Earth Leakage Relay (ELR) requirement according to IEC 60947-2 Annex M

by NS Koh
ELR according to IEC 60947-2 Annex M

Overview

- Introduction of IEC 60947-2 Annex M
  - Market situation
  - The Standards
  - ELR Requirement
  - Demo
Market Situation

- What is the standard for ELR?
  - Hmmm....................
  - No or not sure
  - Yes, some IEC standard

- What is the common standard for ELR?
  - IEC 62020
  - IEC 60755
ELR according to IEC 60947-2 Annex M
Local Product Standard

- **ELR:**
  - IEC60755: RCD ≤ 440Vac
  - IEC62020: RCM for Household ≤ 440Vac
  - IEC61543: RCD ≤ 440Vac (EMC)
  - IEC60947: RCD ELR ≤ 1000Vac
  - CISPR 11/22: RF disturbance
  - Vibration: IEC 60255-2-1
  - Ingress Prot.: IEC 60529
  - Humidity/Temp: IEC60068-2-..
  - EMC: IEC61000-4-..
  - Insulation: IEC60255-5
ELR according to IEC 60947-2 Annex M
Introduction to the Standard

- IEC 60947-2 Annex M
  - IEC 60947: Low Voltage Switchgear and Controlgear
  - -2: Circuit-breakers
  - Annex M: Modular Residual Current Devices (MRCD) without integral current breaking device or ELR
ELR according to IEC 60947-2 Annex M

Introduction to the Standard

- IEC 60947-2 Annex M
  - ELR Standard for up to 1000Vac application
  - Same standard as Breaker, MCCB & ACB
  - EMC: IEC 61000 -3 and -4
  - Radio Frequency: CISPR 11 & 22
  - Higher EMC immunity test level for ELR
  - CISPR 11/22: RF disturbance
ELR according to IEC 60947-2 Annex M
How they work in conjunction with MCCBs
ELR according to IEC 60947-2 Annex M

Wiring
The ELR achieve the monitoring and the protection of low voltage distribution system in combination with an external toroidal transformer. In the event of ground fault the toroidal transformer produces a signal, sent to the residual current relay.

### Toroid selection table

<table>
<thead>
<tr>
<th>Model</th>
<th>Toroid diameter [mm]</th>
<th>Max cable section (4x) [mm²]</th>
<th>Max current (1x) [A]</th>
<th>Min current measurable (mA)</th>
<th>Iron screen thickness (mm)</th>
<th>Iron screen diameter (mm)</th>
<th>Iron screen length (mm)</th>
<th>Max current (1x) [A]</th>
<th>Min current measurable (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRM</td>
<td>29</td>
<td>25</td>
<td>65</td>
<td>25</td>
<td>&gt;1</td>
<td>25</td>
<td>80</td>
<td>85</td>
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<tr>
<td>TR1</td>
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<td>75</td>
<td>25</td>
<td>&gt;1</td>
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<td>80</td>
<td>110</td>
<td>25</td>
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<tr>
<td>TR2</td>
<td>60</td>
<td>50</td>
<td>85</td>
<td>25</td>
<td>&gt;1</td>
<td>30</td>
<td>80</td>
<td>150</td>
<td>25</td>
</tr>
<tr>
<td>TR3</td>
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<td>95</td>
<td>160</td>
<td>100</td>
<td>&gt;1</td>
<td>40</td>
<td>80</td>
<td>225</td>
<td>100</td>
</tr>
<tr>
<td>TR4</td>
<td>110</td>
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<td>250</td>
<td>100</td>
<td>&gt;1</td>
<td>55</td>
<td>250</td>
<td>400</td>
<td>100</td>
</tr>
<tr>
<td>TR5</td>
<td>210</td>
<td>400</td>
<td>630</td>
<td>250</td>
<td>&gt;1</td>
<td>75</td>
<td>250</td>
<td>800</td>
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<td>TR160</td>
<td>160</td>
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<td>400</td>
<td>250</td>
<td>&gt;1</td>
<td>75</td>
<td>250</td>
<td>630</td>
<td>250</td>
</tr>
<tr>
<td>TR160/A</td>
<td>160</td>
<td>400</td>
<td>400</td>
<td>500</td>
<td>&gt;1</td>
<td>75</td>
<td>250</td>
<td>630</td>
<td>500</td>
</tr>
<tr>
<td>TR4/A</td>
<td>110</td>
<td>240</td>
<td>250</td>
<td>250</td>
<td>&gt;1</td>
<td>55</td>
<td>250</td>
<td>400</td>
<td>250</td>
</tr>
<tr>
<td>TR5/A</td>
<td>210</td>
<td>400</td>
<td>630</td>
<td>500</td>
<td>&gt;1</td>
<td>75</td>
<td>250</td>
<td>800</td>
<td>500</td>
</tr>
</tbody>
</table>
ELR according to IEC 60947-2 Annex M
Introduction to the Standard

