LINE Troll 110Eμ
Phase mounted indicator for overhead line

Userguide
TABLE OF CONTENTS

1. LINETROLL 110Eµ OVERVIEW ........................................................................3
2. FUNCTIONAL DESCRIPTION ........................................................................3
   2.1. Sensors .................................................................................................4
   2.2. Activation criteria ................................................................................4
   2.3. Indication ..............................................................................................4
   2.4. Reset criteria .......................................................................................5
   2.5. Battery lifetime / maintenance ..............................................................5
   2.6. Low battery warning ............................................................................5
   2.7. Low battery warning reset ...................................................................5
   2.8. Fault sensitivity ....................................................................................5
3. APPLICATION ..............................................................................................6
4. APPLICATION NOTES ..................................................................................7
   4.1. Energising a healthy line ......................................................................7
   4.2. Connecting a faulty line while the indicator is activated .......................7
   4.3. Transient fault ......................................................................................8
   4.4. Fused lines ...........................................................................................8
   4.5. Multiple faults ....................................................................................8
   4.6. Capacitive discharges .........................................................................9
   4.7. PROGRAMMING ................................................................................10
      4.7.1. Di/dt sensing ..................................................................................10
      4.7.2. Threshold sensing .........................................................................10
      4.7.3. Start/Stop criteria .........................................................................10
      4.7.4. Timer reset .....................................................................................10
      4.7.5. Auto-Reset ....................................................................................10
5. MAINTENANCE .........................................................................................11
   5.1. Battery replacement ............................................................................11
   5.2. Reset battery monitoring ....................................................................11
6. INDICATOR HOUSING .............................................................................11
7. TECHNICAL SPECIFICATIONS .................................................................12
8. DIMENSIONS ..........................................................................................12
9. MOUNTING ..............................................................................................13
10. PROGRAMMING TABLE FOR THE LT110Eµ ..........................................15
11. FLASHING SEQUENCES .........................................................................16

Terms:
Energised line: Voltage or current present
De-energised line: Voltage or current not present
1. LINETROLL 110Eμ OVERVIEW

LINETROLL 110Eμ is used to locate short-circuit and earth faults in overhead line distribution networks. LineTroll 110Eμ is a singlephase unit normally used in groups of 3 at each site, hence fully covering the different fault configurations that may occur.

The indicators are placed at strategic locations along the line such as after branching points and sectionalisers. It mounts directly on the high voltage conductor by means of its spring operated clamp. Live line mounting is easily and rapidly done with a hot-stick and a NORTROLL adapter.

Upon fault sensing, all indicators installed in the faulty phase(s) between the feeding substation and the fault will operate. The indicators placed behind the fault or in the non-damaged phase(s) remain idle.

Upon detecting a fault on the line, the indication by means of an intermittent LED- flash (3 red LED's and 1 amber LED indication for permanent fault and one Green LED for a transient faults). This LED-flash can be seen within 100-200 metres distance. The lens of the indicator allows for uniform 360 degrees monitoring.

LINETROLL 110Eμ provides fast fault location enabling reduction in outage times. This represents enhanced service to the customers thereby improving the utilities image.

Another important aspect of using fault indicators is that unnecessary operations of circuit breakers and sectionalisers to locate the fault are avoided. This way the indicators help reduce wear and tear as reclosing cycles causes stress to the switchgear.

Note: Voltage or current as start and stop criteria are user programmable.
2.1. Sensors

The magnetic field generated by the line current induces a signal in the indicator pickup coil. The induced signal is applied to a di/dt sensor in order to discriminate between fault current and load current. The di/dt sensor detects instant current increases as is the case when faults occur. The trip level of the di/dt can be set to 6, 12, 25, 60, or 120 A by means of a switch bank inside the unit.

A normal variation of the load current will not activate LINETROLL 110Eμ.

2.2. Activation criteria

LINETROLL 110Eμ can be easily set to operate in the wanted mode by altering a number of switches inside the unit.

In order to avoid activating the indicator due to the magnetising inrush current of the line, its di/dt sensor is blocked for 5 sec. upon re-energising of the line. While the blocking time elapses, the line current stabilises and does not cause triggering of the di/dt sensor. A fault duration exceeding 25ms is required to activate the indicator.

In addition to its di/dt sensor, LINETROLL 110Eμ incorporates a common threshold sensor with threshold levels of 250, 500A, 750A or 1000A. The threshold criterion, if enabled, activates the indicator if the fault current exceeds the selected level. (The inrush blocking is still active in this mode)

A rapid line current increase followed by a de-energising of the line within 3 sec. will activate the indicator. It can also be set to indicate upon a rapid current increase without looking for a de-energised line.

