Unofficial translation

RELAY PROTECTION OF THE MAIN GRID AND CUSTOMER CONNECTIONS

Contents

Relay protection of the main grid and customer connections

1 Introduction

Fingrid's application guideline for relay protection presents the operating principles of the relay protection in Fingrid's 110, 220 and 400 kV power networks and the requirements for operation of the protection systems of Fingrid customers (hereinafter referred to as 'customer'). The application guideline ensures that the relay protection of the connected power networks is compatible with Fingrid's systems.

Pursuant to the general connection terms and conditions, a customer connected to the main grid shall collaborate with the parties connected to the customer's network to ensure that the networks and associated electrical equipment of these parties meet Fingrid's general connection terms and conditions and other guidelines and requirements governing the implementation of a connection.

2 Main principles of the main grid relay protection

In accordance with the N-1 redundancy rule used in the main grid, no single network fault may trigger an expanding disturbance or loss of stability. Stability may be lost as a result of a prolonged fault in the 400 kV network or a loss of power in the power network.

2.1 400 kV power network

To maintain stability, all short-circuit faults in the 400 kV power grid are separated by means of a relay protection no later than 0.1 seconds after the start of the fault. To ensure a rapid trip, 400 kV switching stations are equipped with busbar protection and 400 kV power lines and transformers are equipped with duplicated protection that works with no delay. T-branch stations have no busbar protection but their busbars are protected by instantaneous power line protection. All 400 kV circuit breakers have breaker fault protection that isolates the fault in approximately 0.25 seconds if a circuit breaker fails to operate.

2.2 110 and 220 kV power grid

The 110 kV and 220 kV power lines of the main grid are meshed. The 110 and 220 kV lines of the main grid are protected by means of two primary protection schemes (two distance relays or a distance and a differential line relay) or a primary protection relay (distance relay) and a backup protection relay (overcurrent and earth fault relay). All new implementations use duplicated primary protection.

The protection detects short circuits and normal earth faults (fault resistance < 20 Ω) within 0.5 seconds.

A. When the meshed grid is short (0...5 Ω), the non-delayed trip of the primary protection must cover the entire line, which necessitates a communications link for the protection or a line differential protection. A line reactance (x) of 5 Ω corresponds to 13–18 km of overhead lines, depending on conductor type.

B. If the ring lines are long (more than 5 Ω), the tripping of a fault near the end of the line may occur in the delayed zone of the primary protection. The primary protection of the substation near the fault operates with no delay. Only a more distant station may continue to feed fault current. The total duration of current may not exceed 0.5 seconds in such faults.

In the event of a power line short-circuit fault, the backup protection mainly operates with a delay of 0.1–1.0 seconds, depending on the level of fault current and the location of the fault. Backup protection usually operates most rapidly when a fault occurs near the beginning of power lines that originate from large transformer substations. The protection must operate rapidly close to substations, since the reach of voltage dips voltage dips is large in such locations. For faults near the end of long power lines, the time could be a few seconds if the backup protection handles the trip.

Earth faults with a high fault resistance (approx. 20–500 Ω) are usually disconnected in 1–3 seconds, but always within 5 seconds from the start of the fault. Primary protection and/or backup protection contain a sensitive earth fault trip function.

If more than 1 MW of power generation is connected to a 110 kV power line of the main grid, a synchro-check will be implemented at both stations of the power line to prevent an asynchronous connection.

3 Requirements concerning the relay protection of customer connections

3.1 Compatibility

To ensure the dependability of the main grid, customers are expected to have fault clearance times that ensure the customer's network protection scheme is coordinated and compatible with the main grid protection. If the customer cannot implement protection in their network in accordance with the principles presented in this instruction, the customer must contact Fingrid to discuss the protection scheme.

Electrical equipment connected to the main grid and electrical equipment directly or indirectly connected to the first electrical equipment must operate and remain operational within the voltage and frequency ranges required by Fingrid's General Connection Terms (YLE). The customer is responsible for ensuring that loss of voltage or momentary voltage or frequency excursions that exceed the permitted values do not damage the customer's or other parties' electrical equipment. The customer can implement this, for example, by installing over- and undervoltage protection in their electrical equipment and, if necessary, also frequency protection.

