

# LiSa<sup>®</sup> SYSTEM FOR DETECTION OF CUT-OFF POWER LINES



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## **INTRODUCTION**

Power lines in electro distribution network are often severed for different reasons. In most cases such interruptions of a power line is detected by a conventional protection unit which also assures disconnection of such line. This type of protections normally works on the basis of detection of over-current, which appears when a fallen power line makes electrical contact with the ground.

However, there are several situations when the fallen line creates a fault that conventional protections are not able to detect. For example soil conditions with a high resistive value; such as dry sand, rocks or asphalt... Similar problem appears with usage of half-isolated conductors, which despite all the benefits they have, usually when cut- of conductor do not make contact with the ground (high impedance fault). The main reason is that isolation is often extended over both ends of the conductor or the line lands that both ends are lifted from the ground. An additional problem is for example that if a feeder line collapse near to the end of that line. Because of the distance from the protection unit it is possible that the protection unit will not detect the small leakage current.

All above cases of “down” power-lines present a dangerous situation. Humans or animals that come in contact with such conductors can be killed , or suffer grievous injuries. Arcing can start uncontrolled fires.

In some areas power distribution companies are facing another problem and that is stealing of cables and equipment. This presents a problem not only to the distribution companies as a lost of income from interrupted power supply and significant costs with replacing the equipment, but also for clients. Strategic objects, such as hospitals, or other facilities important from the view of state security usually have their own backup supplies, but any such event presents it self as a disturbance in normal operation.

## **RESEARCH**

When trying to find appropriate solution it soon become clear that with classical protection, based on measuring differences in current, this problem can not be solved. That’s why we focused on the quantity that is present before the interruption and changes significantly after the interruption. **This is the system of voltages at the end of the power line.** We found:

- Conditions under which voltages change
- Which voltages, under what circumstances and to what magnitude

## **THE SYSTEM**

System LiSa® with built in network analyzer MC760L and communication adapter MI480L is joining both remote control of power supply quality on the secondary side of transformer station, and possibility of detecting, analyzing and sending information about faults and types of faults in transformer stations and in the network, mostly cut off power lines. It is intended to be used in Medium voltage (MV) and Low voltage (LV) power distribution networks.

### **Remote control of power supply quality and monitoring of transformer stations**

Network analyzer MC760L is intended for constant analysis of power supply quality according to standard SIST EN50160. The onboard memory carries reports for a period of previous 7 years and 170.000 anomalies from standard values can be stored. This allows the user to find possible cause for disturbances in the network. For each observed quantity it is possible to set different limits and required quality in monitoring period. The most important features of MC760L are:

- Analysis of power supply quality according to SIST EN50160
- Measuring of over 140 quantities (U,I,P,Q,PF,PA,f,  $\varphi$ , THD, MD, Energy, Cost management...)
- Accuracy class 0,5
- Harmonics analysis of phase and phase to phase voltages and currents up to 63rd harmonics
- Up to 4 I/O modules (always in pairs – analogue outputs, tariff inputs, pulse outputs, digital inputs, alarm outputs)
- Simple setting via MMC card, which can also be used for data transfer

According to SIST EN50160 it is monitoring:

- Frequency variations
- Voltage variations
- Voltage Dips
- Voltage Interruptions
- Voltage Unbalances
- Transients
- Flickers
- THD's
- Harmonics

MI480L is a GPRS/RS485 communication adapter used for sending data via GPRS communication to the server, the same communication is used for setting the device. For sending alarm messages it is using SMS communication.

### **Detection of cut off power lines**

#### **Philosophy**

Measuring of secondary, low voltages with MC760L gives us information about failure, which can be either, fuse blow, cut off power line or lines, primary supply failure ... but it does not give us unambiguous information about broken conductor(s). For a reliable assessment of the situation more information is required. LiSa<sup>®</sup> can process this information from primary side of transformer from existing indicators, already installed in transformer station or from a voltage indicator installed in the LiSa<sup>®</sup> system and connected to the primary side via capacitive dividers.