2.3. Indication

The main indication; 4 red/amber LED’s indicates permanent faults. The secondary indication is a single green LED.

- Transient fault: Only the green LED flashes for 24h.
- Permanent fault: Both green and red *) until reset (timer-, auto- or manual-reset).

*) Note: to verify a permanent fault, the red indication is delayed 70 sec.

See more detailed info in Ch 11.Flashing sequences.
2.4. Reset criteria

The indicator automatically resets in two different ways:

1) When the line is energised. The voltage or current sensor detects that the line is energised and can in turn reset the indicator after 30 seconds of continuously energised line.

2) Automatic reset by internal timer. This timer can be set to: 2, 6, 12 or 24 hours.

The indicator can also be reset manually at any time by use of a magnet, or by use of the mounting and testing tool KBN-3.

2.5. Battery lifetime / maintenance

A 3.6V 16.5 Ah Lithium battery powers the LINETROLL 110E. When idle, the indicator draws a few micro-Amps only, giving some 9-10 years battery lifetime in normal service. When the unit is activated, approximately 4 mA are consumed, giving more than 1500 hours of flashing capacity. The battery is fitted with a connector for simple replacement.

2.6. Low battery warning

During the last few months of the battery’s life, an amber LED with a low flashing frequency will indicate that less than 20% of capacity remains and that there is a need for battery replacement.

2.7. Low battery warning reset

In the case of battery replacement the battery capacity monitoring must be reset. See Ch 5.2.

2.8. Fault sensitivity

The indicator’s di/dt sensitivity is limited by the load current. See table in Ch. 7. TECHNICAL SPECIFICATIONS.

The indicator detects short-circuit as well as earth-faults provided the di/dt current change exceeds the detection level or absolute threshold level dependent on programming.
3. APPLICATION

The application of LINETROLL 110Eμ usually requires a previous line survey so that the best use of it may be obtained. For the best economic benefit it is recommended that the indicators are used:

- In easily accessibly line points for easy monitoring of the indicator in case of fault, for instance near the road. It is advisable to take binoculars.

- Before and after line points difficult to reach (mountains, woods, etc.) to quickly locate the fault.

- Next to line branching points, to easily locate the damaged branch. When installing indicators at such points, the use of indicators in every branch is recommended in order to provide complete information in the event of fault. Not doing so may cause confusion since there may be an indication in a branch due to a non-permanent fault while another branch without indicator may be faulty yet considered healthy.

- Near line points with sectionalisers to rapidly pinpoint and isolate the fault to facilitate rapid reconnection the healthy sections.

- Compensated and impedance-earthed-neutral networks. If indication of earth-faults are required, the indicators sensitivity and the networks residual fault current has to be taken into account.

- On conductors of 5-24 mm diameter.

with special emphasis on:

- Areas with unpredictable electromagnetic fields caused for example by parallel lines, as a better suited complement to the three-phase fault indicator LINETROLL 111K.

Do not use LINETROLL 110Eμ on:

- Ring lines or multiple fed lines.

LINETROLL-110Eμ is suitable in:

- 6-69kV Distribution networks including SWER-lines.

- Radial lines.

- Multiple circuit lines (Current reset must be used)

- Solidly-earthed-neutral networks.
4. APPLICATION NOTES

The aim of this section is to describe how the LINETROLL 110E indicator behaves in different service situations and network events.

4.1. Energising a healthy line

As the magnetising inrush current of a line can be very high, the indicator is provided with a 5 seconds blocking which prevents it from being activated until the line current is stabilised. Once the blocking time has elapsed, the indicator is enabled for fault detection.

See Figure 6.

Figure 6: Criterion of the blocking time.

a) shows the sequence when a fault occurs less than 5 sec after line has been energised:

⇒ No Indication.

If, upon re-energising of the line, the unit is indicating due to a previous fault, the unit will reset if the voltage- or current reset option is enabled, but even in this case the indicator will flash for 30 seconds (depending on the programming, see 4.7) before finally extinguishing. See Figure 7.

Figure 7: Delayed reset of flashing.

4.2. Connecting a faulty line while the indicator is activated

Closing a breaker onto a fault leads to another trip almost instantly. As the activated indicator needs 30 seconds with the line energised in order to reset, it will continue indicating.

See Figure 8.

Figure 8: Reclosing upon a faulted line.
4.3. Transient fault

Transient fault cleared within the last automatic reclosing, will be detected by the green LED. The LED will flash for 24 hours as extended transient indication.