Each party is responsible for implementing protection schemes on the switchgear stations they manage as well as the functionality of these protection schemes. An exception to this are differential relays, which are the responsibility of the power line owner that connects to the station. The connecting party is responsible for the suitability of the protection and for configuring its settings. If necessary, Fingrid will assist the connecting party in configuring the settings.

If Fingrid renovates the existing substation, Fingrid will calculate the settings for new relays of customer's power lines and will send them to customer for approval.

3.2 400 kV power network

Protection of the customer's 400 kV network must operate without delay in all faults so that a fault is isolated within 0.1 seconds or less, except for earth faults that have a high fault resistance. The primary protection of 400 kV power lines must be duplicated. In addition, 400 kV transmission lines must be protected against high-resistance earth faults.

3.3 110 kV power network

3.3.1 General principles

Protection of the customer's 110 kV network must operate in such a way that the primary protection disconnects the fault within 0.1 seconds or less and the backup protection within 0.5 seconds or less, with the exception of high fault resistance earth faults. For high fault resistance ground faults, the operating time of the protection is usually stepped from m 1–3 seconds and operating times are harmonised with the protection of the main grid. However, the operating time of protection in a customer's radial line should be as short as possible to ensure selectivity over other lines and to shorten the duration of the voltage dip.

At a customer's substation that does not require the busbar protection as described in section 4.1 (i.e. the customer's substation is further than 5 Ω from a Fingrid station), the fault time may not exceed 0.5 seconds in the event of a busbar fault, including breaker and current transformer faults. The fault time in a 110 kV network that the customer uses as a meshed network must not exceed 0.1 seconds.

The protection scheme of a customer's network must be a duplicated scheme. In practice, this can be implemented with two main protection devices or a main protection device and a backup. Backup protection might be, for example, protection in the customer's adjacent station.

3.3.2 Operation of protection during an outage

The main protection must operate normally even when one transmission line is not in use. The operation of backup protection may slow down, but not be totally prevented.

If necessary, a backup grounding location for the 110 kV star shall be used to increase the earth fault current.

3.3.3 Voltage relays

Compensation devices must be equipped with a voltage relay that controls the device during instances when the voltage exceeds or falls below the permitted range of variation. Capacitors must also be disconnected from a de-energised network.

Over- and undervoltage protection is not required in the 110 kV network. However, DSOs must have an over- and undervoltage protection scheme on the low-voltage side to prevent damage to consumer devices.

3.3.4 Under-frequency control

Pursuant to the Network Code on Electricity Emergency and Restoration (COMMISSION REGULATION (EU) 2017/2196), if the frequency of the network falls due to a severe disturbance and the disturbance reserve maintained cannot meet the resulting power deficit, the automatic under-frequency load shedding will disconnect consumption to prevent a major disturbance in the electrical system. Load shedding is performed as specified in the Fingrid document *Implementation of automatic under- and over frequency protection schemes in Finland (Automaattisten ali- ja ylitaajuus-suojausjärjestelmien toteutus Suomessa).* The document forms part of contingency plan created by Fingrid.

3.3.5 Large urban networks

To ensure the security of electricity supply, large 110 kV urban networks are typically connected to the main transmission grid via two or more connections. In such cases, protection in a customer's 110 kV network operates rapidly. Even in faults that are difficult to detect. Otherwise, in the worst case, the fault might lead to a trip of all supply lines. Examples of such faults include:

a. Switching on to a fault, in which case the differential relay or the SOTF (Switch on to Fault) function of the distance relay must cause an immediate trip.

b. A fault between a current transformer and a circuit breaker, in which case a teleprotection signal signal indicating a busbar protection trip is sent to the distance relay of the opposite station.

The operating time of protection must be harmonised with the protection scheme of the main grid.

