LineTroll® 110Tμr

User Manual

LineTroll®

NORTROLL
FIND FAULTS FAST

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Terms:

Energised line: Voltage or current present

De-energised line: Voltage or current not present

LT= LineTroll

Ordering info:

Prod.no.:	Product:
04-1300-01:	LT-110Tµr (with radio & new line-clamp)

1. LINETROLL 110Tμr OVERVIEW

The **LINETROLL 110Tμr** is a line mounted fault indicator for local and remote indication.
The **LINETROLL 110Tμr** has an integrated radio that can communicate with a pole-mounted Nortroll Collector device (CmT 115C or others). The Collector can be interfaced to a SCADA-RTU or a communication device by means of dry relay contacts or serial-port for remote indication of faults..

The LT 110Tμr is a single phase unit, however they are normally used in groups of 3 to fully cover the different fault configurations which can occur. Deliveries come as a kit of **3 units** to each package.

The LT 110Tμr Fault Passage Indicator; detects down-streams faults in the OH-distribution network. Detectable faults include short circuit and earth fault, if the network provides sufficient earth fault current.

The indicators are placed at strategic locations along the line, such as after branching points and sectionalisers. The indicators mount directly on the high voltage conductor.
Live line mounting is easily and rapidly done with a shotgun type Hot-Stick.

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, indication is by means of an intermittent LED- flash (1 super intensive red LED's for a permanent fault and 1 regular Green LED for transient faults).
The LED-flash can be seen within 100-200 metres distance. The lens of the indicator allows for uniform 360 degrees monitoring.

LINETROLL 110Eμr provides fast fault location through remote indication, enabling reduction in outage times. This represents enhanced service to the customer thereby improving the utility image.

Another important aspect of using fault indicators is that unnecessary operations of circuit breakers and sectionalisers to locate faults can be avoided. In this way the indicators can help to reduce wear and tear, as the reclosing cycle can cause stress to switchgear.

2. FUNCTIONAL DESCRIPTION

The LINETROLL 110Tμr continuously monitors the line voltage and phase current, the two sources of information it needs to operate. The unit is fully self contained, no external transformers or connections are required.
During normal line conditions; the indicator does not flash.

The device is looking for a specific sequence of line conditions to occur before it starts indicating locally and remotely. The general sequence is as follows:

A. The line is energised (voltage or current present) for at least 5 seconds.
B. The line current increases instantaneously by a user defined set value (the step level), or exceeds a user defined threshold value (if enabled).
C. The line is de-energised. Voltage or current not present (optional auto reset when the line is re-energised)

The user can program the criteria for operation to suit his local requirement by manipulating a bank of micro-switches inside the indicator.

Note: Voltage or current present as start and stop criteria is user programmable.

2.1. Sensors

The magnetic field generated by the line current induces a signal in the indicators 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 instantaneous current level increases, as is the case when a faults occurs.
The trip level of the di/dt sensor can be set to +500A or +1000 A by means of a switch bank inside the unit.
A normal variation of the load current will not activate the LINETROLL 110Tμr.

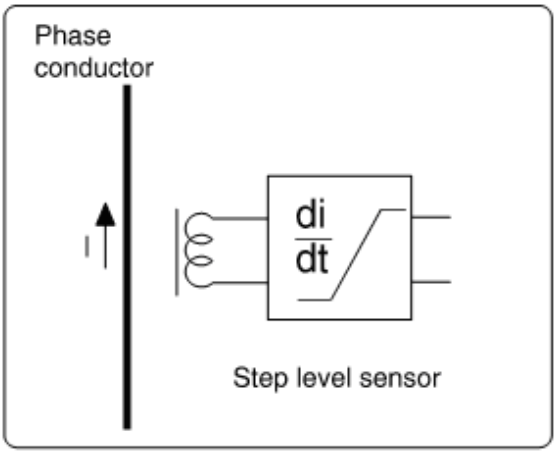

Figure 1: Magnetic field sensor principle.