In case of fault the system with built in logic analyses type of fault. The alarm about the failure is sent to the distribution centre where special software processes all the data and by knowing network topology reports in which sector fault occurred and eventually sends the command to plug out damaged sector.

This description presents basic philosophy of detection of cut off power lines. There are different types of hardware detector with different equipment which corresponds to the topology of the network, protected lines, installation points on the line, equipment of the transformer station and demands of the electro distribution company.

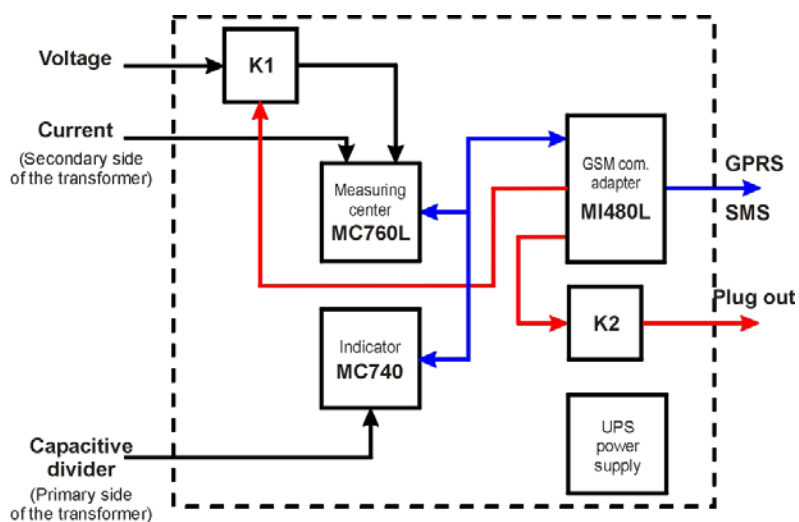
### LiSa® HARDWARE DETECTOR

The main parts of the hardware detector are:

- MC760L Measuring centre (or other appropriate type of MC)
- MC740 Measuring centre (redesigned indicator) (option)
- MI480L Communication adapter and controller
- Capacitor dividers (option)
- UPS power supply module
- Contactor for remote plug out



The system is mounted in standard power case of dimensions 500 x 500 x 210 mm, appropriate for mounting in the inside or on the outside of transformer station.



### MEASURING PART - CONNECTIONS

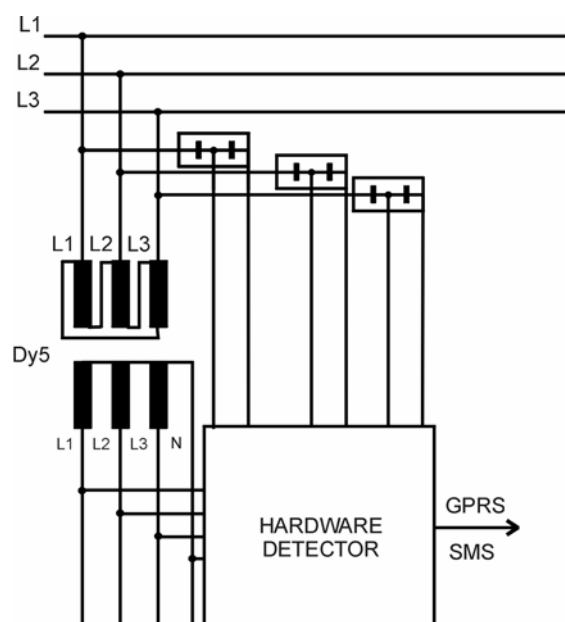
One part of the detector is connected on the secondary side of the transformer, while the other part is connected to the primary side of transformer in front of primary fuses, via appropriate capacitive dividers.

#### Secondary side

Voltages from the secondary side are directly connected to the measuring part of the system (MC760L). Currents, if needed to provide additional information of the system (I, P, Power Quality...), are connected via appropriate current transformers.