4 Connection of a customer's 110 kV transmission line to a main grid switching station

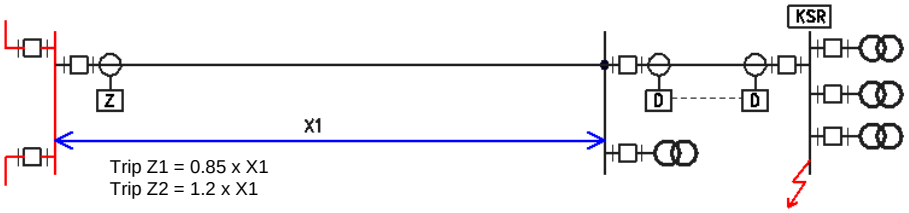
4.1 General principles

The main protection must immediately trip all line any busbar faults that are closer than 5 Ω to the main grid substation. If the customer's transmission line has a circuit breaker closer than this and its protection should be selective with the main grid circuit breaker, the breakers must use differential protection or distance relays with a communications link to protect the transmission line between the circuit breakers. Selectivity can be implemented in circuit breakers further along the transmission line by means of distance relays. The scheme to use in such a case is protecting 85% of the line with an immediate trip and leaving a longer trip time of 0.4 secs for the rest of the line.

a. For short transmission lines, backup protection must also have as short a fault time as possible and the fault time setting must be configured to be selective with the main grid protection.

b. The backup protection must also trip in the event of an exception in the supplying network when the fault current is lower than usual. Particular attention must be paid to faults close to the ends of long lines.

When a customer's substation is connected to a main grid substation and another substation is connected to the customer's substation with a short transmission line, it is recommended that the customer ensures the selectivity of their own network by installing busbar protection on the latter substation. Busbar protection ensures that, in the event of a busbar fault at the latter station, the protection will not trip unnecessarily at the main grid substation, thus causing a power outage for customers of the first station. This scheme is illustrated below.



The delay of a sensitive earth fault protection (60 A) in a radial line should generally be 1.0 seconds or less.

a. If a radial transmission line supplies a high volume of capacitive charging current, the current and time settings must be checked.

b. When selective and sensitive earth fault protection is required for consecutive switches along a radial transmission line, the settings could be configured as 1.0 secs, 0.7 secs and 0.4 secs, for example. If a delay of more than 1.0 sec is required, the setting must be harmonised with the staggering scheme of the main grid.

The distance relay of a radial transmission line must not trip in the event of a ground fault if the fault is elsewhere in the network. When the fault is elsewhere in the network, the distance relays and directional earth fault relays will see the capacitive current supplied by a radial transmission line as an earth fault on the radial transmission line. The magnitude of the capacitive current is affected by the total length of the power lines at the connection point. Furthermore, the capacitive current supplied by cables is much higher than that supplied by overhead wires. If the capacitive charging current exceeds 50 A ($3I_0$), it must be taken into account in the settings. The minimum operating current setting for distance relays is usually 120 A.

If a power plant connects to a main grid switching station directly or via the network of a Fingrid customer, Fingrid does not require a disconnection.

4.2 Implementation of a differential protection scheme

The customer is responsible for the implementation and cost of the communications link between differential relays and other relays of their transmission line.

The customer can implement the line differential protection independently or with the assistance of Fingrid as follows:

4.2.1 Customer is responsible for implementing

a. The customer is responsible for the procurement, configuration, settings and commissioning of the differential relays, as well as testing of the communications link. The commissioning tests are carried out in co-operation with Fingrid, since a tester is required at both ends of the line.

b. The customer is responsible for implementing the communications link between the relays.

c. The relay type can be selected in accordance with the customer's needs.

d. The customer is responsible for factory acceptance testing (FAT) of the relays.

e. The customer supplies the fully configured relay to a Fingrid contractor who installs it in Fingrid's substation.

f. Fingrid is responsible for the mechanical installation, cabling, wiring, planning and documenting of devices at Fingrid's substation, including the cost of such activities.

