REK 510
Current injection device for earth-fault protection of a synchronous machine rotor

User’s Manual
Current injection device for earth-fault protection of a synchronous machine rotor

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1. Application

The purpose of the rotor earth-fault protection is to detect earth faults in the excitation circuit of synchronous machines.

The excitation field circuit is isolated during normal operating conditions. The field circuit can be exposed to abnormal mechanical or thermal stress due to vibrations, overcurrent, choked cooling medium flow, etc. This may result in the breakdown of the insulation between the field winding and the rotor iron at a point exposed to excessive stress. A single earth fault is not very dangerous and does not cause immediate damage, because the fault current is small due to the low voltage. More dangerous is a second earth fault that appears as a rotor winding interturn fault and causes severe magnetic unbalance and heavy rotor vibrations leading to severe damage.

Therefore, it is essential that any occurrence of an insulation failure is detected and that the machine is disconnected as soon as possible. Normally, the machine is tripped after a short time delay.

For generators with slip rings the rotor insulation resistance is sometimes reduced due to the accumulated carbon dust layer produced by the carbon brushes.

This product replaces the current injection device type SPMK 1C40 C2.
2. Operation principle

The injection device REK 510, supplied from a secured 230 V or 100 V 50/60Hz source, sets up a 48 V ac voltage via its coupling capacitors to the rotor circuit towards earth.

This auxiliary ac voltage forms a small charging current to flow via the coupling capacitors, resistances of the brushes and earth capacitances of the field circuit. These field to earth capacitances $C_E$ affect the level of the resulting current, which is a few milliamperes during normal no-fault operating conditions.

If an earth fault arises somewhere in the field circuit, this current increases and may reach a level of 65 mA at a fully developed earth fault (fault resistance $R_E = 0 \, \Omega$). The integrated current transformer of the REK 510 then amplifies this current with the ratio 1:10 to a measurable level even with relays that have a 1 A rated current input.

A definite time earth-fault relay, e.g. REJ 521 is connected to measure this current. The relay used should be insensitive to harmonics as a considerable amount of harmonics can occur in the current, especially with thyristor excitation and rotating diode rectifier systems.

If the machine terminal REM 543/5 is used, dual-stage rotor earth-fault protection can be achieved using the non-directional E/F functions NEF1Low and NEF1High, set to operate in a fundamental frequency mode. In this mode, digital filtering is used to filter out dc and harmonic components that could produce false alarms/trips.

![Principle of the earth-fault protection for the excitation field circuit with ac current injection.](https://example.com/fig2_1.png)
Typically, the alarm level for weakly developed earth faults is set to a current pick-up level corresponding to a fault resistance of $10 \, \text{k}\Omega$, with a time delay of 10 sec. Tripping for fully developed earth faults is set to a current level corresponding to a fault resistance of $1-2 \, \text{k}\Omega$, with a 0.5 sec delay.

**Fig. 2.-2** Protection current measured by REM 543 as a function of the earth-fault resistance with various field-to-earth capacitance values, measuring circuit resistance $R_m = 0.1 \, \text{Ω}$, $f_n = 50 \, \text{Hz}$.

**Fig. 2.-3** Protection current measured by REM 543 as a function of the earth-fault resistance with various field-to-earth capacitance values, measuring circuit resistance $R_m = 3.0 \, \text{Ω}$, $f_n = 50 \, \text{Hz}$. 
3. Connection diagrams

Fig. 3.1 Double-pole connection. Connection to both rotor winding ends is recommended as it gives the most accurate measuring results.

Fig. 3.2 Single-pole connection. If only one end of the rotor winding can be connected to the REK 510, terminals 5 and 6 have to be linked together.
4. Testing instructions

Fig. 4.-1 Test connections

For testing purpose an adjustable potentiometer $R_E$ (0…20 k$\Omega$, 0.6 W), which simulates earth fault, is connected in series with a test switch $S$ between the connectors X1(5) and earth X1(7). The protection relay itself should be tested according to the instructions given in the relay manuals.
## Technical data