- Before the publication of the IEC 60947-2 Annex M
  - General Standard of the electronic relays IEC 60255
  - IEC 62020 (Residual current monitors for household and similar uses – RCMs)
  - Or IEC 60755 (RCD ≤ 440Vac)
ELR according to IEC 60947-2 Annex M
Introduction to the Standard

- Problems in ELR without IEC 947-2 Annex-M
  - Wrong product standard or selection
  - Nuisance and unwanted tripping of ELR
  - Un-define tripping time if used in conjunction with circuit breaker for electrical hazards protection
  - Low system reliability and performance.
ELR according to IEC 60947-2 Annex M
Introduction to the Standard

- **Annex M of IEC 60947-2 issued in 2004**
  - Milestone for ELR with separate ZCT (when used in conjunction with a circuit-breaker to protect against the effects of electric shock hazards).

- **Scope and object of IEC60947-2 Annex M**
  - Applies to RCD which do not incorporate a current breaking device, called “Modular Residual Current Device (MRCD)” or ELR. They are primarily intended to be used in conjunction with circuit-breakers in accordance with this standard....
  - May and may not be functionally dependent on a voltage source.
ELR according to IEC 60947-2 Annex M

- According to new Annex M of IEC 60947-2, the Manufacturer of residual current relays has to check and guarantee protection performances of the entire chain, composed by ELR (toroid + relay) and circuit breakers.
- ELR complied to Annex-M can only installed with circuit breakers declared and tested by manufacturer.
- ELR range has been tested with
  - MCB: S200 up to 63A
  - MCCB: T1 to T5 with rated current up to 630A.
ELR according to EN 60947-2 Annex M

Total Operating Time

How they work:

1) TOROID
2) RELAY
3) CIRCUIT BREAKER

Total operating time of the protection depends from all the components
ELR according to IEC 60947-2 Annex M

Requirement

- For ELR declared according to IEC 947-2 Annex-M
  Manufacturer has to specify:
  - operating time
  - total operating time
  - non operating time
Operating time of ELR

- time which elapses between the instant when the residual operating current is suddenly applied and the instant when the ELR output changes status

Total operating time of ELR and associated Breaker

- time which elapses between the instant when the residual operating current is suddenly applied and the instant of the arc extinction of the associated current breaking device

For the protection, the most important time is Total operating time of an ELR and associated current breaking device
ELR according to IEC 60947-2 Annex M Requirement

- If $\Delta t = 0$ * (non-time-delay configuration)
  - The operating characteristic (maximum break time) for a non-time-delay type is given in this table of the standard (instantaneous tripping)

Table B.1 – Operating characteristic for non-time-delay type

<table>
<thead>
<tr>
<th>Residual current</th>
<th>$I_{\Delta n}$</th>
<th>$2I_{\Delta n}$</th>
<th>$5I_{\Delta n}$</th>
<th>$10I_{\Delta n}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum break time</td>
<td>s</td>
<td>0.3</td>
<td>0.15</td>
<td>0.04</td>
</tr>
</tbody>
</table>

1) For CBRs having $I_{\Delta n} \leq 30$ mA, 0.25 A may be used as an alternative to $5I_{\Delta n}$

2) 0.5 A if 0.25 A is used according to note 1).
ELR according to IEC 60947-2 Annex M Requirement

- If $\Delta t = 0$ *(non-time-delay configuration)*

<table>
<thead>
<tr>
<th>General Type</th>
<th>Category</th>
<th>Max Break Times (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td></td>
<td>$1 \times I_\text{An}$</td>
</tr>
<tr>
<td>IEC 61008</td>
<td>$\Delta n \leq 30\text{mA}$</td>
<td>0.3</td>
</tr>
<tr>
<td>SS 97</td>
<td>$\Delta n &lt; 30\text{mA}$</td>
<td>0.1</td>
</tr>
<tr>
<td>IEC 60947-2</td>
<td>Non-time-delay</td>
<td>0.3</td>
</tr>
<tr>
<td>Annex B &amp; M</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* According Annex M an ELR set at $\Delta t = 0$, it is complied to IEC 61008 tripping time requirement.*
ELR according to IEC 60947-2 Annex M Requirement

