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THE APPLICATION OF TELEPROTECTION SYSTEMS IN COGENERATION PLANTS

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SUMMARY

Cogeneration plants will increasingly play an important role in the supply of electricity. Because of efficiency reasons electricity utilities buy energy generated in cogeneration plants and sell it to their customers.

Though this is indeed a good idea from the point of view of efficiency, it poses a number of technical problems. For example the waveform quality has to be preserved (voltage stability, frequency stability and phase), and islands of generation have to be detected and carefully controlled.

These two goals require new concept of teleprotection systems;

- The breaker has to be tripped even if there is no fault on the line
- A permanent state has to sent to the autoproducer premises to prevent accidental reclosure operation
- Analogue values regarding voltage, power, reactive power and others have to be measured, transmitted to the remote end for proper monitoring and the corresponding decision-making process

A new generation of teleprotection systems for cogeneration plants is described, together with the performance that should be achieved.

KEYWORDS

Cogeneration, Teleprotection, Shannon's Limit, Waveform Quality, Island Operation

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1. COGENERATION PLANTS

As mentioned in the introduction, cogeneration plants generate electricity that is supplied to the network. They are usually located in private premises and the utility has the obligation to purchase this electricity.

Unfortunately the quality of the waveform supplied to the network is not guaranteed, since in fact this extra electricity is generated in private premises not directly under the utility control. For this reason the following applications have to be taken into account when making a cogeneration connection;

- Important parameters should be monitored in real time. This includes, for example, voltage, current, active power and reactive power. The information regarding these parameters should be delivered to the control centre and a decision taken about its quality.

- The utility must provide a means to disconnect the autoproducer from the network if the current situation of the network requires so.

- Also the utility must prevent accidental or unauthorised reconnection of the autoproducer if the current network conditions are not suitable.

All these requirements require the use of special teleprotection systems. The goal is;

- To monitor the significant parameters in real time, such as voltage, current, frequency, or others

- Deliver these measurements to a control centre

- Examine them and make a decision about whether the cogeneration plant is working successfully, generating a waveform that conforms to the utility standards, or not.

- Provide a means of disconnecting the cogeneration plant from the network if the quality of the waveform does not meet the utility standards

In fact, if we take requirements one and three into account, the complete system should be a functional mixture of teleprotection, measurement and telecontrol subsystems, as the following figure implies;