If a new fault occurs within timeout (24h), the indicator will reset the green LED and indicate for the new fault.

4.4. Fused lines

One operation criterion (assuming automatic voltage reset is enabled) is that, after a fault, three-phase disconnection of the line has to be carried out. If, instead of a three-phase trip, a fuse operates in one or two phases, the voltage of the healthy phase(s) may cause no indication or reset of indication.

This is true for indicators placed before the fuse as well as after it.

When the criterion of automatic voltage reset is enabled, LINETROLL-110E is not activated unless the fault causes a three-phase trip in the feeding within 3 seconds after the occurrence of the fault.

If there is one disconnection within 3 sec, followed by an automatic reclosing causing a fuse-operation, the indication starts, but will reset after 30 sec.

If the automatic reset is switched off, the indicator will continue flashing until it is reset manually or after the automatic timer period has elapsed.

4.5. Multiple faults

Multiple faults sometimes occur. Defective network components may burn or break due to the electro-dynamic force of the fault current and cause a second fault.

Another cause of multiple faults is the increase in the phase to ground voltage on the healthy phases due to the initial earth fault.

The phase to ground voltage may reach up to 1.7 times the nominal voltage, depending on the total impedance of the earth loop. If there are weak points in the line, they may not withstand such a large voltage increase. This type of fault may be difficult to find as they often are non-permanent and only appear in situations like the ones mentioned here.

Note: In this situation the indicators may show non-consecutive indication.
4.6. Capacitive discharges

The LINETROLL-110Eμ indicator is not directional, it therefore detects current without discriminating its direction. In case of an earth fault, the network capacitive energy discharges in the fault point. It should be checked that the capacitive discharge current downstream the indicator is below preset trip level in order to avoid the indicator erroneously activating upon earth faults.

If the total capacitive current exceeds the trip level, it is advisable to change the trip level or install the indicators in the branching points instead of in the main line. The capacitive discharge of a branching point is limited by its own capacitance, while in the main line the capacitive current of all the branches downstream the indicator is added. Underground cables have larger capacitance than overhead lines. This has to be taken into account when an overhead line feeds an underground cable.

The following simplified formula may be used to estimate the capacitive discharge current of a line:

\[ I_c = \frac{U \cdot L_a}{300} + \frac{U \cdot L_c}{K} \]

- \( I_c \) = Capacitive current in A
- \( U \) = Nominal voltage in kV
- \( L_a \) = Overhead line length in km
- \( L_c \) = Cable length in km
- \( K \) = 10; for oil impregnated
  5; for PEX cables
  3; for PVC cables

In order to avoid that the LINETROLL-110Eμ is activated by an earth fault downstream the indicator, the following criterion has to be met.

\[ I_c < I_t \]

where

- \( I_c \) = capacitive current downstream the indicator.
- \( I_t \) = Setting of sensitivity (6 ~ 120A)

To estimate the capacitive discharge current at any line point, you have to calculate the contribution from all the overhead lines and underground cables lengths only beyond that point.

![Figure 9: Capacitive discharge current calculation example](image-url)
4.7. PROGRAMMING

Programming of the unit is done from a switch-bank on the printed circuit board.

The indicator can be programmed to different current levels for either di/dt-sensing or threshold sensing.

4.7.1. Di/dt sensing

<table>
<thead>
<tr>
<th>Switch #</th>
<th>Di/dt Current level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 8</td>
<td></td>
</tr>
<tr>
<td>0 0 0 0</td>
<td>6 A</td>
</tr>
<tr>
<td>0 0 1 0</td>
<td>12 A</td>
</tr>
<tr>
<td>0 1 0 0</td>
<td>25 A</td>
</tr>
<tr>
<td>0 1 1 0</td>
<td>60 A</td>
</tr>
<tr>
<td>0 1 1 1</td>
<td>120 A</td>
</tr>
</tbody>
</table>

Table 1: Di/dt setting

4.7.2. Threshold sensing

<table>
<thead>
<tr>
<th>Switch #</th>
<th>Threshold level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 8</td>
<td></td>
</tr>
<tr>
<td>1 0 0 1</td>
<td>250 A</td>
</tr>
<tr>
<td>1 0 1 1</td>
<td>500 A</td>
</tr>
<tr>
<td>1 1 0 1</td>
<td>750 A</td>
</tr>
<tr>
<td>1 1 1 1</td>
<td>1000 A</td>
</tr>
</tbody>
</table>

