# HEMP protection means for civilian critical infrastructure

## SHORT CATALOGUE

2023

**Enough talk about EMP!**
**It's time to act!**

**Periculum in mora!**

# HEMP Protection Means for Civilian Critical Infrastructure

# SHORT CATALOGUE

A nuclear explosion at high altitude does not directly affect people and infrastructure, but the electromagnetic pulse resulting from such an explosion (High Altitude Electromagnetic Pulse – HEMP) disables electronic and electrical equipment over a large area.

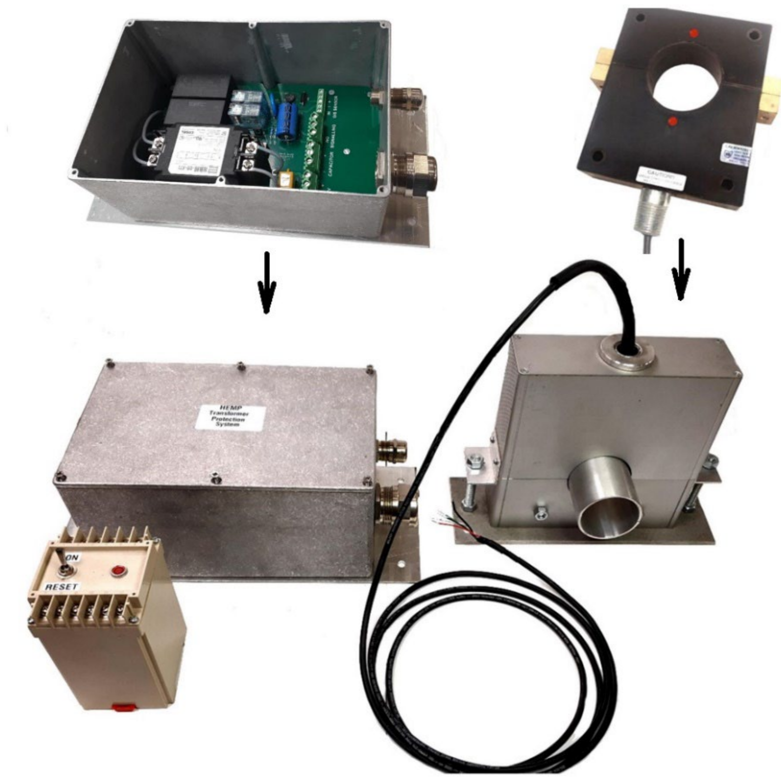
HEMP protective means, which has long been on the market, is designed to protect military equipment and facilities and is not suitable for the protection of civilian critical infrastructure. Therefore, until now, this infrastructure remains unprotected in all countries of the world without exception.

This catalog provides brief information about the first HEMP protective means designed specifically to protect civilian critical infrastructure (electrical substations, power plants, water supply systems, communication centers, banks, medical centers, etc.).

The catalog is intended for manufacturers of HEMP protective means as well as for representatives of critical civilian infrastructure.

# High Power High Voltage Transformer Protection System

Geomagnetically induced current (GIC) arising from a high-altitude nuclear explosion (component E3 of the HEMP). This is a quasi-direct current, ranging in size from several tens to several hundred Amperes, which leads to saturation of the transformer core, a sharp decrease in its impedance and unacceptable overheating. In addition, there are a bulk of harmonics in the network. These harmonics disrupt the operation of relay protection, affect capacitor batteries and other critical equipment.




The protection system consists of a protected sensor and a protected electronic unit. The sensor is mounted on the neutral conductor (ground bus) without turning it off, and the protected output of the electronic unit is connected to the transformer trip circuit. When a dangerous constant component of the current (about 20A) appears in the neutral circuit of the transformer, the electronic unit with a slight delay, which excludes false trip, gives a command to turn off the transformer. After 2-3 minutes, the flow of current in the neutral circuit from the component E3 stops and the transformer can be returned automatically to normal operation.

The system is protected against overload from short-circuit currents flowing through the neutral of the transformer.

This protection system must be installed on all transformers with a grounded neutral.

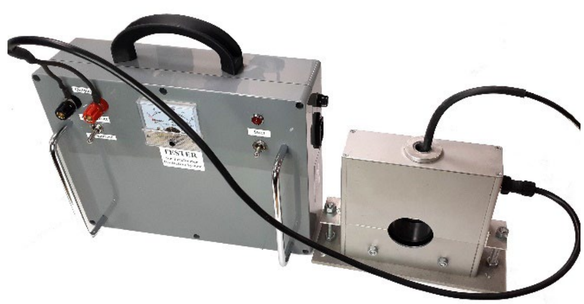
# Testers for Checking the Operability of the GIS Protection System for Power Transformers

In order to be sure of the serviceability of the protection system of the power transformer, it is necessary to systematically (once a year or once every two years) check it. This test consists of applying a DC current to the sensor of less than 20 A (the system should not trip) and a current of more than 20A (the system should be triggered).