4.2.2 Assisted by Fingrid

a. When Fingrid is constructing a new substation or refurbishing an existing one, Fingrid will arrange a tendering process for the differential protection scheme as part of the substation project, if the customer so requests. The tendering process includes the differential relays, their configuration and settings. If the customer accepts a service provider's tender, the customer must contact the service provider directly to agree upon invoicing terms.

b. Commissioning tests are carried out in co-operation with the customer, since a tester is required at both ends of the line.

c. The customer is responsible for implementing the communications link between the relays.

d. The relay type must be listed in Fingrid's list of approved relay types.

e. Fingrid performs its normal factory acceptance tests (FAT) on the relay cabinets. During the FAT, the differential relays can be connected to each other with fibres, which ensures verification of the configuration and settings before the differential relays leave the factory.

f. Fingrid will supply the fully configured relay to the customer's contractor, who will install it in the customer's substation.

g. The customer is responsible for mechanical installation, cabling, wiring, planning and documenting the devices at their own substation.

h. Fingrid is responsible for the mechanical installation, cabling, wiring, planning and documenting of devices at Fingrid's substation, including the cost of such activities.

4.2.3 Operation and maintenance

The customer may keep the devices referred to in these instructions at Fingrid's substation free of charge.

The customer is responsible for the maintenance and monitoring of the relays and communications links at both ends of their transmission line. Periodic testing and other testing must be agreed upon and carried out in co-operation with Fingrid. Testers operating at a Fingrid substation must be approved by Fingrid. If requested, the customer is obligated to deliver the relay testing protocols to Fingrid.

Fingrid is not responsible for monitoring the customer's relays and communications links. Fingrid is not obligated to connect the monitoring/alarms of the customer's relay or communications links to their own operation control system.

5 Connection of a customer's 110 kV transformer to a main grid switching station

If the customer's substation is located in the immediate vicinity of a Fingrid substation, the circuit breaker and current transformers protecting the customer's transformer are typically located at the Fingrid substation. In such cases, Fingrid owns the primary devices and is responsible for control of the main transformer field. Real-time information exchange complies with the existing application guidelines.

In such cases, customers must equip their transformers with a differential protection scheme. The differential protection scheme must protect the customer's transformer and the stretch of transmission line or cable between the transformer and the 110 kV field of the main grid. The differential protection relay is located at the customer's substation. Secondary currents are cabled for the relays from Fingrid's substation. Other signals between the stations (trips, alarms, interlocks and status information) are transferred using signal transmission devices and a fibre optic connection between the devices. The customer is responsible for the implementation and cost of the required secondary circuits between the customer's substation and Fingrid's substation. Secondary circuits and the differential relay will remain the customer's property.

Fingrid's substation has an overcurrent/earth fault relay that acts as backup protection for the customer's transformer and the 110 kV transmission line or cable that runs between Fingrid and the customer. The protective relay is owned by Fingrid.

The voltage regulator of the customer's main transformer is located in the customer's substation. The voltage regulator is the customer's property.

A transformer through which production is connected to the grid must be equipped with a 110 kV earth fault protection (Electrical Safety Act 1135/2016 and standard SFS 6001, section 4.2.2). Earth fault voltage is measured either at the 110 kV bus voltage transformers or the 110 kV star point of the transformer. An earth fault voltage relay disconnects production in the event of an earth fault in the 110 kV transmission line. Production can be disconnected by tripping the 110 kV or low-voltage circuit breaker or the medium-voltage lines which are energised by production. A tripping earth fault

protection must always be constructed if the output power of an individual power plant (for example, a wind farm) in the connection exceeds 1 MW. If the production power behind the transformer is less than 50% of the minimum consumed power and no individual power plant outputs more than 1 MW, an earth fault voltage relay is not required. If an earth fault relay is omitted by virtue of the 50% rule, the connecting party is responsible for monitoring the ratio of consumption to production.

6 A customer's 110 kV connection to a main grid transmission line

6.1 General requirements

In the event of a fault in a customer's 110 kV network, the primary protection must operate without delay, so that the maximum duration of a typical short circuit and earth fault does not exceed 0.1 seconds.

a. It is recommended that the customer's transformer is protected with a differential relay.

b. The delay-free trip zone of the protection of a main grid transmission line always extends to the customer's branch line. The customer's protection of the branch line must be delay-free, because the customer's circuit breaker might otherwise remain closed during a permanent fault in the branch line, resulting in the main grid transmission line re-switching on to a fault in the branch line. As a result, all customers supplied by the main grid transmission line would be left with no power, and detecting the fault location would take longer.