Table 2: Threshold setting

4.7.3. Start/Stop criteria

<table>
<thead>
<tr>
<th>4</th>
<th>Start/Stop criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Current</td>
</tr>
<tr>
<td>1</td>
<td>Voltage</td>
</tr>
</tbody>
</table>

Table 3: Start/Stop criteria

4.7.4. Timer reset

<table>
<thead>
<tr>
<th>5 6</th>
<th>Timer reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0</td>
<td>2 hours</td>
</tr>
<tr>
<td>0 1</td>
<td>6 hours</td>
</tr>
<tr>
<td>1 0</td>
<td>12 hours</td>
</tr>
<tr>
<td>1 1</td>
<td>24 hours</td>
</tr>
</tbody>
</table>

Table 4: Timer reset

4.7.5. Auto-Reset

Programming of the automatic reset (AR) of indication when line has been energised for more than 30 sec (voltage or current).

<table>
<thead>
<tr>
<th>7</th>
<th>AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>OFF</td>
</tr>
<tr>
<td>1</td>
<td>ON *</td>
</tr>
</tbody>
</table>

Table 5: Auto-Reset

*) Note:
If Auto-Reset = ON, then CB-trip (circuit-breaker trip) must occur within 3 sec before indication starts.
5. MAINTENANCE

It is advisable to inspect the indicator once a year or 1 year after it was last activated. The inspection should include a functional test to show that the flash frequency is normal. NORTROLLs KBN-3 test and mounting tool is very useful for the test purpose, although any magnet could be used.

5.1. Battery replacement

The battery is fitted into the top cap of the indicator housing. To replace the battery, first disconnect the battery from the electronics board by pulling the battery plug, then pull the battery from the top cap. Fitting a battery is the reverse of removing. The spare battery, KBB-11, comes with a connector so the replacement can be carried out on-site.

![Battery Connector](image)

Figure 11: LINETROLL 110Eµ connectors

5.2. Reset battery monitoring

When the battery is replaced with a new battery the battery monitoring must be reset. This is done by short-circuiting the two pads on the PCB next to the dip-switch while at the same time powering the indicator by connecting the battery. See photo below.

To activate the reset, the battery must be disconnected and connected again.

The indicator has now reset the battery monitoring.

6. INDICATOR HOUSING

The indicator housing is made of high strength plastics. The material is highly UV stabilised and is flame retarding. The lens material, in addition, has excellent optical characteristics. An O-ring with silicon grease joint is used to provide a good seal between the upper cap and the lens. The line clamp is made of anodised aluminium and stainless steel. To protect the conductor the clamp has a semi-conducting neoprene layer.

The top cap of the indicator has a colour-coded label indicating the year of manufacture. See Figure 12.

![Top-cap Colour Coding](image)

Figure 12: Top-cap colour coding versus the year of manufacture
7. TECHNICAL SPECIFICATIONS

Nominal voltage: 6-66 kV

Starting criteria:
- Line energised for at least 5 seconds followed by a stepped instant current increase of 6, 12, 25, 60 or 120A

OR
- absolute phase current exceeding 250, 500, 750, 1000A

AND
- a three-phase disconnection of the line within 3 sec.

Required fault duration: approx. 25 ms.

(Factory programmable)

Reset criteria:
1) Voltage/Current reset after 30 sec. (Can be disabled)

The minimum required current for start/reset, depends on the settings of di/dt or threshold!

<table>
<thead>
<tr>
<th>Thr. hold [A]</th>
<th>Min. start/reset current [A]</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>10</td>
</tr>
<tr>
<td>500</td>
<td>50</td>
</tr>
<tr>
<td>750</td>
<td>50</td>
</tr>
<tr>
<td>1000</td>
<td>50</td>
</tr>
</tbody>
</table>

2) Timer reset 2h, 6h, 12h, or 24h.

3) Manually (KBN-3 reset tool/magnet)

Current consumption:
- Non-activated: 30–40 µA.
- Activated: 4 mA.

Battery:
- 3.6 V 16,5Ah type KBB-11

Battery replacement every 8-9 years or every 1500 operational hours, whichever comes first.

Indication: LED flash flashes: 12 lumens every 5 sec. (10 sec after 12 hours)

Ambient and storage temperature:
- -40°C to +74°C.

Weight: 460 grams.

Standards: Conform to IEC 68-2.

Tested according to:
- EN 61000-6-3 Generic standard — Emission for residential, commercial and light-industrial environments
- EN 61000-6-2 Generic standard — Immunity for industrial environments
- IEEE 495-1986 § 4.4.8

8. DIMENSIONS

Figure 13: LINETROLL 110Eµ physical dimensions
9. MOUNTING.