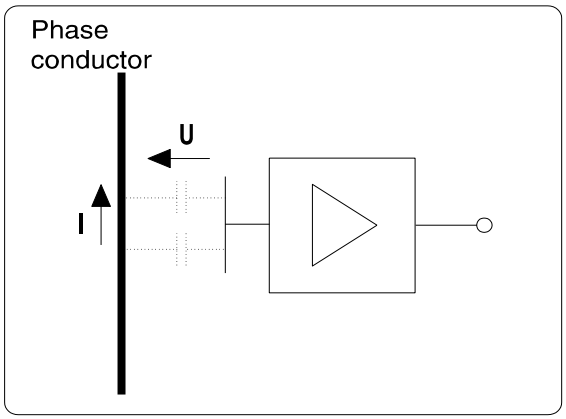

Figure 2: Electric field sensor principle

The line voltage is detected by means of an antenna housed inside the indicator.

2.2. Activation criteria

The LINETROLL 110Tμr 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 magnetising inrush current, it's di/dt sensor is blocked for 5 sec upon energising of a line. While the blocking time elapses, the line current can stabilise so as not to cause triggering of the di/dt sensor.
A fault duration exceeding 60ms is required to activate the indicator.

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

A rapid line current increase followed by a de-energising of the line within 5 sec will activate the indicator.

2.3. Indication

The main mode of local indication is 1 super intensive red LEDs which indicate for permanent faults.
Secondary indication is a single regular green LED.

- For a transient fault: The green LED flashes for 24h (no red LED's flash).
- For a permanent fault: The super intensive red LEDs flash until reset (timer, auto or manual reset).

*** Note: to verify a permanent fault is present, the red LED indication is delayed 70 sec. See more detailed info in *Ch 10 Flashing sequence.***

2.4. Reset criteria

The indicator can be set to 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.

2.5. Battery lifetime / maintenance

A 3.6V, 16.5 Ah Lithium battery powers the indicator. When idle, the 110Tμr consumption is a few micro-amps only. This gives some 7-10 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.

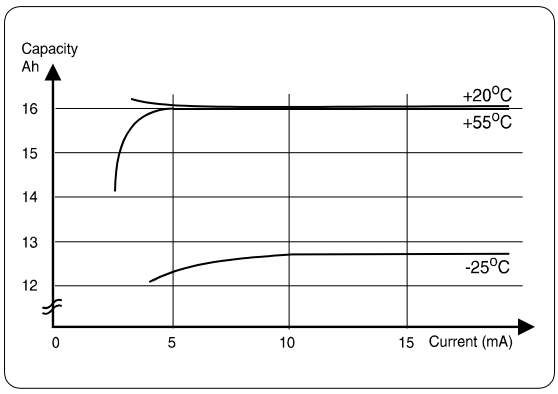

Figure 3: Initial battery capacity.

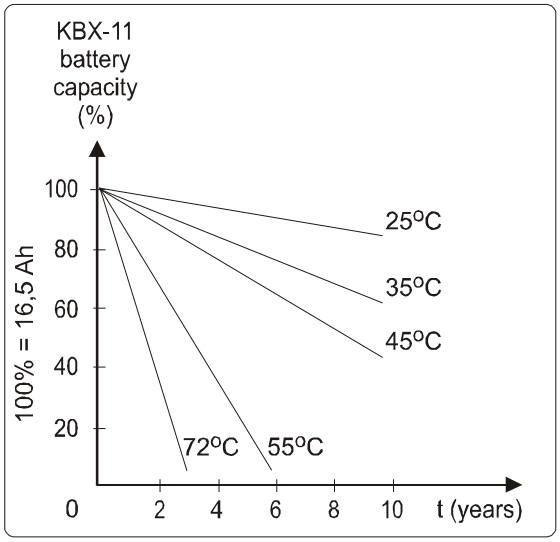

Figure 4: Remaining battery capacity as a function of years and temperature

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.
The 110Tμr will send a message "Low battery" to the Collector.

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 that the di/dt current change exceeds the detection level or absolute threshold level dependent on programming.

3. APPLICATION

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

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

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

- Next to line branching points, to help 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 an indicator installed may be faulty yet remain unidentified as such.

- Near line points with sectionalisers to rapidly pinpoint and isolate any faults, and to facilitate rapid reconnection of the healthy sections.