Due to the selectivity of protection, the branch line protection scheme must not use rapid reconnection. Instead, the reconnection could comprise a single 5–15 second reconnection, which is shorter than the reconnection of the Fingrid transmission line. In addition, a sensitive earth fault relay trip must prevent reconnection.

The operating time of backup protection must be harmonised with the protection scheme of the main grid. Instead of backup protection, Fingrid recommends the use of two relays that trip with no delay.

The delay of a sensitive earth fault protection (60 A) must be 1.0 seconds or less.

When the circuit breaker of a customer's main transformer is undergoing maintenance, other circuit breakers must be responsible for the transformer protection trips.

For busbar short-circuits on the low-voltage side of a customer substation that is connected to a transmission line of the main grid, or short-circuits near the start of medium-voltage lines, the maximum permitted trip time is 1.0 secs. If the main transformer rating exceeds 25 MVA (ONAN), the maximum permitted trip time is 0.2 secs.

A transformer through which production is connected to the grid must be equipped with 110 kV earth fault protection. Earth fault voltage is measured either at the 110 kV bus voltage transformers or the 110 kV star point of the transformer. An earth fault voltage relay disconnects production in the event of an earth fault in the 110 kV transmission line. Production can be disconnected by tripping the 110 kV or low-voltage circuit breaker or the medium-voltage lines which are energised by production. A tripping earth fault protection must always be constructed if the output power of an individual power plant (for example, a wind farm) in the connection exceeds 1 MW. If the production power behind the transformer is less than 50% of the minimum consumed power and no

individual power plant outputs more than 1 MW, an earth fault voltage relay is not required. If an earth fault relay is omitted by virtue of the 50% rule, the connecting party is responsible for monitoring the ratio of consumption to production.

6.2 Disconnection of power production at a transmission line connection

6.2.1 General principles

In this context, 'production' means the sum of total power of electricity production at a connection to a main grid transmission line. The sum of total power may comprise one or more individual power plants or battery banks.

To succeed, a rapid reconnection of a main grid power line requires that the production connected to it – either directly or via some other party's network – does not maintain voltage at the power line when a fault in the electric network has caused the circuit breakers that supply the power line to open at the substations of the main grid.

If production connects to Fingrid's network over a backup connection that does not contain disconnection functionality, the terms and conditions of the connection must be agreed with Fingrid on a case-by-case basis.

A power plant's own protection should be configured to ensure that the plant does not disconnect from the network, except when a fault occurs in the plant's own connection line. The settings of the undervoltage and frequency relays of power plant generators must not conflict with the technical requirements of power plant systems (VJV). The following settings are recommended:

Undervoltage relays:

	voltage (p.u.)	time (sec)
U <	0.8	1.5
U <<	0.2	0.5

Frequency relays:

	frequency (Hz)	time (sec)
f <	47.4	0.5
f >	51.6	0.5

Relays whose operation is based on the rate of frequency change are not permitted in disconnection schemes for production in the 110 kV network, medium-voltage network and low-voltage side.

6.2.2 Disconnection of a production connection or a joint production and consumption connection

The following principles apply to the disconnection of production depending on whether the connection is a dedicated production connection or a joint production and consumption connection. Production can be disconnected by tripping the 110 kV circuit breaker of the connection or circuit breakers on the low-voltage side.

6.2.2.1 Disconnection of a production connection

In the case of a production connection, production that exceeds 1 MW must be disconnected from the transmission line after a protection relay trip before rapid reconnection is initiated. The combined production power is used to determine whether production disconnection should take place by means of local disconnection relays or a disconnection communications link (EVY):

a. Local disconnection relays are required for 1–5 MW production that connects to a main grid transmission line (implemented as specified in section 6.2.3).

b. A disconnection communications link is required for 5–30 MW production that connects to a main grid transmission line (implemented as specified in section 6.2.4).

