State-of- the-Art Protection for Cafayate Substation

SIPROTEC protection systems of the latest generation in Argentina

The company

EDESA is a power supply company in the province of Salta. The integration of the local substation in island operation into the Argentinean power supply system (SADI) was a challenge for EDESA, especially as all new substations have to comply with special standards and, like any private investment, must be profitable.

EDESA awarded Siemens the contract to implement the incorporation of the city of Cafayate into the SADI power system.

The starting situation

Power generation in the Northwest of Argentina is mainly thermal. The power system is characterized by transmission lines with average distances of 100 km, large loads located in the main cities and medium-sized customers scattered over a large area. EDESA's task was to build up a substation in Cafayate with the following features:

- Optimum protection
- Integration of many functions in one device to reduce space requirements
- Telecontrol function
- Cost-effectiveness

For the Pampa Grande substation that had to be connected to the Cafayate substation, EDESA demanded a solution for a reliable and efficient operation.

The concept

The Cafayate substation project comprised the construction of a T-line configuration in the middle part of a 132 kV transmission line connecting two substations: Trancas in the province of Tucuman and Cabra Corral in the province of Salta.

The new, 130 km long transmission line starts at the Pampa Grande substation.

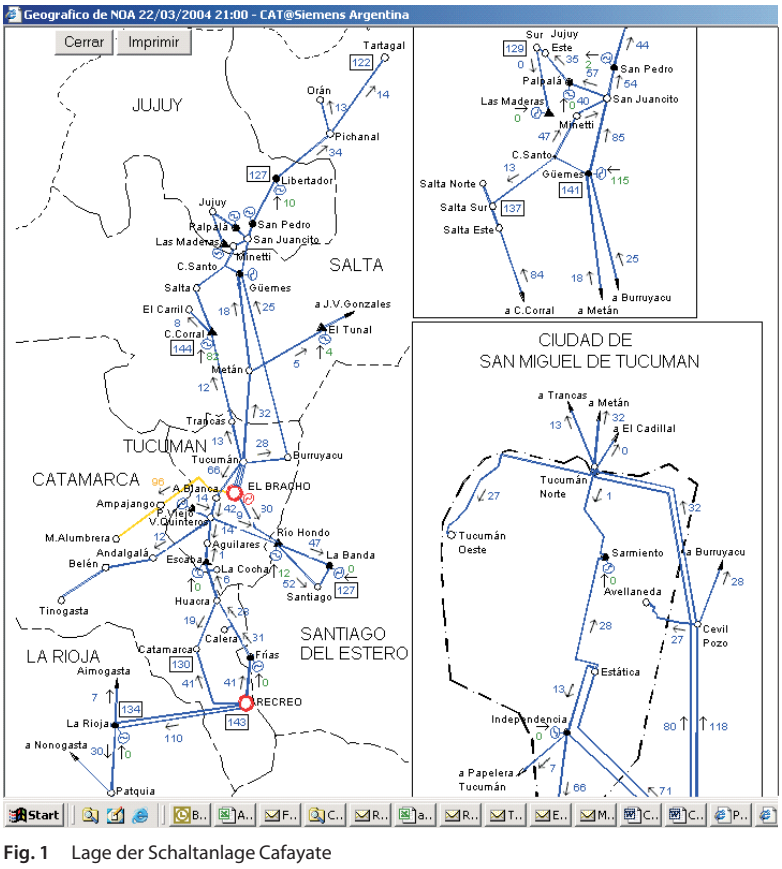

Fig. 1 Lage der Schaltanlage Cafayate

The Cafayate substation featured the following:

- Panel for a power transformer (132 kV/33kV, 20 MVA)
- HV circuit-breaker
- Medium-voltage switchgear with transformer panel and three panels for outgoing feeders, supplying the Cafayate area with power
- Isolated operation with local power generation as backup option only.

Communication between Cafayate – Pampa Grande, Pampa Grande – Cabra Corral and Cabra Corral – San Francisco substations is via Siemens Digital Power Line Carrier ESB2000i and an integrated SWT3000 teleprotection equipment. Four independent commands are transmitted via an interconnection data transmission channel.