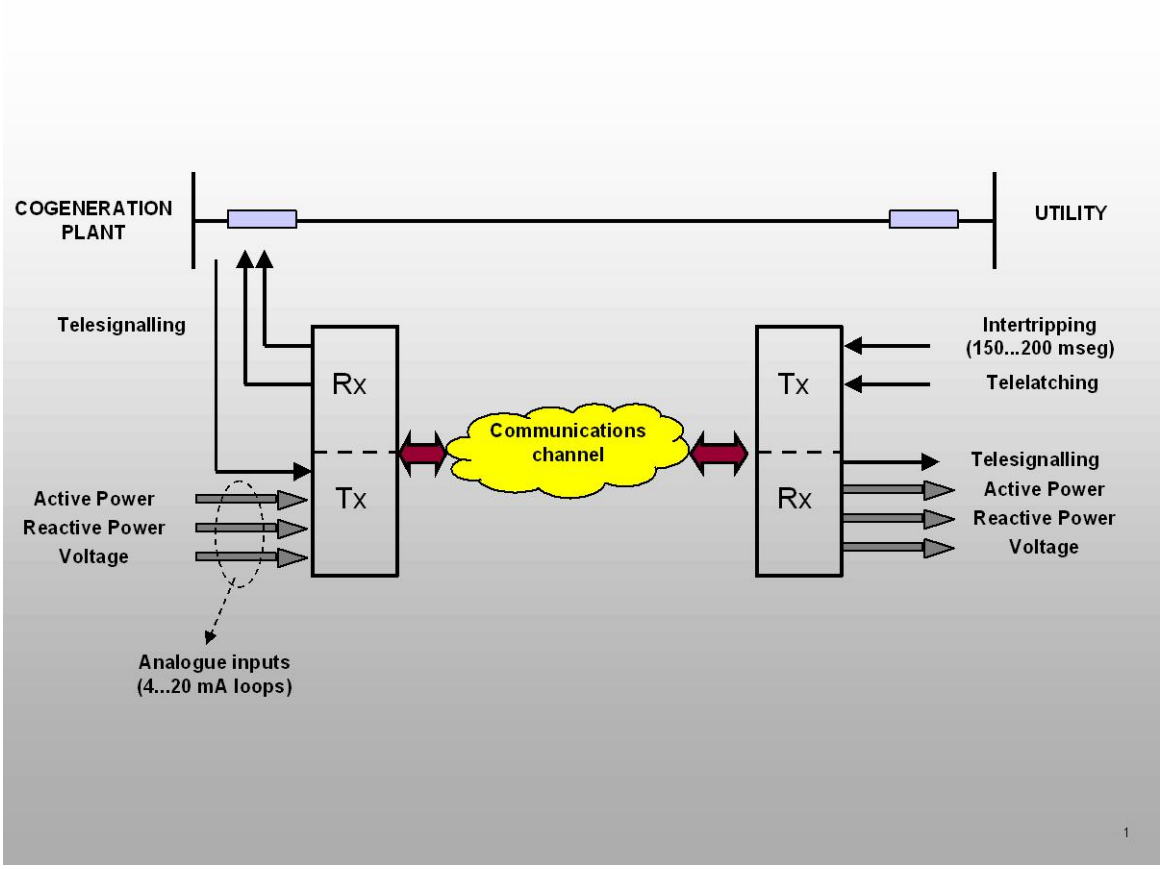

Figure 1. Teleprotection system for cogeneration plants

2. TELEPROTECTION SYSTEMS AND SHANNON'S LIMIT

As already mentioned the system that supports these applications should be a mixture of a teleprotection subsystem with measurement and telecontrol features. This poses a challenge for the design of such a system, since the requirements expressed in terms of quality of service are quite different.

By "quality of service" we refer to the requirements of transmission capacity, latency and quality that the information to be transmitted requires. Not all types of information are the same, as figure 2 depicts;

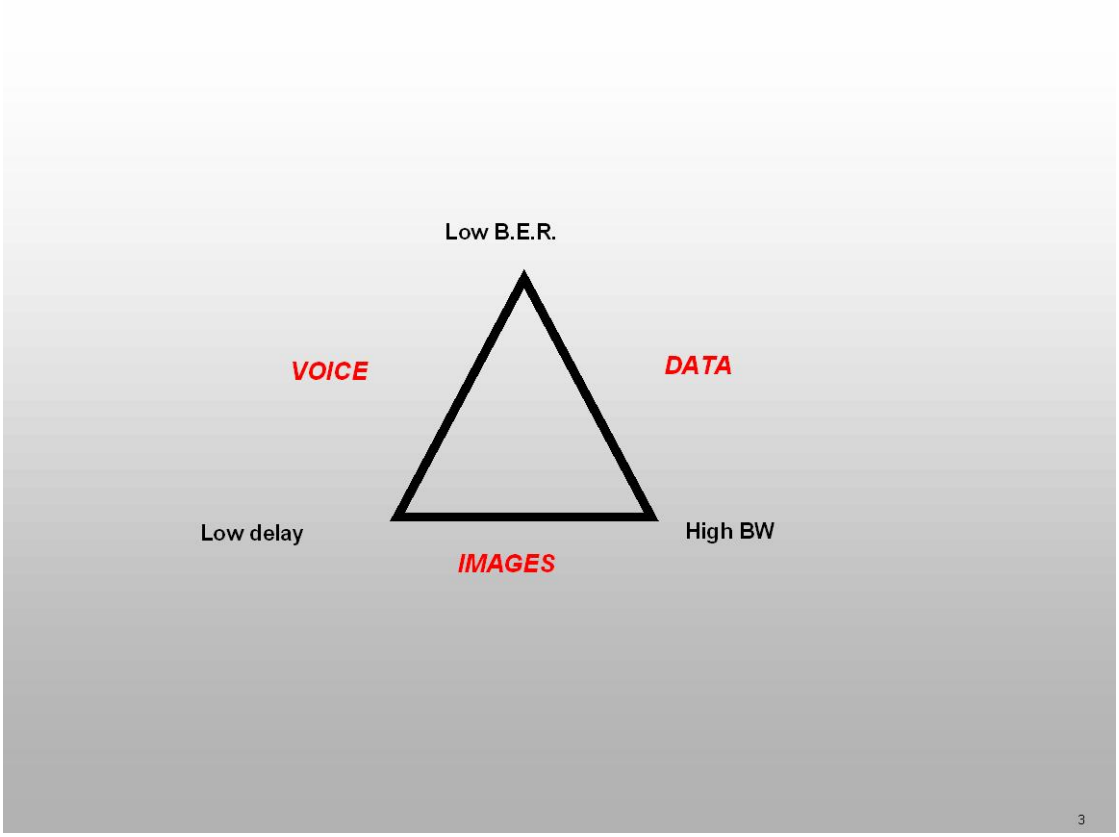

Figure 2. The Quality of Service concept

When applying this concept to teleprotection systems for cogeneration plants we find the following considerations;

