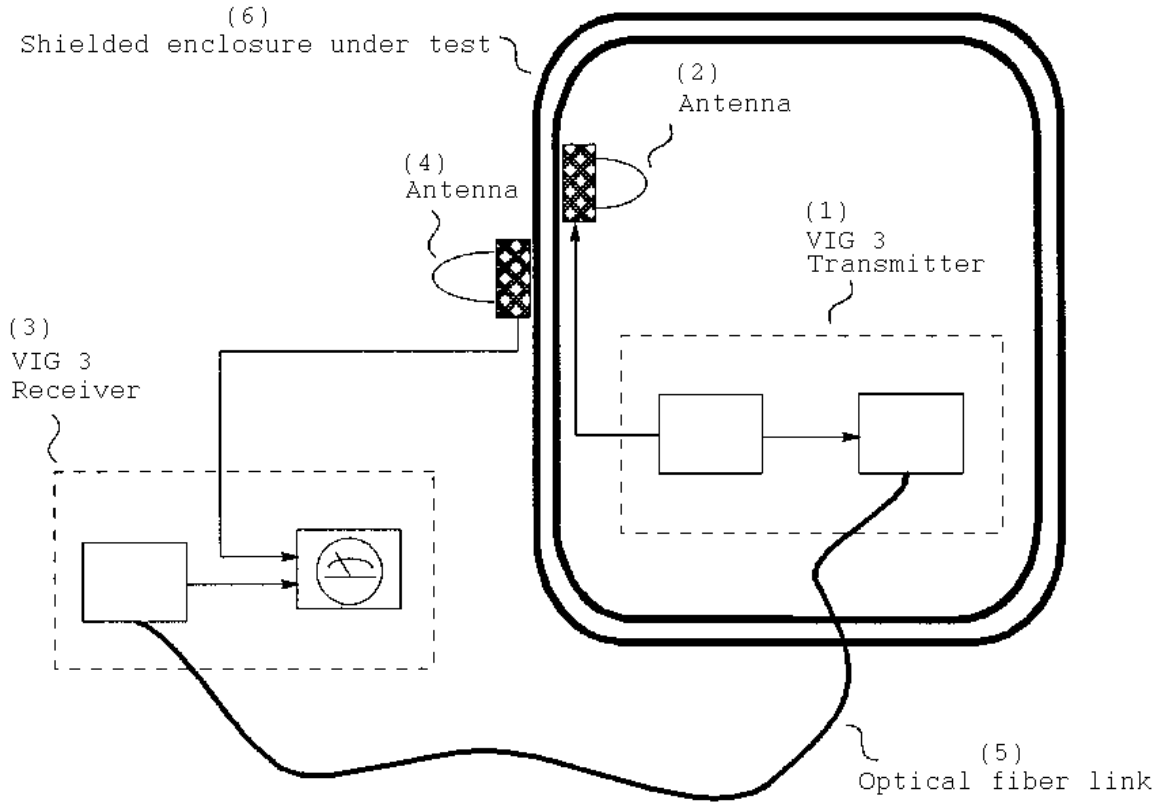

Fig. 2: the principle of the VIG 3

3. Acceptance tests and monitoring tests

3.1 Acceptance tests

We will distinguish between measurements intended as acceptance test for the shielding effectiveness of a shielded enclosure, and measurements intended for monitoring tests.

Usual shielding effectiveness requirements for acceptance tests of shielded enclosures include the use of an extensive number of measurement frequencies. Also, an accurate test plan has to be followed whith regard to the setup of antennas inside and outside the shielded enclosure. Such requirements can be found in U.S. standards such as MIL-STD-285, NSA 65-6, or the french military standard GAM-T-20.

Most acceptance tests require that the antennas (of specified characteristics), usually cumbersome, be installed at one spot of the Faraday cage, and that the measurement be repeated at many other places, in order to obtain different transmission loss values. Several antenna orientation must often be used, and measurement must be done at several frequencies (requiring some change of antenna). It is normally required that those measurements be made with an empty shielded room. For these reasons, acceptance tests of shielded enclosures are lengthy and expensive, and are only implemented once in the enclosure's lifetime.

Measurement system according to the VIG 3 technology have been built for measurements up to 500 MHz, and could implement a sufficient number of measurement frequencies for acceptance tests below 500 MHz. Fig. 3 shows the setup when the VIG 3 is used for acceptance tests of a shielded enclosure.