- If \( I_{\Delta n} = 30 \text{mA} \) * (with time-delay configuration)

<table>
<thead>
<tr>
<th>General Type</th>
<th>Max Break Times (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 x ( I_{\Delta n} )</td>
</tr>
<tr>
<td>Standard</td>
<td>Category</td>
</tr>
<tr>
<td>IEC 61008</td>
<td>( I_{\Delta n} \leq 30 \text{mA} )</td>
</tr>
<tr>
<td>SS 97</td>
<td>( I_{\Delta n} &lt; 30 \text{mA} )</td>
</tr>
<tr>
<td>IEC 60947-2 Annex B &amp; M</td>
<td>Non-time-delay</td>
</tr>
</tbody>
</table>

* According Annex M an ELR set at \( I_{\Delta n} = 30 \text{ mA} \), all time-delay setting should auto bypass and trip instantaneously, ELR complied to IEC 61008 tripping time requirement.
ELR according to IEC 60947-2 Annex M Requirement

- For $\Delta t \neq 0$ (time-delay configuration)
  - set $\leq 0.06$ s
- The operating characteristic (maximum break time) for a time-delay type in this situation is given in this table of the standard

Table B.2 – Operating characteristic for time-delay-type having a limiting non operating time 0.06 s

<table>
<thead>
<tr>
<th>Residual current</th>
<th>$I_{\Delta n}$</th>
<th>$2I_{\Delta n}$</th>
<th>$5I_{\Delta n}$</th>
<th>$10I_{\Delta n}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum break time</td>
<td>0.5</td>
<td>0.2</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>
ELR according to IEC 60947-2 Annex M

Requirement

- For $\Delta t \neq 0$ (time-delay configuration)
  - set $\leq 0.06\,\text{s}$

<table>
<thead>
<tr>
<th>Selective S-Type</th>
<th>Max Break Times (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard</strong></td>
<td>Category ($I_n &gt; 25,\text{A}$)</td>
</tr>
<tr>
<td>IEC 61008</td>
<td>$I_{\Delta n}&gt;30,\text{mA}$</td>
</tr>
<tr>
<td>SS 97</td>
<td>$I_{\Delta n}&gt;30,\text{mA}$</td>
</tr>
<tr>
<td>IEC 947-2 Annex B &amp; M</td>
<td>Time-delay</td>
</tr>
</tbody>
</table>

* According Annex M an ELR set at $\Delta t = 0.06\,\text{s}$ it is also complied to SS97 & IEC 61008 tripping time requirement for S-type RCCB.
ELR according to IEC 60947-2 Annex M
Requirement

- **Responsibility of the manufacturer:**
  - products have to be tested in real configurations ELR+ZCT+MCCB/MCB
  - detailed instructions for faultless wiring has to be provided (assembly and installation guide)
  - manufacturer has to declare types of MCBs/ MCCBs and toroids
ELR to IEC 60947-2 Annex M
Conformity to IEC 60947-2 Annex M

- Toroid selection table for use with RD3/ELR as ELR according to IEC/EN 60947-2 Annex-M in combination with MCBs S200 range and MCCBs Tmax range up to T5:

<table>
<thead>
<tr>
<th>Model</th>
<th>Toroid diameter [mm]</th>
<th>Conductor max size per cable [mm²]</th>
<th>Rated current max [A]</th>
<th>Min current measurable [mA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRM</td>
<td>29</td>
<td>25</td>
<td>65</td>
<td>25</td>
</tr>
<tr>
<td>TR1</td>
<td>35</td>
<td>35</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>TR2</td>
<td>60</td>
<td>50</td>
<td>85</td>
<td>25</td>
</tr>
<tr>
<td>TR3</td>
<td>80</td>
<td>95</td>
<td>160</td>
<td>100</td>
</tr>
<tr>
<td>TR4</td>
<td>110</td>
<td>240</td>
<td>250</td>
<td>100</td>
</tr>
<tr>
<td>TR4/A</td>
<td>110</td>
<td>240</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>TR160</td>
<td>160</td>
<td>2x185</td>
<td>400</td>
<td>250</td>
</tr>
<tr>
<td>TR160/A</td>
<td>160</td>
<td>2x185</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>TR5</td>
<td>210</td>
<td>2x240</td>
<td>630</td>
<td>250</td>
</tr>
<tr>
<td>TR5/A</td>
<td>210</td>
<td>2x240</td>
<td>630</td>
<td>500</td>
</tr>
</tbody>
</table>
ELR to IEC 60947-2 Annex M
Use outside the Standards