The LINETROLL-110Tμ/r is suitable on:

- 66-138kV Sub-Transmission & Transmission networks.

- Radial lines.

- Multiple circuit lines (In this case current reset must be used)

- Solidly-earthed-neutral networks.

- Resistor grounded and isolated neutral networks.
  If indication of earth-faults is required, the indicators sensitivity and the networks residual fault current has to be taken into account.

- On conductors of 5-36 mm diameter.

with special emphasis on:

- Areas with unpredictable electro-magnetic fields caused for example by parallel lines. Here the indicator can be used as a better suited complement to the three-phase fault indicator LineTroll 111K & LineTroll 3100.

Do *not* use LT110Tμr on:

- Ring lines or multiple fed lines.

4. APPLICATION NOTES

The aim of this section is to describe how the LINETROLL 110Tμr indicator behaves for 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 5 seconds inrush blocking which prevents it from being activated until after the line current has stabilised. Once the blocking time has elapsed, the indicator is enabled for fault detection.
See Figure 5.

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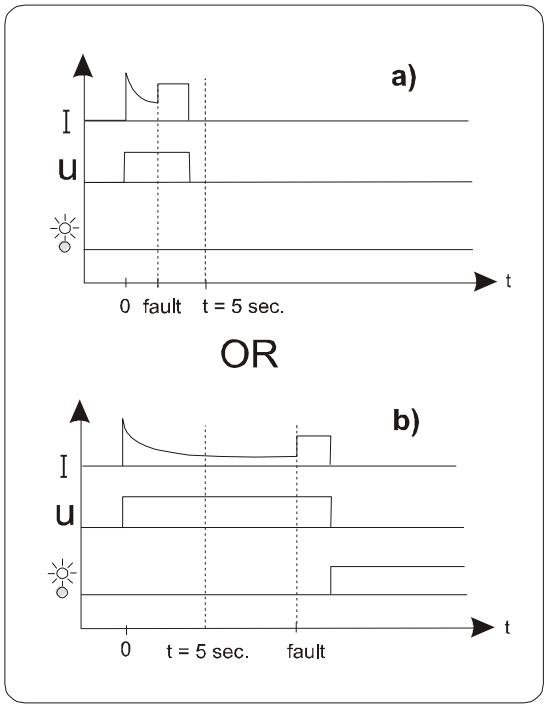


Figure 5: Criterion of the blocking time.
a) shows the sequence when a fault occurs less than 5 sec after line has been energised:
→ No Indication.

If, upon re-energising of a line, the unit is already indicating due to a previous fault, the unit will reset if the voltage or current reset option is enabled. However even in this case the indicator will flash for 30 seconds (depending on the programming, see 4.7) before finally extinguishing. *See* Figure 6.

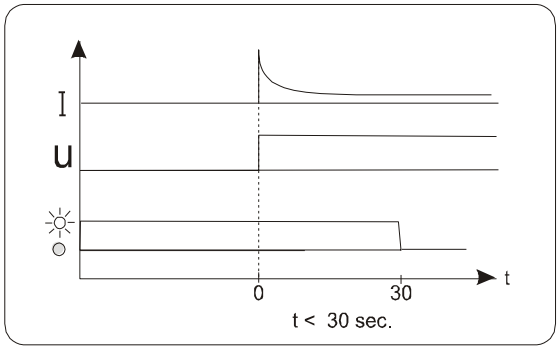


Figure 6: Delayed reset of flashing.

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 7.