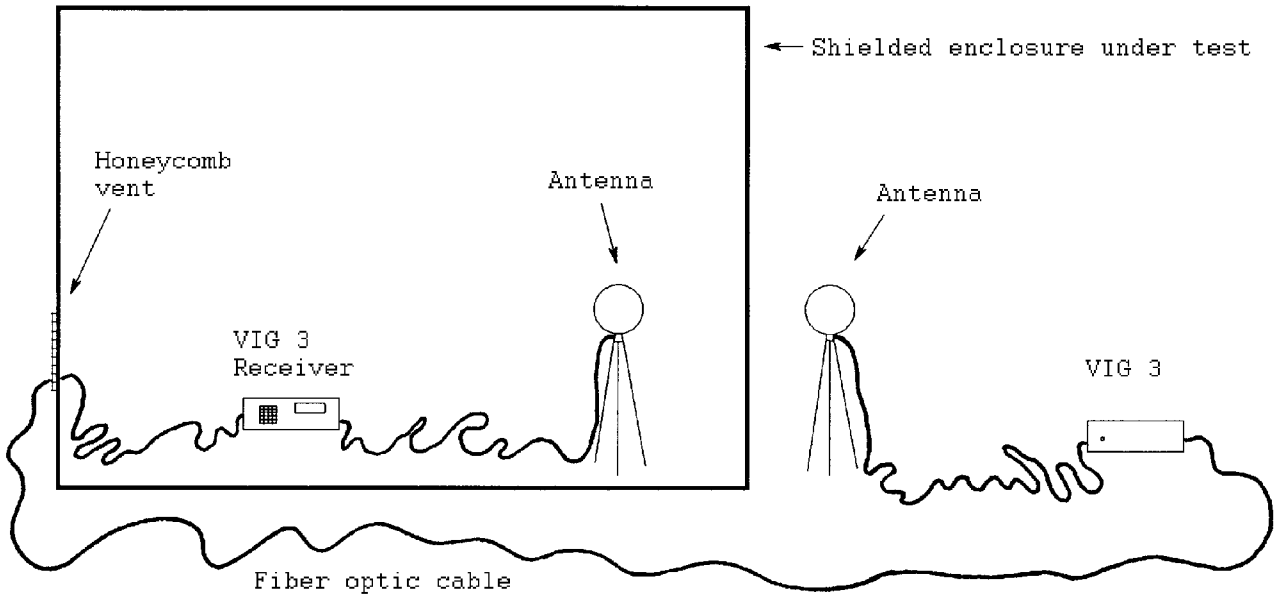

Fig. 3: test setup for acceptance tests

3.2 Monitoring tests

Acceptance tests are time-consuming, and it is therefore desirable to be able to make simpler measurements for detecting possible degradations of the shielding effectiveness performances of a Faraday cage. Such a procedure, intended as a monitoring test may use a limited number of frequencies, and also a limited number of antenna positions and polarizations. In order to guarantee a good reproducibility of the measurements, it becomes important to have an automated process, and to use only fixed antennas of small dimensions.

The monitoring process could be continuous: sudden degradation such as those produced by the opening of a door, or the introduction of a length of wire in a wave guide or a honeycomb vent would then be immediately detected. It is also possible to implement the control process only once in a while, in such a way that (for instance) no personnal be in the Faraday cage or in its vicinity when measurements are performed (in which case measurement accuracy may be improved). A VIG 3 shielding monitoring system is shown on fig. 4. The system includes antenna switching units for entirely automatic measurements.