- Toroid selection table for use with RD2/ RD3/ ELR as Residual Current Monitors:

<table>
<thead>
<tr>
<th>Model</th>
<th>Toroid diameter [mm]</th>
<th>Min. current measurable [mA]</th>
<th>Rated current max [A]</th>
<th>Permanent residual current overload max [A]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRM</td>
<td>29</td>
<td>25</td>
<td>160</td>
<td>1000</td>
</tr>
<tr>
<td>TR1</td>
<td>35</td>
<td>25</td>
<td>250</td>
<td>1000</td>
</tr>
<tr>
<td>TR2</td>
<td>60</td>
<td>25</td>
<td>400</td>
<td>1000</td>
</tr>
<tr>
<td>TR3</td>
<td>80</td>
<td>100</td>
<td>800</td>
<td>1000</td>
</tr>
<tr>
<td>TR4</td>
<td>110</td>
<td>100</td>
<td>1250</td>
<td>1000</td>
</tr>
<tr>
<td>TR4/A</td>
<td>110</td>
<td>250</td>
<td>1250</td>
<td>1000</td>
</tr>
<tr>
<td>TR160</td>
<td>160</td>
<td>250</td>
<td>2000</td>
<td>1000</td>
</tr>
<tr>
<td>TR160/A</td>
<td>160</td>
<td>500</td>
<td>2000</td>
<td>1000</td>
</tr>
<tr>
<td>TR5</td>
<td>210</td>
<td>250</td>
<td>3200</td>
<td>1000</td>
</tr>
<tr>
<td>TR5/A</td>
<td>210</td>
<td>500</td>
<td>3200</td>
<td>1000</td>
</tr>
</tbody>
</table>
ELR according to IEC 60947-2 Annex M
ELR Product Standard

- **ELR:**
  - IEC60755: RCD ≤ 440Vac
  - IEC62020: RCM for Household ≤ 440Vac
  - IEC61543: RCD ≤ 440Vac (EMC)
  - IEC60947: RCD ELR ≤ 1000Vac
  - CISPR 11/22: RF disturbance
  - Vibration: IEC 60255-2-1
  - Ingress Prot.: IEC 60529
  - Humidity/Temp: IEC60068-2-..
  - EMC: IEC61000-4-..
  - Insulation: IEC60255-5
ELR to IEC 60947-2 Annex M
Panel Mount Product Range

- **Available sizes:**
  - 96x96mm; 72x72mm; 48x48mm
- **Rated supply voltage ranges:**
  - 24, 48, 110, 230, 400V a.c; 24, 48V d.c
- **Sensitivity settings $I_i n$ [A]:**
  - 0.03, 0.1, 0.3, 0.5.. 30
- **Time settings [sec]:**
  - 0.02, 0.06, 0.2, 0.3... 5
- **Pre-alarm & Alarm output contacts:**
  - 1NO/1NC on basic versions
  - 2CM on P versions
- **Alarm:** 60% $I_i n$ on P versions
- **Digital Leakage Current Display**
ELR to IEC 60947-2 Annex M
Panel Mount Product Range

- **Available sizes:**
  Dinral Mounting, 3 modules width

- **Rated supply voltage ranges:**
  12, 48, 110, 230, 400V a.c; 24, 48V d.c

- **Sensitivity settings $I\Delta n$ [A]:**
  0.03, 0.1, 0.3, .. 30

- **Time settings [sec]:**
  0, 0.06, 0.2, 0.3 ... 10

- **Pre-alarm & Alarm output contacts:**
  1NA/1NC on basic versions
  2CO on M & P versions

- **Pre-alarm:** 60% $I\Delta n$ on M & P versions

- **LED Bar Leakage Current Display**
Power and productivity for a better world™