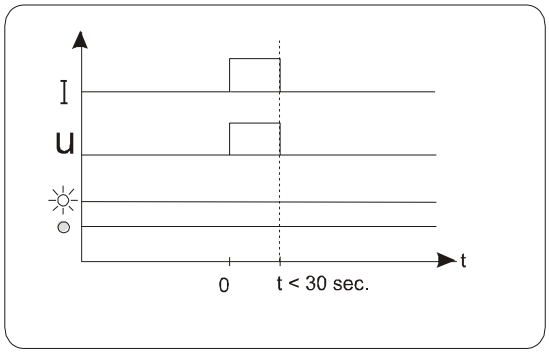
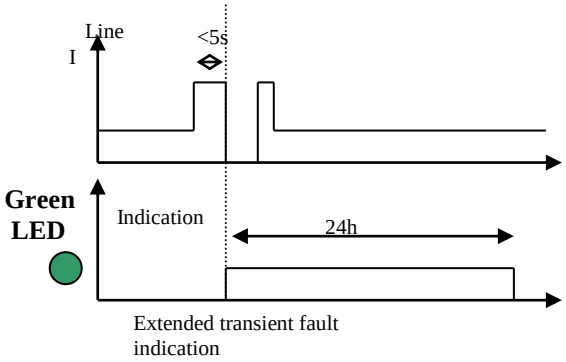


Figure 7: Reclosing upon a faulted line.

4.3. Transient faults

Transient faults cleared within the last automatic reclosing, can be detected by the green LED. The green 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, then the voltage of the healthy phase(s) may result in no indication or a reset of indication.
This is true for indicators placed before a fuse as well as after it.

When the criterion of automatic voltage reset is enabled, the LINETROLL-110Tμr is not activated unless the fault causes a three-phase trip within 5 seconds after the occurrence of the fault.
If there is only one disconnection within 5 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 can sometimes occur. Defective network components may burn or break due to the electro-dynamic force of a fault current and cause a second fault.

Another cause of multiple faults for network where the neutral is isolated from earth or earthed via a resistor, is an increase in the phase to ground voltage on healthy phases due to an 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 any 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-consequent indication.

4.6. Capacitive discharges

The LINETROLL-110Tμr indicator is not directional, it therefore detects current without discriminating 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 of the indicator is below the 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 of 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 for a line:

$$Ic = \frac{U * La}{300} + \frac{U * Lc}{K}$$

Ic = Capacitive current in A
U = Nominal voltage in kV
La = Overhead line length in km
Lc = Cable length in km
K = 10; for oil impregnated cables
5; for PEX cables
3; for PVC cables

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

$$Ic < It$$

where
Ic = capacitive current downstream of the indicator.
It = Setting of sensitivity (500 or 1000A)

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 beyond that point only.

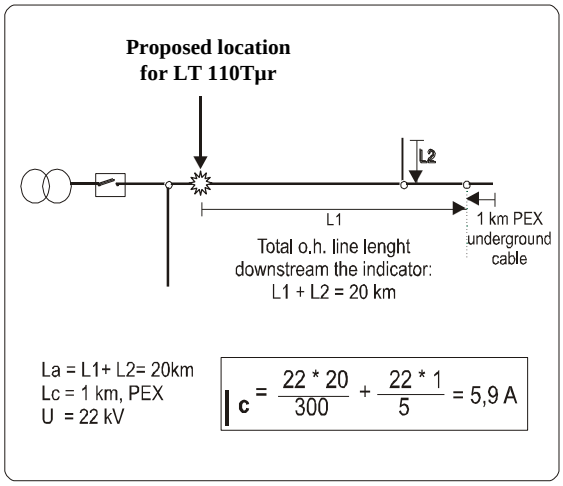


Figure 8: Capacitive discharge current calculation example

4.7. PROGRAMMING

Programming the unit is done via a switch-bank on the printed circuit board. See fig. 9 The indicator can be programmed to different current levels for either di/dt-sensing or threshold sensing.

4.7.1. Status Indication

Red led: Energized line (voltage/current)
Yellow led: Not energized: yellow led.

Switch # 1	Duration of status indication
0	2 min
1	5 min

4.7.2. Di/dt sensing

Switch #			Di/dt & Threshold level
2	3	8	
0	0	0	Di/dt = + 500 A
0	1	0	Di/dt = + 1000 A
1	0	0	Threshold = + 500 A
1	1	0	Threshold = + 1000 A

Table 1: Di/dt setting

4.7.3. Start/Stop criteria

Switch # 4	Start/Stop criteria
0	Current > 50A
1	Voltage > 50kV

Table 3: Start/Stop criteria.