6.2.2.2 Disconnection of a joint production and consumption connection

When the connection is a joint production and consumption connection, it must be equipped with a disconnection if production output might even temporarily exceed 50% of the minimum consumption of the connection, or if the production output of an individual power plant (such as a wind farm) in the connection exceeds 1 MW. If the production output is less than 50% of the consumption power of the connection, it can be assumed that the production cannot maintain voltage in the transmission lines of the main grid.

The choice between local disconnection relays (6.2.3) and a disconnection (6.2.4) communication link is made by applying the same principles as for a production connection. The options for implementing disconnection are as follows:

a. The primary option is to disconnect a transformer’s low-voltage lines which have production on them. In such cases, thanks to automatic reconnection, voltages are automatically restored in transient faults, initially to the 110 kV line and then to the transformer’s low-voltage lines.

b. Trip the 110 kV circuit breaker of a transformer. In such cases, voltage is restored to the transformer manually after voltage has been restored to the 110 kV transmission line.

c. Only a part of production is disconnected following the 50% rule above, which results in a situation in which production cannot maintain voltage in the network.

6.2.3 Disconnection relays for production output of 1–5 MW

A transmission line connection requires a local disconnection relay scheme as follows:

a. An under and over frequency relay that measures high, medium or generator voltage.

b. An earth fault relay that measures 110 kV voltage.

c. A sample-and-hold-circuit that permits a frequency relay trip to pass through, even if the operating condition of a voltage relay is quickly restored.

For a diagram of the implementation and settings, see Appendix 1 (Fingrid instruction S22410L16).

An undervoltage relay is not permitted in the disconnection scheme. An undervoltage relay might unnecessarily trip the disconnection during a severe 400 kV disturbance. In short-circuit faults of main grid transmission lines, the generator's own protection is expected to work rapidly enough.

6.2.4 Communications link for the disconnection of 5–30 MW of production

A remote trip for production is created by building a communications link for disconnection (EVY) from the transmission line protection scheme at the other terminal substation of a main grid transmission line. The remote trip signal does not trip the production switch directly, but travels through a reception condition that verifies the presence of a fault in the electric network. As a result, production is not accidentally disconnected due to an unintentional EVY signal sent as a result of human error or a fault in the telecommunications network.

The relay set of the reception condition comprises the following:

a. A 3U< relay that operates even if one of the line-to-line voltages falls below the set value.

b. An U_0 > relay measuring the 110 kV earth fault voltage.

c. A sample-and-hold circuit that permits the remote EVY trip to pass through even if the operating conditions of the voltage relays are quickly restored.

For a diagram of the implementation and settings of an EVY, see Appendix 2 (Fingrid instruction S22410L17).

To ensure that a protection scheme of a main grid transmission line is actually operating, the symmetric fault current supplied by a 5–30 MW production output at a transmission line connection may not exceed 1.2 times the nominal current of the plant after 300 ms from the beginning of the fault. The nominal current is calculated from the rated power of the power plant. If the fault current cannot be limited to the required level within 300 ms from the beginning of the fault, the customer must install a protection scheme that ensures the disconnection of the fault current supply. In such cases, Fingrid will instruct the customer about the protection requirements on a case-by-case basis.

When an primary connection is disabled due to maintenance, repair or some other reason, the customer may temporarily use a connection point intended as a backup connection. The use of a backup connection must always be agreed in advance with Fingrid. When a backup connection is used, the starting point of protection is to serve as a backup for the operation of the rapid protection of the main grid. When production is connected to a main grid ring line via a backup connection, operation of the protection scheme must be verified on a case-by-case basis in accordance with a procedure laid down by Fingrid:

a. Communications link for disconnection, or

b. A local protection scheme based on a voltage and frequency condition (as in 6.2.3).

In addition, an earth fault voltage relay must be present in all transformers through which production can be supplied to the transmission line of the main grid.

If no disconnection communications link is implemented in the spare connection, rapid reconnection (<1 s) of the ring line might not be carried out, but when the earth fault voltage relay of a transformer trips production, a delayed (approx. 5 secs) rapid reconnection or a timed reconnection (approx. 60 secs) will be performed.

6.3 Implementing a communications link for disconnection

During the planning phase of the connection, the customer and Fingrid will agree upon the implementation of the disconnection communications link (EVY).

