FO Differential Protection Communicates via Existing Telephone Wires

Differential protection over conventional pilot wires at the Varel paper and board factory

■ The company

The paper and board factory Varel in the north of Germany (see Fig. 1) occupies the region supplied by the Weser-Ems power supply company (EWE). The company operates its own power generation plant, which runs on natural gas and biogas, to produce heat and power.

■ The starting situation

A new switchgear has been installed on the factory campus. A 20 kV double feeder safe-guards the factory's power supply, and can exchange power over two approximately 0.5 km long feeder cables.

The power supply company recommended differential protection relay 7SD51 to protect the cables. The relay had already proved viable for the protection of short cables, and for reasons of standardization it made sense to specify it here as well.

However, no fiber-optic cables had been laid along the cable routes, only conventional telephone wire pairs. This created a problem, since 7SD51 relied on fiber-optic cables or communication networks for transmission, exchanging data between the devices by means of asynchronous serial messages at 14.4/19.2 Kbps.

■ The concept

In mid-2001, a communications converter 7XV5662-0AC00 was rolled out for the SIPROTEC 4 differential protection relays 7SD52 / 7SD610. This made it possible for the first time to transmit synchronous serial differential protection messages with virtually no delay, thereby closing a technical loophole.

Depending on the cross-section of the pilot wires that have been laid, it is now possible to bridge long distances (see Table 1).

The converter connects to the differential protection relay with noise-immune 62.5/125 µm multi-mode fiber-optic cables up to a maximum distance of 1.5 km., with ST connectors at both ends. Two screw terminals connect the pilot wires to the converter, so there is no need to observe polarity.

Fig. 1 Varel paper factory

The dielectric strength of the converter with respect to the pilot wires is 5 kV. Consequently overvoltages induced in the parallel pilot wires by short-circuits in the cable do not result in flashovers at the converter and so do not impair the protection function. Voltages as high as 20 kV can be obtained with external isolation transformers 7XR9516.

This made the converter ideal for the application in Varel. One further challenge remained: since the device was tailored to the application with 7SD52/7SD610, it was designed only to transmit synchronous serial data at 128 Kbps on the pilot wire.

Data on pilot wires with bridgeable distances for the communication converter					
AWG	Diameter mm	Cross section mm^2	Ohm/km (0 Hz)	Ohm/km (80 kHz)	Max. distance U ↔ K
10	2.59	5.27	3.38	18.39	38.1
11	2.3	4.15	4.28	20.84	33.6
12	2.05	3.30	5.39	23.55	29.7
13	1.8	2.54	6.99	27.06	25.9
14	1.63	2.09	8.53	30.12	23.2
15	1.45	1.65	10.78	34.21	20.5
16	1.29	1.31	13.62	38.91	18.0
17	1.15	1.04	17.14	44.22	15.8
18	1.02	0.82	21.78	50.64	13.8
19	0.91	0.65	27.37	57.74	12.1
20	0.81	0.52	34.54	66.17	10.6
21	0.72	0.41	43.72	76.18	9.2
22	0.64	0.32	55.33	88.01	8.0
23	0.57	0.26	69.76	101.86	6.9
24	0.51	0.20	87.13	117.73	5.9
25	0.45	0.16	111.92	139.47	5.0
26	0.41	0.13	134.82	159.04	4.4
27	0.36	0.10	174.87	192.88	3.6
28	0.32	0.08	221.32	232.45	3.0

Table 1: Data of standard pilot wires

Resistance with modulation frequency of the converter
Data for a twisted telephone wire pair

The challenge for Siemens Power Automation Division was to expand the existing converter for the transmission of asynchronous serial data, opening up a broad field of other applications, such as the transmission of serial protocols including IEC 60870-5-103/101, DNP 3.0, and MODBUS. Together with the two-channel binary transducer 7XV5653, binary signals for comparing the distance or overcurrent-time protection signals could be exchanged via pilot wires.

An analysis of the converter hardware and firmware showed that this function could be implemented successfully on the existing hardware. The asynchronous transmission function could only be implemented in the converter firmware; it could be developed swiftly within a few weeks.

Tests successful

In January 2003 the converter with adapted firmware was available for the first tests. Long-term laboratory trials tested the converter with the 7SD51 and verified its capabilities. At the asynchronous baud rate of 19.2 Kbps, tests recorded no errors in the messages and found 100% reliability, typical of transmissions with differential protection. The message delay with the protection relay amounted to only 0.8 ms, which allows a command time of 25 ms, equivalent to that of a direct fiber-optic cable link.

In comparison, 1996 trials transferring data over dedicated line modems achieved a minimum 50 ms command time, with a delay time of 25 ms. This solution also failed to meet the EMC requirements and therefore could not be used for real-time protection data transmission over pilot wires. Not until seven years later was a marketable solution available that allowed protection data to be transferred virtually without delay.