4.7.4. Timer reset

Switch #		Timer reset
5	6	
0	0	2 hours
0	1	6 hours
1	0	12 hours
1	1	24 hours

Table 4: Timer reset

4.7.5. Auto-Reset

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

Switch 7	Auto reset on return of voltage/current
0	OFF
1	ON *

Table 5: Auto-Reset

*** Note:** If Auto-Reset = ON, then a transient fault will be indicated for 24h by a single green led.

Note:
To enable new switch-settings, a RESET of the indicator is required; This can be achieved via reconnection of the battery or a magnet at the RESET-spot.

4.7.6. Emote programming

Switch # 8	Remote programming
0	OFF (only local programming)
1	Enables the indicator for remote programming from a collector f.ex. CmT-115C.

Table 6: Remote programming

4.7.7. Battery counter reset

Rotary switch	Battery Reset LT 110Tμr
Switch for Radio address setting	
0	Reset battery counter

Table 7: Battery counter reset

Figure 9: Close-up of switch-banks.

4.7.8. Programming of radio addresses

For programming of the radio addresses please refer to the User Guide for the Collector.

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 with a magnet to show that the flash frequency and intensity are normal.

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 new battery is the reverse of the removal procedure.
The spare battery, KBB-11, comes with a connector so the replacement can be carried out on-site.

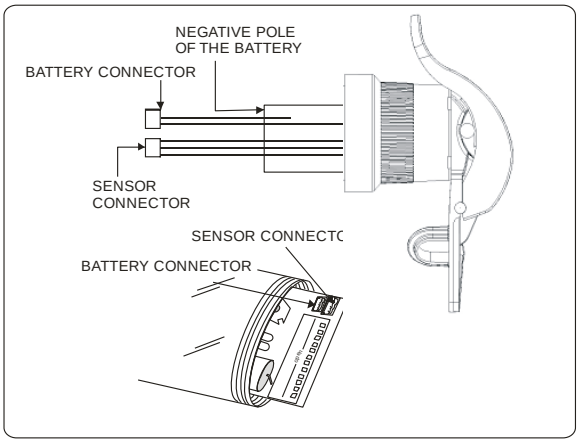


Figure 10: LINETROLL 110Tμr connectors

5.2. Reset battery monitoring

When the battery is replaced with a new battery, the battery monitoring must be reset. With the battery disconnected reset can be done setting Rotary switch to position.*(see figure 11b.)* while at the same time powering the indicator by connecting the battery.
The indicator will confirm the reset with a continuous green flashing. Unplug the battery and then plug the batter in again.

LineTroll 110Tμr

Figure 11b. Rotary switch in location 0 for resetting battery counter on LineTroll 110Tμr.

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The indicator battery monitoring has now been reset, and the green led will stop flashing.

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 joint is used to provide a good seal between the upper cap and the lens.
The line clamp is made of PA (Poly Amid).

The top cap of the indicator has a colour-coded label indicating the year of manufacture. See *Figure 11Figure 11: Top-cap colour coding versus the year of manufacture*

7. TECHNICAL SPECIFICATIONS

Nominal voltage : 66-138 kV

Starting criteria :

- Line energised for at least 5 seconds followed by a stepped instantaneous current increase of >500 or >1000A

OR

- absolute phase current exceeding 500 or 1000A

AND

- a three-phase disconnection of the line within 5 sec.

Required fault duration: > 60ms (20ms on request)

Reset criteria:

1) **Voltage/Current reset** after 30sec. (Can be disabled)

The minimum required current/voltage for start/reset'

Min. start/reset current [A] / Voltage [kV]	
Current	>50A
Voltage	>50kV

2) **Timer reset** 2h, 6h, 12h, or 24h.
3) **Manually** (magnet)

Line diameter: 5 – 36mm

Current consumption:

Non-activated: 300 µA.

Activated (flashing): 4 mA.

Battery: 3.6 V, 16.5Ah type KBB-11

Shelt life: More than 10 years

Flashing: 1500 flashing hours

Battery replacement normally every 7 – 10 years.