**Primary side (optional)**

On the primary side of transformer, in front of the primary fuses, are connected appropriate capacitive dividers. MC740 indicator is connected on them, to provide the information about the asymmetry and the presence of primary voltage. These information are transferred to the MI480L communication adapter via RS485 communication. As mentioned before different variations of the detector are possible

**TEST PART**

If we take in to consideration that cut- off of power line is a very rare event, the system is usually in a state of readiness. To ensure its full functionality, the MI480L communication adapter has built in controller which does periodical tests and control of the UPS. Frequency of testing can be set by the user or started manually. On completion of the test a report is send to the database server.

**COMMUNICATION PART**

A MI480L communicator adaptor is used for communication with the database server .Settings are downloaded and measurements uploaded through this piece of equipment. The MI480L communication adapter has a built in GSM modem, facility to function with a SIM card of the local mobile communication provider, RS485 communication, digital inputs, relay outputs, microprocessor... The MI480L uses standard commercial mobile network of the local mobile communication provider to communicate with database server and SMS concentrator. RS485 communication via MODBUS protocol is used for communication with internal devices.

## DESCRIPTION AND PRINCIPLE OF OPERATION

### Measuring centre MC760L

Measuring centre MC760L is a high speed instrument that is capable of constantly measuring more than 140 parameters of the three phase system. Besides measuring inputs it is also equipped with two digital inputs.

The instrument have programmable features that allow the user to set limits on the measuring values and on the state of the digital inputs (1-0) that are detected as an alarm conditions. To avoid any unwanted false alarms that may occur because of disturbances or short-time interruptions, the alarm can be delayed by manual setting of 1 to 10 seconds. These alarms, conditions, are constantly monitored by MI480L communication adapter via RS485 communication.

### Setting of MC760L

Primary and secondary voltages are set depending on transformer characteristic.

Alarms in the first two alarm groups are set for purpose of detection of failures. Other alarms can be set by the user as will.

The MC760L has the ability to analyse the Quality of Power supply. The instrument collects the data about the quality of the power supply in the network and compiles reports based on this information

Detailed reports and user defined measurements, can be stored in 8Mb built in flash memory. This data can be downloaded by MMC memory card in order to make detailed analyses of the system. Shorter form of report and selected measurements of the system (I, U, P, PF, f...) can also be sent to the database server via GPRS communication.

### Communication adapter MI480L

Communication adapter MI480L constantly monitors the MC760L. The primary reason for this is to that in case of alarms, it collects all information from the MC760L and according to this data the appropriate SMS message is formed. This message is then sent to the SMS concentrator or directly to the maintenance staff via the standard SMS mobile communication. Messages from different points, gathered in concentrator are than processed, to formulate logical messages, taking in to consideration topology of power distribution network and setting points of LiSa<sup>®</sup> devices in this network.

The other function of MI480L is to collect the data and measurements from the MC760L in user defined intervals (from 5 – 120 minutes). This data is stored in the internal memory and sent via GPRS communication to database server at the predetermined time intervals. Download intervals can be set from 15 minutes to 24 hours. A weekly report about the quality of power supply can also be sent.

MI480L is also responsible to trigger the test procedure in the system. Test report is sent to the SMS concentrator and via GPRS to the server with the next set of data. If there is a problem in procedure it informs SMS concentrator or specified mobile phone via SMS.

## ***OPERATION***

The system operates in two regimes:

- The first one is normal operation, where MC760L is measuring and comparing voltages and digital inputs, to detect anomaly in the operation and report it to SMS concentrator, user.
- The other one is testing regime. Self test of the device can be triggered manually or remotely. In this phase the system is simulating faults in order to check if all devices are working OK. Self test can also be triggered periodically. In both cases, if the system is OK or if a problem persists, the SMS is send to the SMS concentrator.

## ***DETECTION OF FAULT***

When it comes to cut- off of power lines, a difference in phase to neutral and phase to phase voltages occur. Values are not zero; because of induction and transformation of voltage potential, they have a certain value.