- Teleprotection must be, above all, fast and reliable (see IEC60834-1). In fact this standard requires Tac=40 msec, Pmc= 1e-4 and Puc = 1-6 (analogue channels) and 1E-8 (digital channels) for intertripping applications. However the required bandwidth is small compared to that of, for example, telecontrol messages

- Telecontrol and remote measurements require higher bandwidth but latency is not so important, usually hundreds of msec is enough since they are informative messages.

From a more mathematical point of view the different requirements of quality of service can be summarised in Shannon's Limit. Claude Shannon, a PhD student working towards his thesis in 1947, discovered the so-called Shannon's Limit. The maximum information rate that can be transmitted over a channel of bandwidth Bw and signal-to-noise ratio SNR is given by...

$$C = Bw \cdot \log_2\left[1 + \frac{S}{N}\right]$$

The derivation of this expression makes the following assumptions;

- The channel is ideal. This is to say, flat amplitude response and constant group delay
- The noise is Additive, White and Gaussian
- The receiver has infinite decoding delay

The physical interpretation of this expression is clear: the more information capacity you want to transmit the more decoding delay and the more fragile the transmission becomes.

Teleprotection systems go clearly in the opposite direction. They put more emphasis on the reliability of the information and short detection times (see figure 2) rather than information capacity. In fact common teleprotection systems are based upon the detection of sine waves.

3. TELEPROTECTION SYSTEMS FOR COGENERATION PLANTS

The teleprotection system for cogeneration plants must transmit the aforementioned information with the corresponding signal processing to meet the different requirements of quality of service;

Direct tripping to disconnect the cogenerator from the network:

This information should be treated from the teleprotection point of view. It is to be transmitted from the utility to the autoproducer. It should meet the requirements given in IEC 60834-1 for intertripping applications in terms of dependability, security and transmission time. This is the "teleprotection part" of the system.

Measurement of voltage, active power and reactive power:

This is the measurement part of the system. All this information should be measured at the cogenerator's premises and transmitted to the utility. The emphasis now is not on the maximum transmission time but on the amount of information.

Prevention of accidental or unauthorised reconnection of the cogeneration plant:

This is the "telecontrol" part of the system. The emphasis should now be put on reliability of the transmission since accidental or unauthorised reconnection to the network can result in physical damage to the infrastructure. Transmission time is not so important since it is a non-real-time information. In fact most utilities have transmission times in the order of hundreds of msec. This is one order of magnitude greater than the maximum transmission time of a teleprotection system (tens of msec).

In order to achieve these simultaneous goals the system should have the following interfaces;

- An external input/output for teleprotection applications. All information relevant to this interface should be treated according to IEC 60834-1. An example of such information processing is the traditional F6 modulation, where the system transmits a guard tone and replaces it with a command tone whenever the command is to be transmitted.

- An external input/output to measure analogue magnitudes. In fact it would be more adequate to say "one external input/output per each analogue magnitude that has to be monitored". The most widespread technology for such purpose is the use of 4-20 mA loops, converting the analogue information into digital, transmitting it over the communications channel and converting it back to analogue at the receive side. This information can be transmitted over the service channel, for example, since it is to be measured under operating conditions, when the cogeneration plant is connected to the network and so the teleprotection system is transmitting the guard signal

- An external input/output for the telecontrol of the cogeneration plant. This external contact is a binary contact whose purpose is to interlock the cogenerator and prevent it from reconnecting to the network when the conditions are not suitable.

4. CONCLUSION

Traditional teleprotection systems can be used for new applications such as measurement and control of cogenerator's premises provided the system can transmit additional channels with the required quality of service, such as the internal service channel modulating a guard signal of an F6 modulation. It is interesting to note that such systems have been commissioned successfully and are in operation in a number of cogeneration plants.

5. BIBLIOGRAPHY

[1] IEC 60834-1: Performance and Testing of Teleprotection Systems. Part1; Narrow-band Command Systems.