Indication:

1 Super intensive red Flash every 3 sec (10 sec after 12 hours).

1 green LED for transient fault

1 amber/Yellow LED for battery warning

Intensity: > 30 Lumens

Ambient & storage temp.: -40° → +85°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

Short Range Radio:

The radio transmits a status telegram to the Collector (ComTroll 110C or other) every 1min; containing permanent or transient fault info, low battery warning and Heart Beat.
Frequency: ISM band, 2.4 GHz
Output: 1mW (0dBm), range: up to 20m* Line Of Sight (LOS).
* Margin = 20dB, with a Receiver sensitivity = -90dBm (=CmT 110C).
Longer distance may be achieved by taken special action when mounting and positioning the antenna and the indicators.

8. DIMENSIONS

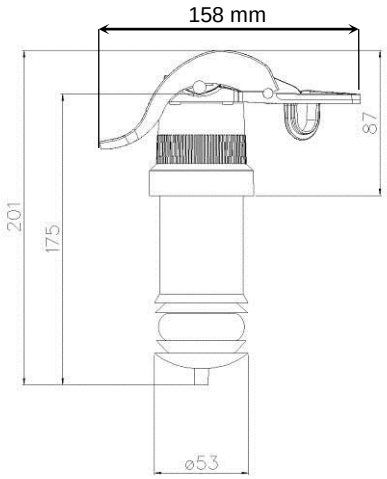


Figure 12: LINETROLL 110Tμ/110Tμr physical dimensions. All figures in mm.

9. MOUNTING.

LINETROLL 110Eμ mounts directly on the high voltage conductor using a shotgun type Hot-stick as shown in fig 14. It should be mounted as close as possible to a traverse to escape line vibrations.

Figure 14Hot-stick mounting, - close to the traverse

To fully cover all kinds of faults, NORTROLL recommend mounting indicators on all the phases in multi-phase networks. Locate the indicators at strategic points along the line.

9.1 Before mounting.

Make sure the indicator is programmed (see *4.7 Programming*) and battery connected before mounting on the line.

9.2 Live-line mounting by using a *Grip-All-Clamp* (shot-gun) Hot-Stick:

1. Fix the indicator to the hot-stick and raise/lift it to the line as shown in fig 14.
2. Pull the stick downwards and against the line, until the line is in the correct position within the clamp, see fig 15.
   Release the Grip-All-Clamp stick.

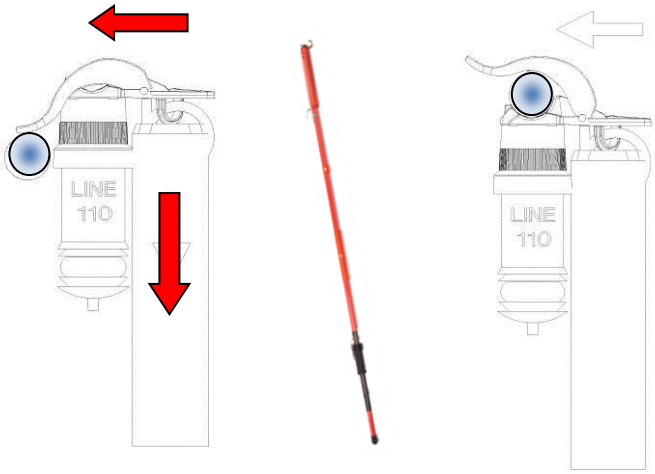


Figure 15: Mounting using Grip-All clamp hot stick

9.3 Removal.

1. Fix the claw in the “eye” on the horizontal part of the line-clamp, see fig 15.
2. Pull down, to release the indicator from the line.

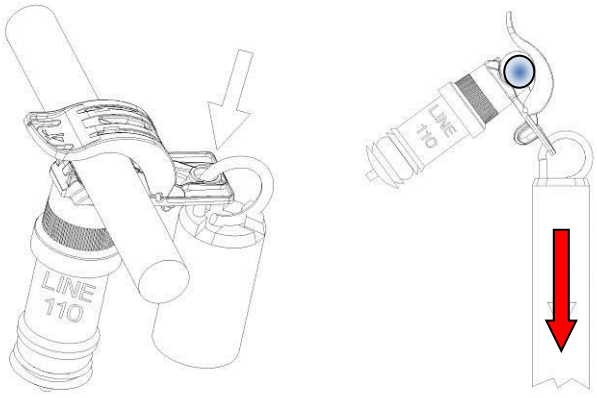


Figure 16: Removal from the line.