For simple and convenient performance of such a test, special testers are designed that are connected via a small connector to the sensor of the protection system.

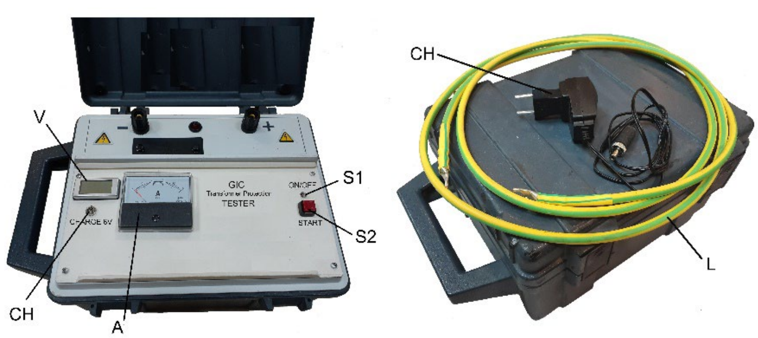
There are two variants of such testers: one with a built-in battery that does not require an external power source, and the second with power supply from an alternating current network of 127V or 220 V.

Usually, in control cabinets on large transformers there is always a standard outlet with a standard auxiliary AC voltage. For such a case, a type "A" tester is intended, which requires power from a standard AC mains.



Type “A” tester connected to sensor

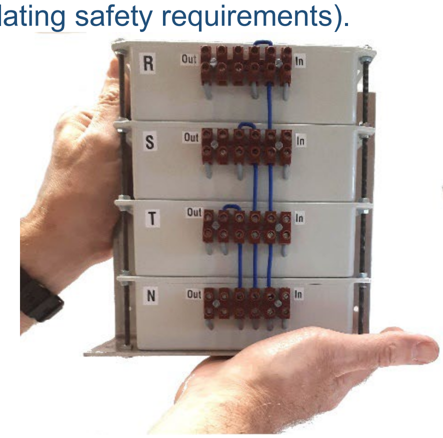
The tester type "B" is equipped with a built-in battery, and does not require an external power supply. However, such a battery must be periodically recharged, like any other battery embedded in electronic measuring instruments.

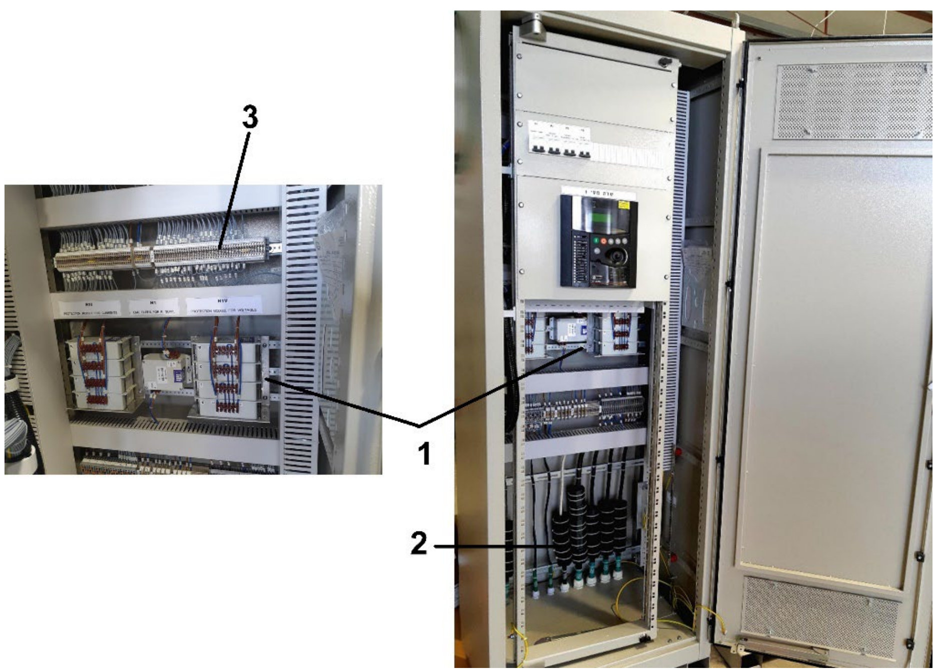



Type “B” tester with internal battery

# Set of Special HEMP Filters Intended for Control Cabinets with Digital Relay Protection

Military electromagnetic filters designed to protect against HEMP are not suitable for use in civilian cabinets with microprocessor-based relay protection for a number of reasons. Therefore, new filters have been developed specifically for civilian critical infrastructure. These filters intended for installation in current and voltage circuits of microprocessor-based protection relays, in control circuits, in auxiliary power supply circuit, and also in grounding circuit (without violating safety requirements).