6.3.1 Fingrid is responsible for implementing

If the customer has paid a connection fee for their transmission line connection (after 30 June 2012), Fingrid will implement the EVY at its own expense.

For production, the reception of an EVY remote trip is constructed in a single location in which measurement data on the 110 kV voltage is available and can be forwarded. The customer must provide adequate space for telecommunications equipment and arrange the necessary auxiliary power supplies.

If necessary, the customer must extend the remote EVY trip to the circuit breakers of other potential terminal sites. The interface for Fingrid’s delivery is the installation of the customer’s EVY device into a cabinet chosen by the customer. The customer must construct the wiring for the EVY trip from the EVY device to the circuit breaker(s).

6.3.2 Customer is responsible for implementing

If the customer has not paid a connection fee for their transmission line connection (after 30 June 2012), the customer shall implement the EVY at their own expense.

When connecting to a network that is owned by another party and connects to a Fingrid transmission line, the network owner is responsible for implementing the EVY in co-operation with the production owner.

The EVY device is placed into a separate cabinet at Fingrid's substation. The cabinet is labelled with the owner's name and contact details. Fingrid will supply the cabinets with tripping information of distance relays and the necessary auxiliary electric power. This cabinet will also be home to the relays of the backup connection, unless they are already present in the field's relay cabinet.

6.3.3 Operation and maintenance

The parties may keep the devices referred to in this guideline on the substations owner by the other party free of charge.

An EVY communications link supplied by the DSO or production owner remains the property of the DSO/power plant owner at both substations. The DSO/power plant owner is also responsible for the maintenance of such a connection. In such cases, the DSO/power plant owner must assume responsibility for monitoring EVY and its alarms at their own substation.

An EVY communications link supplied by Fingrid remains the property of Fingrid up to the signal transfer device at the customer's substation. Fingrid is also responsible for the maintenance of such a connection. In such cases, Fingrid assumes responsibility for monitoring EVY and its alerts at their own substation.

Any testing must be agreed upon and performed in cooperation with Fingrid.

6.3.4 Technical requirements

Technical requirements for the EVY communications link:

a. The technology is not restricted. An EVY communications link can be implemented, for example, as a fibre optic connection, radio link, IP-based solution or via the mobile network.

b. An EVY remote trip must trip a fault current within 500 ms, which means that the maximum delay of telecommunications devices may not exceed 400 ms. Consequently, the delay in a loop measurement may not exceed 800 ms.

c. The reliability of the signal pass-through in an EVY trip must be at least 95%.

Technical requirements for an EVY device:

a. EVY devices can be signal transmission devices (such as Siemens 7XV5673), protection message devices type approved by FG or other devices with which a secure communications link can be implemented.

b. EVY monitoring requires that EVY devices have an alarm contact that issues an alarm when the communications link is inoperative. This connection is monitored by the communications link owner.

c. The length of the incoming EVY signal must be configurable at the EVY terminal device.

d. The power supply for an EVY device must be redundant and come from a battery bank or an inverter.

e. An EVY device shall be equipped with a protective power switch that is also used to exchange remote trip data between protective relays and the EVY device. The protective switch is placed in the same cabinet as the EVY device. If more than one communications link for disconnection is implemented at a substation, all terminal devices must have their own protective switch.

Other requirements for EVY implementation:

a. When a main grid transmission line is protected by a distance relay and zone Z1, Z2 or SVY (communications link zone of protection) of this relay causes a trip at the terminal station of the transmission line, an EVY signal will be sent to production.

b. If the transmission line is using a backup connection, the EVY signal will be sent when a distance relay trips on the busbar circuit breaker field.

c. If the transmission line or one of its its legs has no shield wires, the EVY signal will also be sent when a ground fault relay trips.

d. At Fingrid's substation, the following signal is added to operation control: AExx XXX EVY Normaali/Vika [AExx XXX EVY Normal/Fault] (xx denotes the field name and XXX is the name of the power station). The signal contains both a communications link fault and an EVY fault. If Fingrid is responsible for the connection, the signal will be classified as an alarm. Otherwise, the signal will be classified as a notification.