General .
LINETROLL 110Eµ mounts directly on
the high voltage conductor as shown in
Figure 16. It should be mounted as close as
possible to a traverse to escape line
vibrations.
To fully cover all kinds of faults,
NORTROLL recommend to mount
indicators on all the phases in multi-phase
networks. Locate the indicators at strategic
points along the line.

Before mounting.
LINETROLL 110Eµ is a programmable
fault current indicator.
See Table 6 for a complete survey of all
programming options.

Live-line mounting.
1. Fasten the LT110Eµ mounting and
testing tool to a hot-stick,
See Figure 14.
2. Open the indicator clamp.
See Figure 15.
3. Insert the indicator in the mounting
tool. Twist the indicator until the 2
luggs grip into the line clamp.
The indicator now starts flashing.
See Figure 14.
4. Force the indicator against the
conductor until the clamp closes.
To avoid lifting the conductor when
mounting move the indicator closer
to the line pole.
See Figure 16.
5. Untwist the hot-stick to unlock the
gripping lugs of the mounting tool
and remove it from the indicator.
The indicator will now stop
flashing.

Removal.
Fit KBN-3 mounting tool to a hot-stick.
Lock the mounting tool to the indicator.
Pull to release the indicator from the line.
Test of the battery.

Fasten the mounting tool to the indicator as described under "Live-line mounting" §3.

During the last few months of the battery’s life, an amber LED with a low flashing frequency (1/10 Hz) will indicate that less than 20% of capacity remains and that there is a need for battery replacement.

Programming.

Open the indicator by unscrewing the top-cap from the lens. See Figure 18.

Pull out the electronics board just as far as to enable operation of the switch-bank levers. See Figure 19.

Set the switches as required. Push the electronics board back into position. Align the top-cap arrow with the lens label arrow before closing the unit. See Ch 4.7 for programming details.
10. PROGRAMMING TABLE FOR THE LT110Eµ

<table>
<thead>
<tr>
<th>Sw #:</th>
<th>Description</th>
<th>Sw pos. (1 = ON)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensing technology</td>
<td>0</td>
<td>di/dt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Threshold</td>
</tr>
<tr>
<td>2 &amp; 3</td>
<td>Trip level (Low DR required: Sw #8 = 0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>00</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>01</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>60A</td>
</tr>
<tr>
<td>2 &amp; 3</td>
<td>Trip level (High DR required: Sw #8 = 1)</td>
<td>Threshold</td>
<td>di/dt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>00</td>
<td>250A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>01</td>
<td>500A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>750A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td></td>
<td>120A</td>
</tr>
<tr>
<td>4</td>
<td>Start/Stop criteria</td>
<td>0</td>
<td>Voltage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>Timer reset</td>
<td>00</td>
<td>2 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>01</td>
<td>6 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>12 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>24 hours</td>
</tr>
<tr>
<td>7</td>
<td>Auto-Reset (voltage or current)</td>
<td>0</td>
<td>OFF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>ON</td>
</tr>
<tr>
<td>8</td>
<td>Dynamic range (DR)</td>
<td>0</td>
<td>Low &lt; 100A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>High &gt; 100A</td>
</tr>
</tbody>
</table>

Table 6 Programming table
11. Flashing sequences

Transient fault:

![Transient fault diagram]

Comments:
- On transient fault, only the green LED flash until timeout after 24h.
- The indicator is ready for new fault within this 24 hour period.
- The red LED’s will NOT flash on transient fault.

Permanent fault:

![Permanent fault diagram]

Comments:
- The Permanent Fault indication (red LED’s) is delayed 70 sec to verify a permanent fault.
- Both red and green LED’s will flash on permanent faults until reset (timer, automatic on energizing of line or manual by use reset-tool).

Flashing frequency for both red & green LED’s are 1/5 Hz the first 12 hours and thereafter 1/10 Hz of the remaining time.
**Test & Reset**

The magnet must be kept at the yellow reset spot for minimum 2 sec to activate test or reset.

---

### Manual with magnet

![Diagram of test and reset sequence]

**Test sequence**

1. 2s
2. 2s
3. 2s

**RESET sequence**

- If the line energised; the GREEN LED only, flashes for 3 sec:

  ![Green LED sequence diagram]

- If the line is de-energised line; the RED LED’s only flashes for 3 sec:

  ![Red LED sequence diagram]

---

**Battery monitoring**

Battery Capacity monitoring (Yellow or amber LED)

- 8-9 years
- > 6 mnd
- Battery empty

---

*Bf=1/10 Hz*