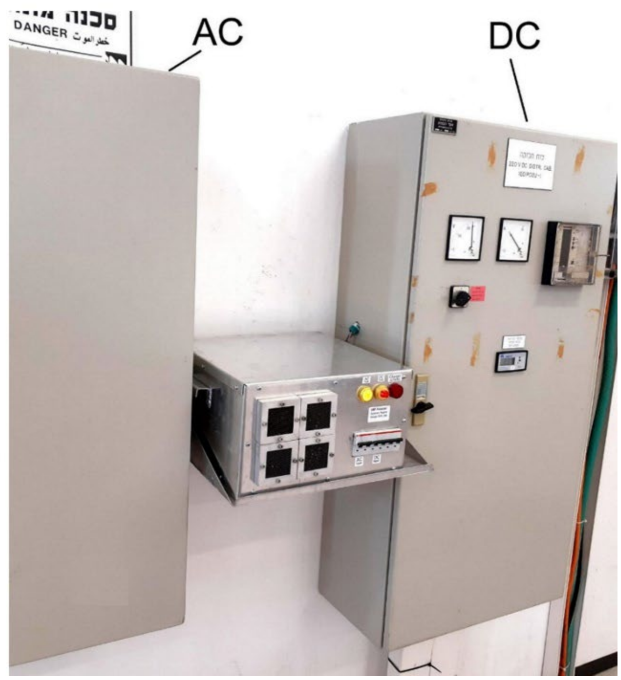




1 and 2 – special HEMP filters, installed in control cabinet witch digital relay protection;
3 – special surge protection elements

# Automatic HEMP Protected Reserve Charger for Auxiliary DC Power Supply System

A battery charger for DC auxiliary power supply system of substations and power plants is the most important type of equipment, without which any electronic equipment cannot function normally. At the same time, modern electronic chargers are very sensitive to the effects of HEMP and will necessarily be disabled by such exposure.

To increase the survivability of the DC auxiliary power supply system, an automatic reserve charger protected against HEMP is designed, which starts working when the main standard charger fails and the voltage in this network drops below a predetermined threshold. For example, when the voltage drops below 227 V in a DC network with a normal voltage of 237 V.


Such a compact automatic charger is connected between the AC and DC systems at the substation and provides an output current of at least 25 A at a voltage of 237 V.

If the AC system is also damaged, the charger can be powered by a small diesel generator with a capacity of 5 - 7 kW, which should start automatically.

Such an automatic reserve charger is a critical equipment for critical substations and allows to maintain the operability of the substation after exposure to HEMP.

# Automatic HEMP Protected Disconnecting Unit for Damaged Charger

As known, many chargers have an accelerated mode of charging batteries, which is called "boost". In this mode, the charger outputs an increased to 2.7 V per cell. In the presence of 106 cells (for a rated voltage of 220 V), the voltage at the output of the charger in this mode reaches 286 V! That is, up to a value that is dangerous both for the battery (in a long-term uncontrolled mode) and for electronic equipment connected to the DC network at that time. From practice, there are cases of damage to both batteries and equipment when the charger is switched to this mode uncontrollably.  When exposed to HEMP on an electronic charger, such a mode of operation is very possible.



1 – substation battery charger; 2 - automatic disconnecting module

The automatic disconnecting module, protected from HEMP, disconnects the charger from the DC mains if the output voltage of the charger rises above 250 V. The maximum DC current disconnected by this device is 63 A.

To prevent false shutdown of the charger, a double set of internal control units is used in the disconnecting module.

The device also has an auxiliary contact that signals the device trip and the charger disconnection

This module can be combined, of course, with an automatic backup charger.

# Backup Power Supply for DC Main Simulation

It is clear that automatic chargers will not be installed everywhere. And after exposure to HEMP, there is a need to check the serviceability of electronic equipment before actuating. To do this, we need a power supply that simulates a conventional auxiliary DC power system.