Test of the battery.

Battery can be tested by placing a magnet on the yellow spot marked: *RESET*.

After 2 sec the indicator will respond by flashing all the LED's, see section *10. Flashing sequences -Test/Reset*.

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

The LT-110Tμr will in addition, transmit a "Low-Battery" message to the Collector.

Programming.

Open the indicator by unscrewing the top-cap from the lens. *See **Figure 17***.

Pull out the electronics board just as far as to enable operation of the switch-bank levers. *See **Feil! Fant ikke referansekilden. 18***. 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 section 4.7 for programming instructions.

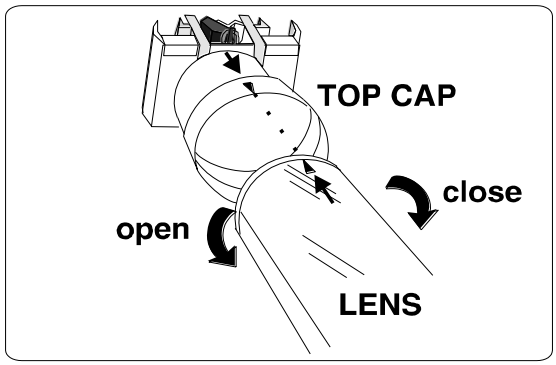
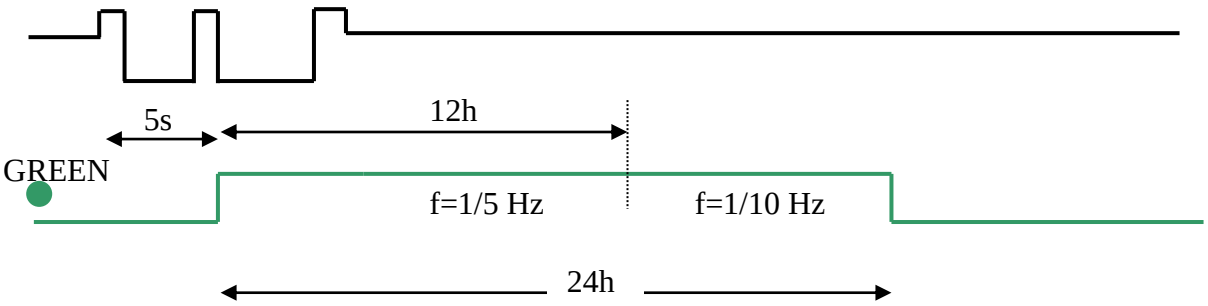


Figure 17: Opening/ closing the LINETROLL 110Tμ.

10. FLASHING SEQUENCES

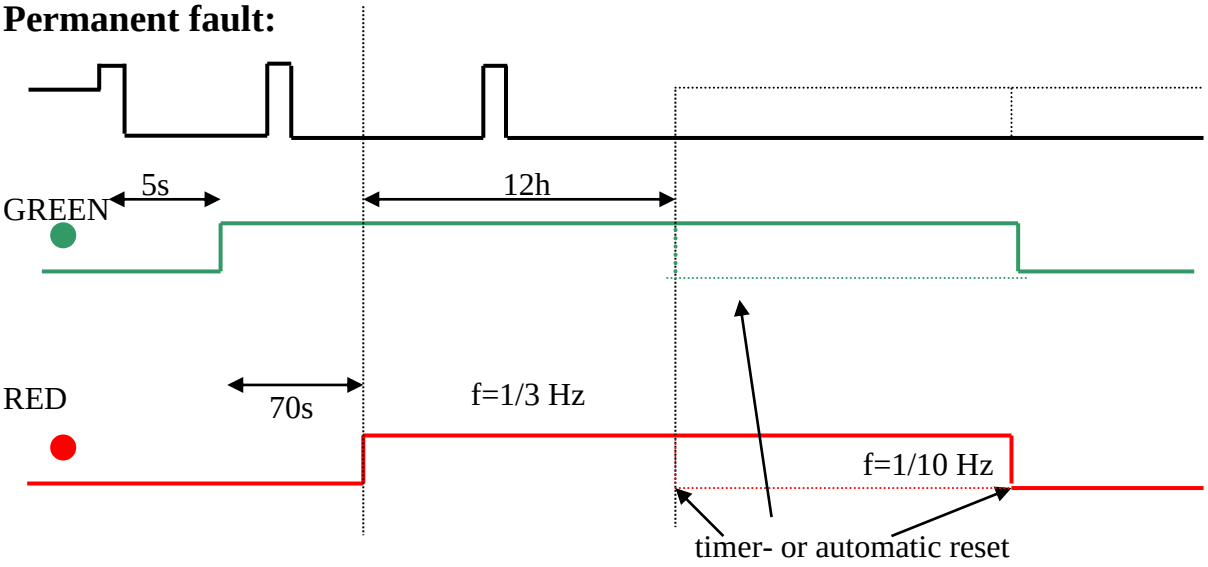
Transient fault:



Comments:

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

Permanent fault:



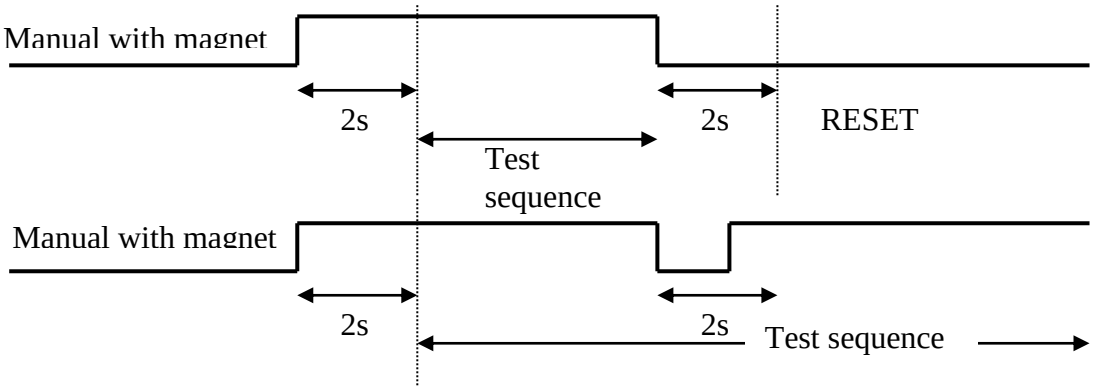
Comments:

- The Permanent Fault indication (red LEDs) 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 LEDs is 1/3 Hz the first 12 hours and thereafter 1/10 Hz of the remaining time.

Test & Reset

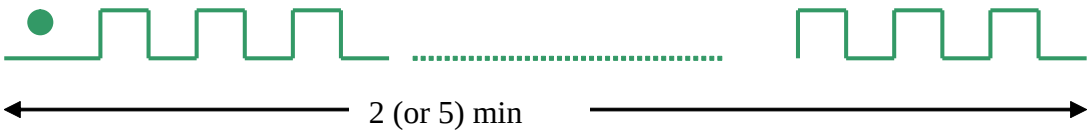
The magnet must be kept at the yellow reset spot for minimum 2 sec to activate test or reset.



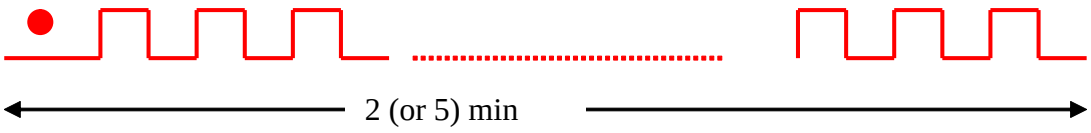
TEST-sequence; all LED flashes and a "Fault" signal is sent to the Collector.

RESET-sequence

- If the line is energised; the GREEN LED only flashes for 2 (or 5) min (ref SW#1).



- If the line is de-energised line; the YELLOW LED only flashes for 2 (or 5) min (ref SW#1).



Battery monitoring

Battery Capacity monitoring (Yellow or amber LED)