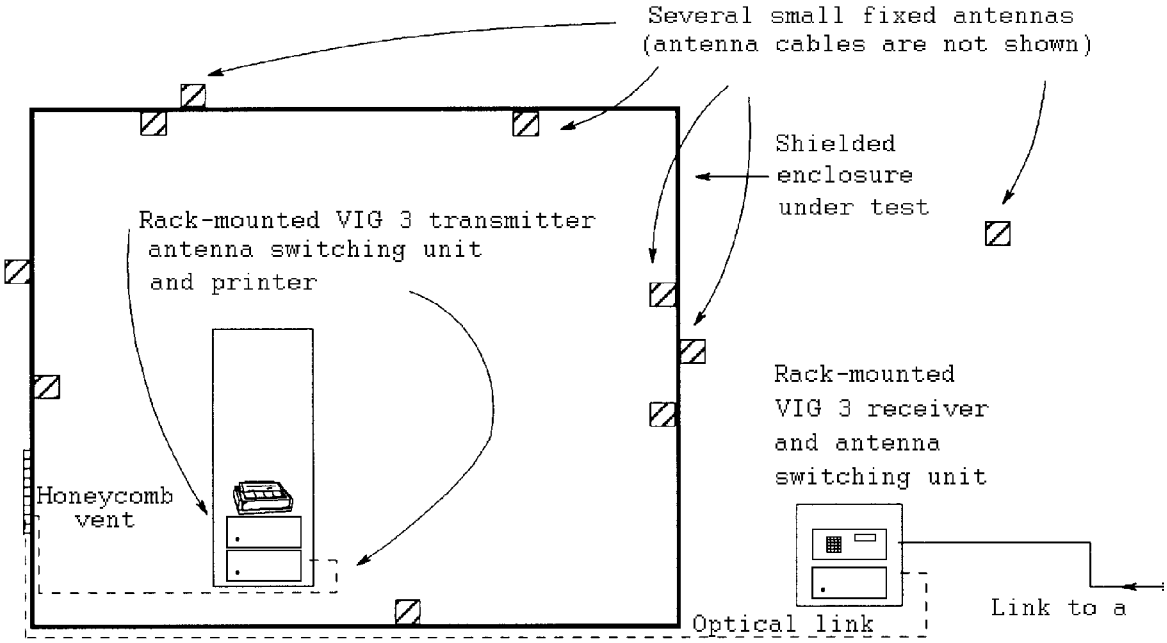

Fig. 4: a VIG 3 sytem for screened room monitoring

It must be recalled that because of the laws of electromagnetism, measurements made according to two different measurement procedures give different results. It is even possible that two teams performing an acceptance test do not come up with the same shielding effectiveness values, when measuring the same shielded room the same day: a possible cause for this may be that the antenna are not installed at the same spots or with the same polarizations. Measurement made according to fig 3 and fig. 4 will therefore not give exactly the same result. However, the practice shows that, when performed in an appropriate manner, both types of measurements can be correlated.

Moreover, if one chooses to use fixed antennas, the results of two different monitoring tests can effectively be compared, and one may in this manner assess accurately the degradation of performances of the Faraday cage under test.

Let us insist on the fact that the control is the most effective and the most reliable when it is performed by an automated system installed permanently in the Faraday cage, because:

- antennas are not moved between two measurements, and measurements are therefore made in the same conditions.
- measurements may be automatically performed on a periodical basis, or continuously, for increased efficiency.
- alarms can be triggered in the case of a degradation appearing suddenly (apparition of a crack, opening of a door, sabotage).

In some cases, it is also relevant to connect the VIG 3 to current clamps instead of antennas, or in addition to antennas, in order to be able to assess the attenuation of common-mode current through the screened room.

VIG 3 systems have proved that they have unique characteristics which make them the ideal equipment for control tests of Faraday cages: their sensitivity and selectivity allow measurements in electromagnetically noisy environments, with small antennas, relatively far apart one of each other. Moreover these equipments are able to memorize complex control procedures, and to perform the necessary operations: changes of frequency, changes of transmission power, switching of antennas, etc.

4. Implementation of a VIG 3 monitoring system

4.1 The most critical questions to be answered

When designing a shielding effectiveness measurement system for your application three technical questions should be answered:

- which structure should one use (receiver inside or receiver outside the screened room).
- which frequencies for the measurements.
- how many antennas, where should the antennas be installed, with which polarisation.

These questions are discussed in the following paragraphs, in order to help you to select the optimum set-up.

4.2 Installing the receiver inside or outside the shielded room?

The VIG 3 technology is designed for measuring and controlling the shielding effectiveness of a screened room under test (SUT). It offers unprecedented sensitivity and immunity to external disturbances. Up to now, due to the limitations of the available instrumentation, the measurement of shielding attenuations exceeding 100 dB required in most cases:

(1) to use the receiver and the receiving antenna inside the SUT, in order to avoid that the measurement be corrupted by external disturbances.
(2) to use large antennas installed nearby each other and on both sides of an area "under test" of the shielded enclosure, and to perform measurement at different frequencies and for both polarizations, then to move the antennas to another area, etc...