This compact backup power supply protected from HEMP and is capable of supply up to 25 A at 237V. The device is equipped with internal electronic protection against external short circuits and overloads. It is also equipped with a digital voltmeter and an ammeter for external circuit monitoring.

Such a compact, inexpensive backup power supply, simulating a standard DC power network, should be at every substation, in every laboratory.

Among other things, such a power supply is very convenient to use when checking, repairing and adjusting the equipment of stations and substations.

# HEMP Protection Module for Telecommunications

Telecommunications are widely used in relay protection systems and other important systems at substations, power plants, and water supply systems. As a rule, it is based on 10 Base-T and 10/100 Base-TX Ethernet (IEEE 802.2).

Complex equipment that provides transmission and premium data in such a system contains microprocessors and other electronic chips operating at very low voltages, that is, it is very sensitive to electrical influences. This is the most vulnerable part of the infrastructure, which requires special high-effective HEMP protection. Moreover, such protection should not affect the work of telecommunication.


Ethernet
IEEE 802.2

**10 BASE-T**
**10/100 BASE-TX**

MIL-STD-188-125
ITU-T K.78

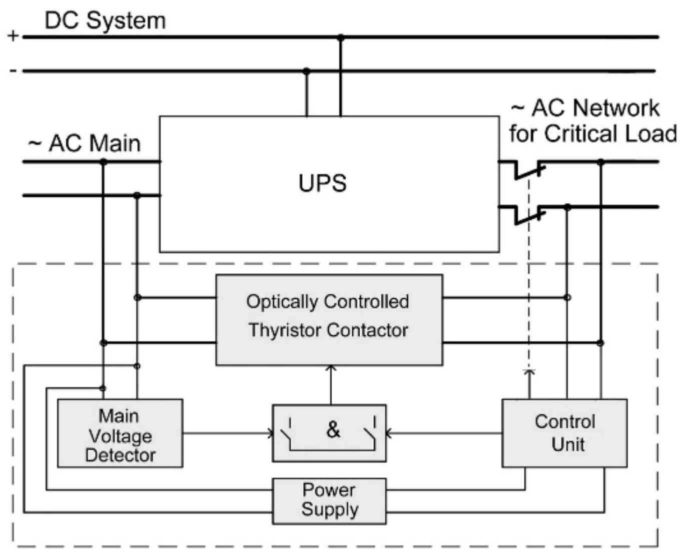
Such a protective module was developed and tested for compliance with standards MIL-STD-188-125 and ITU K.78.

In one of the addition tests, a high voltage short pulse was applied to an unprotected input of telecommunications equipment, and in the second test, the same impulse was applied to an input protected by this protection module. In the first case, the equipment was damaged, and in the second, it remained fully operational.

To confirm the absence of the influence of the protective module on the operation of the Ethernet network, such a module has been used for a long time when switching on between a computer network and a personal computer. During the test period, no side effects of the module on the operation of the computer were detected.

# UPS Protection System

Some types of electric consumers in critical infrastructure systems are powered through the Uninterrupted Power Systems (UPS) with a capacity from several kilowatts to hundreds of kilowatts. But the UPS itself is a very complex electronic unit that uses many microelectronic components and microprocessors, that is, it is a type of equipment that is very vulnerable to HEMP. That is, it turns out that using UPS to power critical consumers, we significantly increase the vulnerability of these critical consumers from HEMP. There is a clear contradiction here: on the one hand, UPS are used to improve the reliability of critical types of electrical equipment, on the other hand, the use of UPS leads to a significant decrease in the reliability of this equipment when exposed to HEMP. Large industrial UPS have an automatic bypass that provides power to the critical load directly from the main AC power (i.e., bypassing the UPS inverter) in the events of some types of internal faults. But this does not solve the problem in the case of HEMP, since this electronic bypass itself is a complex electronic module controlled by a microprocessor. That is, in the event of HEMP exposure, this bypass will inevitably be damaged along with the rest of the UPS internal electronic modules. There are external electronic bypasses on the market that can be connected to the UPS, but these are just as complex electronic devices as the internal bypass. Due to these problems, the most appropriate solution for civil applications, in my opinion, is to use a protected optocoupler controlled thyristor contactor equipped with the simplest specially designed HEMP-protected control system. In fact, this is an external bypass, but only a very simple, cheap and HEMP-resistant one.