To detect a broken power line the MC760L uses standard built in alarm function. With additional information from the indicator, voltage drop because of other reasons such as a blown primary fuse are eliminated.

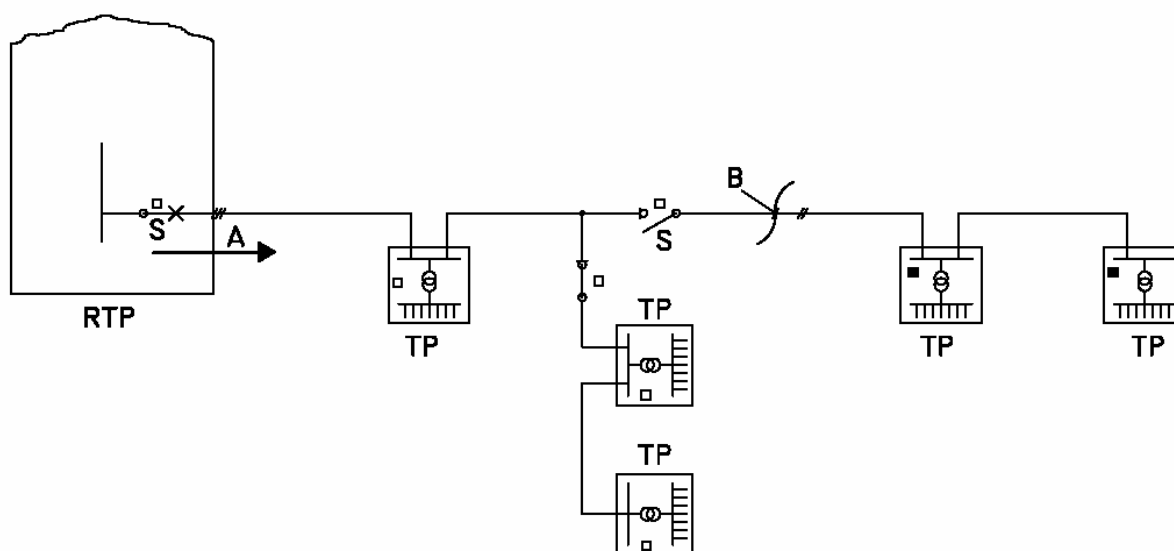
To eliminate an alarm because of short time disturbances in the network, the delay function on the MC760L can be set for a delay between 1 to 10 seconds

## CONCLUSION

Example of setting LiSa® devices in MV network

Legend:

- |   |                      |    |                     |
|---|----------------------|----|---------------------|
| ■ | Device activated     | B  | Line cut off        |
| □ | Device not activated | S  | Switch              |
| A | Energy flow          | TP | Transformer station |



RTP Divider transformer station

With appropriate location of LiSa® devices and with remote automatic switches location of failure can be detected and damaged line disconnected. In simple applications a message can be sent to mobile phone.

In case of wide application and with combination of data collecting, monitoring of power supply quality and in combination of existing SCADA system for management and control, SMS concentrator and database server should be used.



## DATABASE SERVER AND SETTING APPLICATION

Database server is developed on the Linux platform. On it runs web application that enables user to set the parameters of the hardware detector and collects the data from them. Data and measurements are stored in the MySQL database, and can be viewed in graphical or tabular form. Access from other applications is also possible to import the data into an existing system.

LiSa<sup>®</sup> hardware detector connects to the server in a user defined periods in order to send measurements and reports and to download new settings if they exist. For this it uses GPRS communication.

## SMS CONCENTRATOR

SMS concentrator is a specific application which can also run on the database server or some other computer. It is combination of GSM modem, which collects SMS messages from hardware detectors and software with built in topology of electro distribution system and positions of the hardware detectors.

This device collects and collates the SMS messages, alarms, from hardware detectors, processes this data and forwards it to the responsible staff by SMS and/or e-mail. Depending on the built in logic, type of hardware detector and equipment of the transformer station (automatic disconnection switch) it can also provide the information to disconnect the damaged power line.

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