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply voltage, range according to IEC 60255-6</strong></td>
<td>230 V or 100 V -20% ...+10%, 50/60 Hz</td>
</tr>
<tr>
<td><strong>Output voltage, nominal</strong></td>
<td>48 Vac</td>
</tr>
<tr>
<td><strong>Short-circuit current between connected terminals 5 and 6 against terminal 7</strong></td>
<td>$I_1 = 80$ mA; withstands continuous short circuit</td>
</tr>
<tr>
<td><strong>Max. excitation voltage withstand from terminals 5 and 6 to terminal 7</strong></td>
<td>600 V dc</td>
</tr>
<tr>
<td><strong>Maximum current of protection unit (terminals 11-12)</strong></td>
<td>$I_2 \leq 800$ mA</td>
</tr>
<tr>
<td><strong>Maximum measuring circuit resistance of the protection unit (terminals 11-12)</strong></td>
<td>$R_m \leq 3 \Omega$</td>
</tr>
<tr>
<td><strong>Coupling capacitors</strong></td>
<td>2 x 2 $\mu$ F</td>
</tr>
<tr>
<td><strong>Power consumption</strong></td>
<td>$\leq 3.5$ W</td>
</tr>
<tr>
<td><strong>Degree of protection provided by enclosure of the device according to IEC 529</strong></td>
<td>IP 20</td>
</tr>
<tr>
<td><strong>Weight of the unit</strong></td>
<td>3.8kg</td>
</tr>
</tbody>
</table>

### Environmental tests and conditions

**Service temperature range IEC 60255-6** | -10°C ... +55°C |
**Transport and storage temperature IEC 60255-6** | -40°C ... +70°C |
**Dry cold test according to IEC 60068-2-1** | -10°C |
**Dry heat test according to IEC 60068-2-2** | +55°C |
**Damp heat test, cyclic according to IEC 60068-2-2** | +25°C ...55°C, RH > 93% 6 cycles (12+12 -hour cycle) |
**Storage temperature test according to IEC 60068-2-48** | -40°C ...+70°C |

### Dielectric tests

**Dielectric test according to IEC 60255-5** | 2.3kV 50Hz 1 min |
**Input to outputs, output to output and all to earth** | 7.3 kV 1.2 $\mu$s /50 $\mu$s |
**Insulation resistance measurement according to IEC 60255-5** | >100 M$\Omega$, 500 V dc |

### Electromagnetic compatibility tests

**1MHz burst disturbance test according to IEC 60255-22-1** | 2.5 kV common mode 1.0 kV differential mode |
**Electrostatic discharge test according to IEC 60255-22-2, IEC 61000-4-2** | 6 kV contact discharge 8 kV air discharge |
**Radio frequency interference tests:**
- **Conducted, according to IEC 60255-22-6, IEC 61000-4-6** | 10 V (rms) f = 150 kHz...80 MHz 80% amp. mod. with 1 kHz sinewave |
- **Radiated, amplitude-modulated, according to IEC 60255-22-3, IEC 61000-4-3** | 10 V/m (rms) f = 30...1000 MHz 80% amp. mod. with 1 kHz sinewave |
- **Radiated, pulse-modulated, according to ENV 50204, IEC 60255-22-3** | 10 V/m, f = 900 MHz f = 1.89 GHz Rep. frequency = 200 Hz, duty cycle 50% 4 kV |

**Fast (5/50 ns) transient disturbance test according to IEC 60255-22-4, IEC 61000-4-4** | 10 V (rms) f = 150 kHz...80 MHz 80% amp. mod. with 1 kHz sinewave |
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<table>
<thead>
<tr>
<th>Test Description</th>
<th>Specification/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power frequency (50 Hz) magnetic field test</td>
<td>300 A/m</td>
</tr>
<tr>
<td>Surge immunity test</td>
<td>4 kV common mode</td>
</tr>
<tr>
<td></td>
<td>2 kV differential mode</td>
</tr>
<tr>
<td>Electromagnetic emission tests</td>
<td></td>
</tr>
<tr>
<td>Conducted rf emission EN 55011 (EN 55022), EN 60255-25</td>
<td>class A mains</td>
</tr>
<tr>
<td>Radiated rf emission EN 55011 (EN 55022), EN 60255-25</td>
<td>class A enclosure</td>
</tr>
<tr>
<td>Mechanical tests</td>
<td></td>
</tr>
<tr>
<td>Vibration tests IEC 60255-21-1</td>
<td>class 1</td>
</tr>
<tr>
<td>Shock and bump tests IEC 60255-21-2</td>
<td>class 1</td>
</tr>
</tbody>
</table>
6. **Mechanical dimensions and mounting instructions**

6.1. **Dimensions**

![Dimensional Drawing](image)

*Fig. 6.1.-1 Dimensional drawing*

6.2. **Mounting instructions**

The unit is enclosed in a metal case designed to be attached to the wall with four M6 size screws.

External connections have to be done according to the connection diagram. The numbering of the contacts runs from bottom to top. The screw-compression type terminal block X1 is dimensioned for one max. 6 mm² or two max. 2.5 mm² wires. A separate earth lead (2.5 mm²) should be connected from the earth screw to the earth bar. No soldering is needed.
7. References

Technical Reference Manual REJ 521 1MRS750939-MUM
Technical Reference Manual REM 54_ 1MRS750915-MUM
8. **Order information**

Injection device REK 510 for rotor earth fault protection  REK 510-AA