In May 2003, the converter was released for delivery under the designation 7XV5662-0AC01.

■ The special advantages

Transmission over conventional pilot wires

The converter makes it possible to transfer asynchronous, serial data from 300 bps to 38.4 Kbps over pilot wires without noise interference. The values for the 7XV5662-0AC01, subjected to comprehensive tests before its market rollout, apply to the bridgeable transmission distance (see Table 1) and noise immunity.

Fast commissioning

With the support of the sales and marketing divisions, Power Automation Division installed the protection system (configuration as shown in Fig. 2) at the customer's facility. The 7SD51 protection relays had already been installed, and the brand new converters were delivered for commissioning. The communication converter was connected to the protection relay via a short fiber-optic cable, with ST plug connectors attaching to the converter and FSMA connectors attaching to the protection relay. The pilot wires were connected to the converter. The entire section was commissioned successfully within a few hours. The protection relay's integrated commissioning help functions aided in checking the correct connection to the current transformers and to the pilot wires.

Minimum time expenditure for parameterization

Compared to the commissioning of conventional wire differential protection, the probability of faults and the time taken for commissioning was reduced considerably. Only three parameters, the current transformation ratios and the measured delay 0.8 ms, need to be set in the protection relay (Fig. 3). All other parameters could remain at their default setting. The converter adapts itself to the serial data rate of the protection relay and only requires the setting of the master and slave mode via a jumper in the relay. This setting needs to be made for only one relay, which minimizes the time needed for parameterization.

■ Conclusion

With a special converter, it was possible to use the stipulated SIPROTEC differential protection relay 7SD51 for the paper factory in Varel and transfer asynchronous serial data over conventional pilot wires. The protection system has been in service since May 2003, to the customer's full satisfaction.

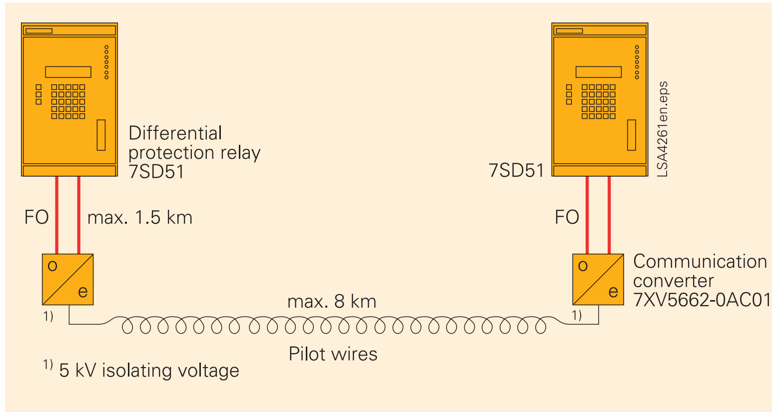

Fig. 2 Differential protection with communication converter

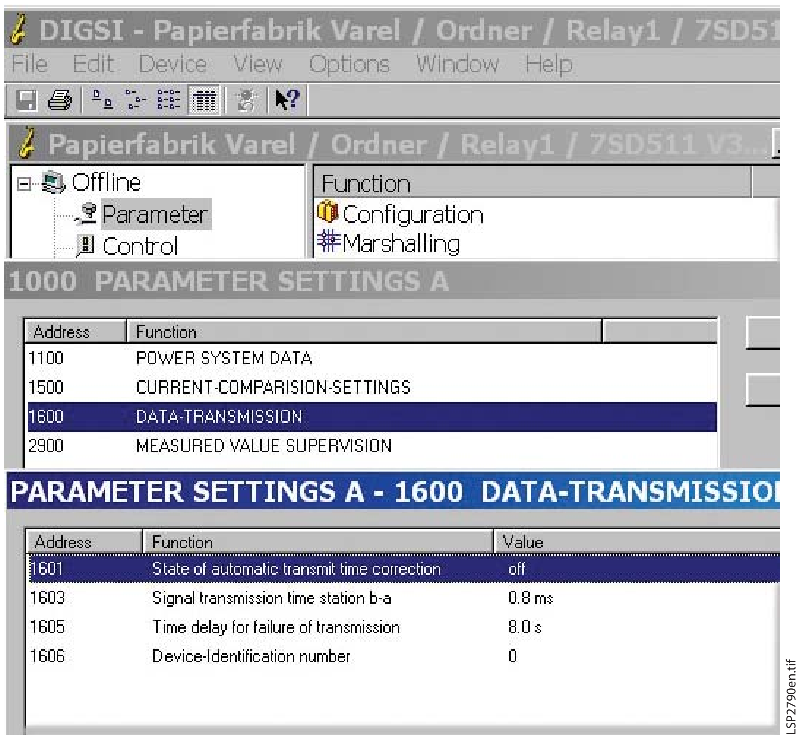

Fig. 3 Setting parameters in DIGSI