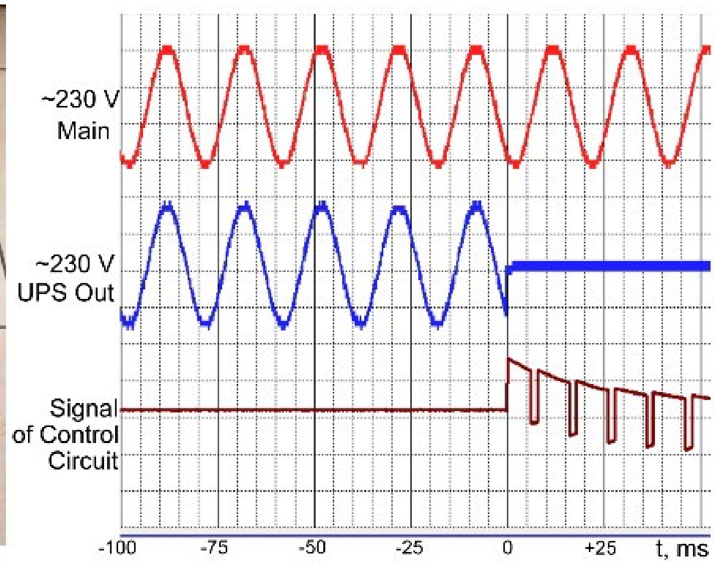

Unfortunately, the bypass switch cannot simply be connected in parallel with the UPS (between its input and output) without synchronization with the UPS operating mode. This is due to it that when the voltage in the main AC network is turned off by the personnel, the voltage will remain in it, since it will come from a working UPS that is powered by a battery. This is a very dangerous situation and therefore this mode of operation is expressly prohibited by IEC 62040-1-1 standard. To prevent such a situation, the thyristor contactor's control unit (CU) should contain an element (device) that constantly monitors the presence/absence of voltage in the main AC network and at the UPS output.

Special control modules and voltage unbalance sensors that are not sensitive to HEMP have been developed to solve these problems.

# Tester for Express Verification of the Serviceability of the UPS Unit

Unfortunately, not all UPS units will be protected at critical infrastructure facilities, but only the most important of them. For the rest of the UPS, a special tester (Figure 17) has been developed that allows to very easily and quickly determine the serviceability of the UPS units, exposed to HEMP.

A possible situation when, after HEMP impact and shutdown of many types of electrical equipment and power supply networks, a gradual return of all electrical equipment to a working state is required. In this case, it will be necessary to check its performance. One of the main functions of the UPS is its ability to very quickly switch the power supply of the critical load from the main AC supply network to battery power. Without special technical means, it is not easy to check the serviceability of this UPS function.

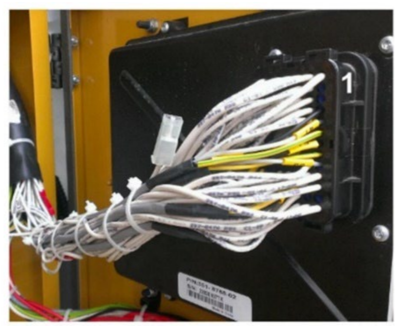

The tester allows to very easily and quickly determine the serviceability of the UPS units, exposed to HEMP, before its restoration.

One of the inputs of this instrument is connected to the main AC network, and the second – to the electrical network intended for critical loads. When the operator disconnects the UPS from the main AC network by external circuit breaker, the LED in the instrument should not turn ON. This will confirm that the voltage at the UPS output was not interrupted (or its interruption did not exceed 1 ms).

# Special Means for Backup High Power Diezel Generator Protection

The problem of diesel generator (DG) protection from HEMP becomes particularly relevant. First of all, DGs act as backup power sources and are designed to power up critical loads in emergency situations. Consequently, they need to be ready for use even after the HEMP. Secondly, DGs are often stored outdoors (outside of the buildings that can partially mitigate the HEMP impact).

Medium-capacity industrial DGs (from dozens to hundreds of kilowatts) are large and heavy devices that are intended for transportation. As a rule, they are confined in a casing with many sensors and microprocessor-based controllers that control the DG's operation, measure and display various parameters, as well as protect them from overload and emergency modes.

High- and medium-power diesel generators are equipped with large and powerful fans ensuring the high-speed movement of large volumes of cooling air within the diesel generator enclosure. As a rule, there are two separate rather big cut-outs (0.5 sq. m – 2sq. m) provided in the enclosure to intake and discharge the air. This is a serious problem from the point of view of protection against HEMP. In addition, there are many other problems associated with the design of such diesel generators, which are absolutely not protected from nuclear power EMP.



For reliable protection of such a diesel generator, a whole set of protective means is offered.

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