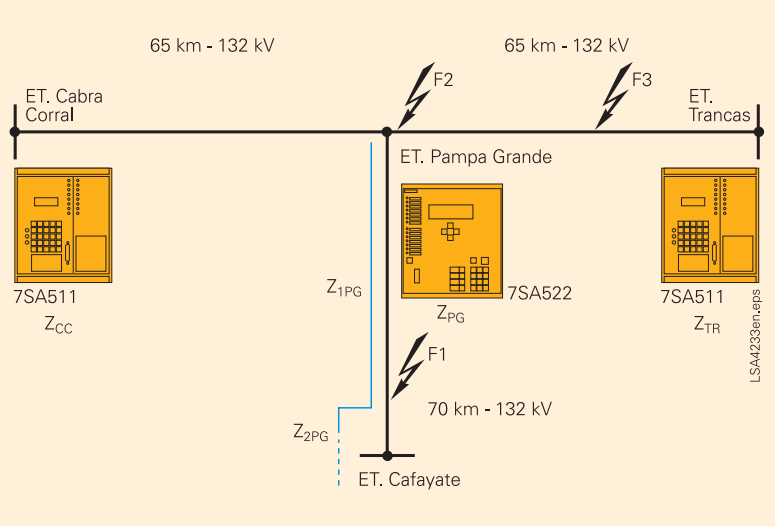

Fig. 2 Zone setting of 7SA522 relay

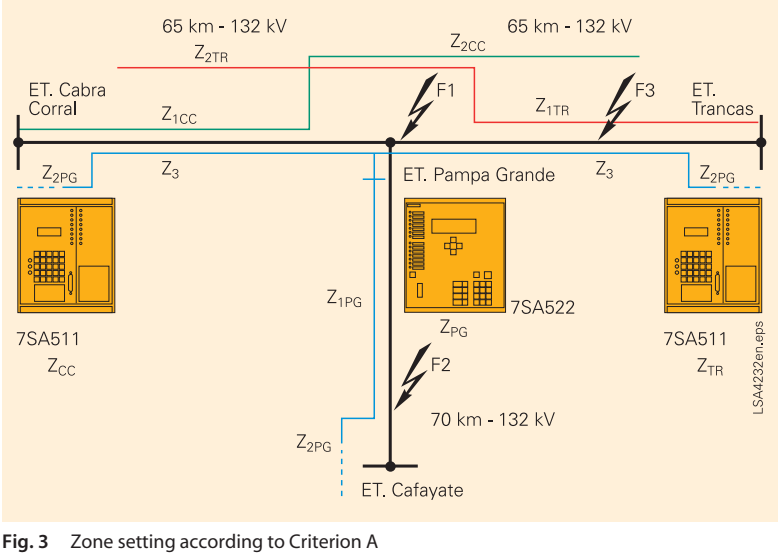

Fig. 3 Zone setting according to Criterion A

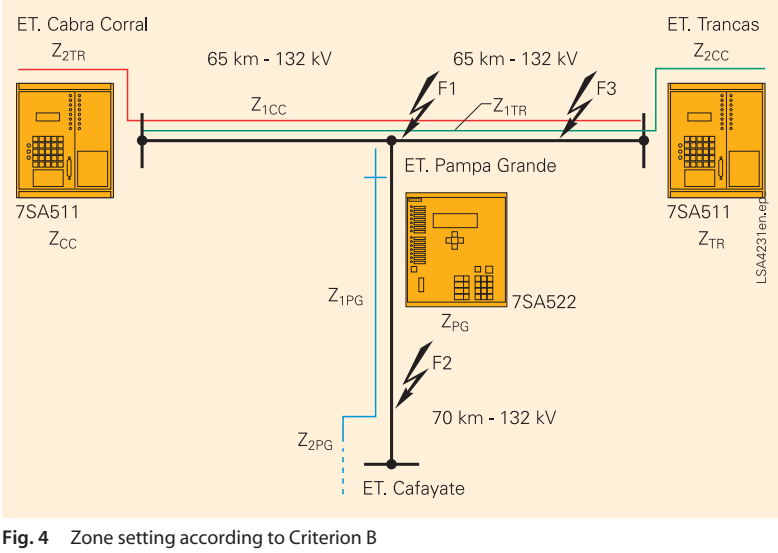

Fig. 4 Zone setting according to Criterion B

For the Cafayate substation Siemens offered an integrated solution, comprising:

- 7SJ63 multifunction relay for the 13.2 kV medium-voltage switchgear, including protection and control and measuring functions plus interfacing for telecontrol systems.
  The following protection functions are applied:
  - Directional and non-directional overcurrent protection
  - Auto-reclosure
  - Over/undervoltage protection and
  - Over/underfrequency protection
- 7UT633 relay for protection and control of the power transformer with differential protection for a three-winding transformer plus overcurrent protection as backup protection.

In one single panel EDESA integrated the transformer protection functions, the automatic voltage control, the thermal replica relay and the Buchholz protection. Control and protection can be either local or remote via telecontrol systems.