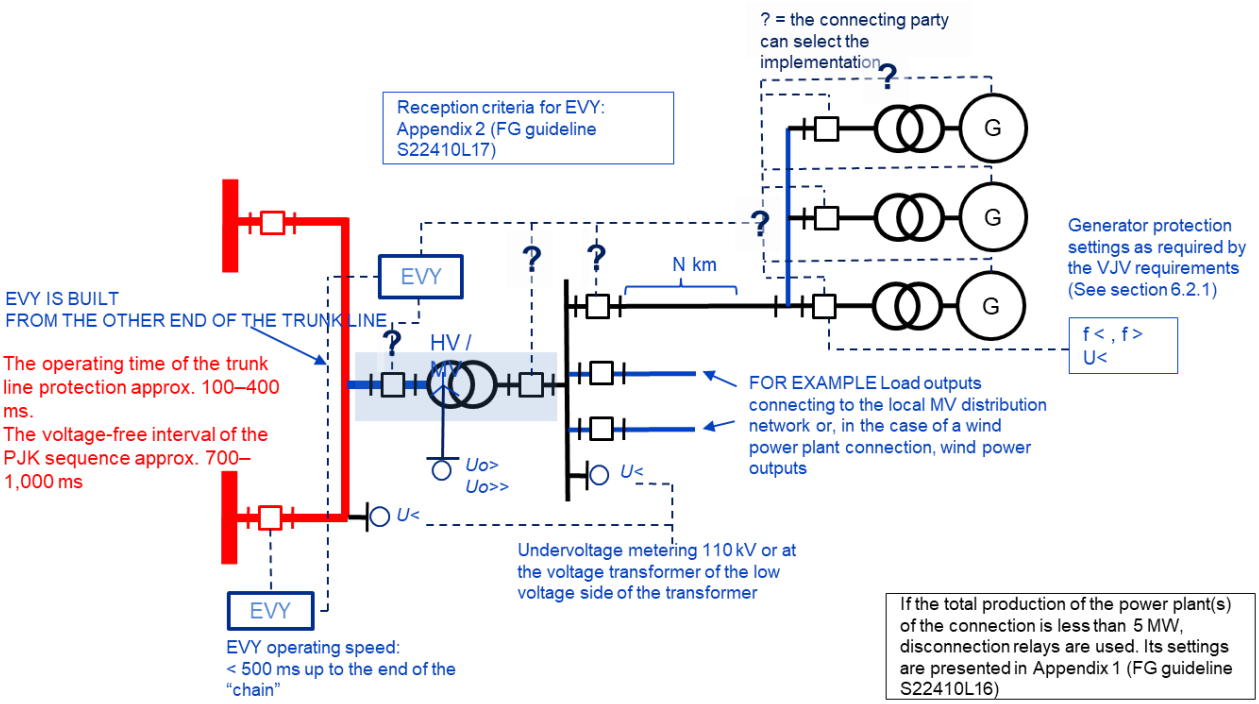
e. To monitor the delivery of the EVY signal and transit time, a feedback loop is created from the receiving terminal device to the sending substation. If necessary, this signal can be connected to a disturbance recorder and/or remote operation.

f. An EVY terminal device requires a separate maintenance switch. The switch must be designed and implemented in a way that permits the EVY to be safely tested when the switch is open. Terminal blocks must be used in the installation to enable measurements on the EVY connection to. To monitor the status of the switch, an alarm concerning an abnormal position of the switch must be added to the substation. Fingrid substations do not need a separate alarm for EVY switches. Instead, the alarm is combined with the joint alarm of the substation: KYTKIMEN TILA normaali/hälyttää [SWITCH STATUS normal/alarm].Before production is connected to the network, EVY devices and the connection link must be tested, including transit time measurement.

g. The illustration below shows an example of implementation of an EVY connection.

h. Before production is connected to the network, EVY devices and the connection link must be tested, including transit time measurement.

i. The illustration below shows an example of implementation of an EVY connection.



Appendix 1: A diagram of disconnection delays (Fingrid guideline S22410L16)

Appendix 2: EVY diagram (Fingrid guideline S22410L17)