In replacement of the techniques (2), it was sometimes suggested to wrap the internal and the external surfaces of the screened room with two leaky coaxial cables, but this techniques has many drawbacks, including a higher cost.

In order to satisfy the requirement (1), a monitoring system would radiate outside the SUT (continuously or not), and measurement would be legal only at frequencies for which the emission is permitted (through a general permit or a special licence). The requirement (2) implies that an automated monitoring system would be very expensive, space-consuming, and in most cases altogether impossible to implement.

Of course, a system making use of the VIG 3 technology can be used in a conventionnal way such as the one discussed above. However, thanks to outstanding selectivity and sensitivity, it can also be used with the receiver and receiving antenna outside the SUT, and the transmitter and transmitting antenna inside. The power of the transmitter can be reduced at such a value that:
(4) the other equipments inside the SUT won't be disturbed;
(5) the radiation outside the SUT will allways remain within legal limits (a feedback from the receiver may be selected, so that when the fields are too high outside the SUT, the transmitter power is further reduced);
(6) small antennas can be used, in a limited number, appropriate for the size of the SUT.

Therefore, one can state that the VIG 3 technology makes automatic monitoring of the shielding attenuation of screened room possible and desirable.

4.3 Defining the measurement frequencies: legal aspect

Once connected to an antenna, the transmitter of a VIG 3 system will radiate at frequencies where emission may be forbidden (according to the frequencies that you choose) above a certain level defined in applicable regulations and standards. The user will therefore have to satisfy one of the following requirements:

- to install all antennas connected to the transmitter inside a Faraday cage, thus providing a substantial shielding, in such a way that the radiated fields do not exceed allowed levels. This condition is automatically fulfilled if it was decided to install the transmitter and its transmitting antenna inside the shielded enclosure under test (like the set-up of fig. 4),
- or to obtain a frequencies allocation from the competent authorities in your country, for operating the transmitter and its antennas outside the shielded room,
- or to select frequencies where radiated emission is allowed without permit in your country. The so-called ISM frequencies are usually available for this purpose.

The use of a spread-spectrum techniques (optional in VIG 3) may also help to reduce the probability of interference.

4.4 Defining the measurement frequencies: technical aspect

For acceptance tests, the frequencies to be used are usually imposed by the standard that you want to implement.

For monitoring applications, a more limited number of measurement frequencies might be suitable:

- a measurement at relatively low frequency, around 50 kHz to 200 kHz, with magnetic fields (loop antenna) is useful for a good estimate of the effect of a possible superficial oxydation on the door contacts. A given antenna will only monitor a limited surface around the antenna, because of the $1/r^3$ decrease of the near field. The result of the measurement is independant of the presence of people in the Faraday cage near the antenna.
- a measurement at a frequency between 1 MHz and 10 MHz is also useful because at these frequencies the Faraday cage is usually specified for an important attenuation, which it is useful to check..
- a measurement at a frequency between 200 MHz et 1000 MHz, is twice useful. First of all at these frequencies, localised defects are very visible (for instance a missing contact fingers). Secondly because the field intensity is relatively uniform throughout the Faraday cage, thanks to multiple reflections (provided the cage is not exceedingly absorbing). Frequencies between 800 MHz and 1000 MHz should be recommended for small Faraday cages (some cubic meters). One can advise to reduce this frequency to 200 MHz for larger enclosures. Thanks to these properties, it is possible at such frequencies to scrutinize the entire screened room with a limited number of antennas. However these measurements are strongly affected by the presence of people inside the Faraday cage, or in its vicinity.

Considerations such as those, combined to the requirements of the previous paragraph, may guide you in the choice of the measurement frequencies. However, do not hesitate to call us if you need more information.

4.5 Defining the number and the installation of antennas

Choosing an appropriate number of antennas and their positions could be the result of a thorough design of the installation. It could also be decided from experience. For the monitoring of a 30 m^2 encryption room, we for instance recommended to install inside the screened room:

a) about 6 antennas for frequencies in the 50 kHz to 10 MHz region (four near the door, one near the air conditionning vent (honeycomb), one near the input-output plate.
b) about 4 to 6 antennas for frequencies in the 200 MHz to 1000 MHz region, according to the size of the enclosure, scattered as uniformly as possible.
c) a current clamp on power cables at the output of the power filter, and other clamps on signal cables bundles (where optical links are not implemented).

One normally puts the same number of antennas inside and outside the Faraday cage.