For the Pampa Grande substation the 7SA522 protection relay which covers a wide range of protection functions, has been chosen. It features the following:

- Non-switched distance protection with 6 measuring systems (full scheme)
- 5 independent distance zones
- Auto-reclosure (1 pole and 3 pole) (with ADT functionality)
- Synchro-check
- Switch-onto-fault
- High resistance earth-fault (directional or non-directional)
- Phase-overcurrent protection
- Power swing detection/blocking
- Teleprotection for distance protection (PUTT/POTT)
- Fault locator

Remote control is effected by DIGSI remote control query of the Pampa Grande 7SA522 distance protection. The operator staff may control and change the settings and download fault and event logs.

In the first zone the 7SA522 distance protection relay measures in the direction of the transmission line to Cafayate substation, which is 80 % of the line length. This means that the fault disconnection and clearance times for the transmission line sections from Pampa Grande to Cabra Corral and Trancas have to be kept to a minimum.

Among others, two main criteria had to be considered:

Criterion A (see Fig. 3)

1) Distance protection Z_{PG} (7SA522) measures in first zone (Z_1) 80 % of the line length in the direction to the Cafayate substation (forward). In the second zone (Z_2) the remaining 20 % of the line are measured and at the same time the relay serves as backup protection for the power transformer. In the third zone (Z_3) 60 % of the line length measured from Pampa Grande are measured in reverse direction.

2) 80 % of the line length Cabra Corral – Pampa Grande and Trancas - Pampa Grande are measured in the first zone (forward direction) by the distance protection relays Z_{CC} and Z_{TR}. An overreaching zone of 115 % is formed in the second zone Z_2 with the substation at the remote line end.

3) For the distance protection relays Z_{CC} and Z_{TR}, the settings of the independent zone Z_{1B} correspond to those of the second zone Z_2. ($Z_{1B} = Z_2$).

With these settings, different types of faults were analyzed (Fig. 3) with the protection relays showing the following behavior:

1) Fault F 1: Distance protection relay Z_{PG} trips in the first zone (Z_1) and since the other two protection relays are measuring in the second zone Z_2, Z_{PG} trips first in t_{Z1}.

2) Fault F 2: Distance protection relay Z_{PG} measures the fault in the third zone (Z_3) in reverse direction and sends a signal to the protection relays Z_{CC} and Z_{TR} to release to the independent zone Z_{1B} and both protection relays clear the fault .
This signifies: signal transmission time + trip time of Z_{1B} (t_{Z1B}) = reaction time.

3) Fault F 3: In this case protection relay Z_{TR} trips in minimum time (t_{Z1}) and the Z_{CC} receives the release signal for the independent zone Z_{1B}
This signifies: signal transmission time + trip time of Z_{1B} (t_{Z1B}) = reaction time.

Criterion B (see Fig. 4)

1) Distance protection Z_{PG} (7SA522) measures in first zone (Z_1) 80% of the line length in the direction to the Cafayate substation (forward). In the second zone (Z_2) the remaining 20 % of the line are measured and at the same time the relay serves as backup protection for the power transformer.

2) 120 % in direction of the lines Cabra Corral – Trancas and Trancas – Cabra Corral are measured by the distance protection relays Z_{CC} and Z_{TR} in the overreach zone (Z_{1B}). Both working in POTT teleprotection scheme (a release signal has to be received from the remote end so that the distance relay locally trips the circuit-breaker). The trip time for zone Z_{1B} of protection relays Z_{CC} and Z_{TR} should be greater than the trip time for the first zone of protection relay Z_{PG}.
This results in time selectivity between the transmission lines Pampa Grande – Cafayate and the other two transmission lines with regard to faults on the first line.

With these settings, different types of faults were analyzed (Fig. 4) with the protection relays showing the following behavior:

1) Fault F 1: Distance protection relay Z_{PG} trips in the first zone (Z_1). And because the other two protection relays have a longer time for tripping the first zone, relay Z_{PG} is the first to trip in t_{Z1}.

2) Fault F 2: Distance protection relays Z_{CC} and Z_{TR} measure the fault in overreach zone Z_{1B} and – after a release command - both protection relays clear the fault. Trip time therefore is: signal transmission time + trip time Z_{1B} (t_{Z1B})

3) Fault F 3: same as in 2)

After analyzing and evaluating the two criteria, criterion B was opted for, aiming at homogeneity within the system.

The special advantages

The distance protection 7SA522 provides the following:

- Minimized fault clearing time in the different sections of the transmission lines from Pampa Grande to the other substations.
- Unnecessary three-phase trips, caused by simultaneous single-phase faults in different phases on both transmission lines, are avoided.
- Service life of circuit-breaker is prolonged thanks to reduction of unsuccessful auto-reclosures.

Conclusion

Since January 2004, the Pampa Grande and Cafayate substations have been in operation to the customer's full satisfaction.
EDESA has integrated the power supply for the city of Cafayate into the Argentinean power supply system. Thanks to the SIPROTEC protection relays, the Cafayate substation is now being protected by an optimal and cost-effective protection concept.