Remote Monitoring System for Transformer Substations

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***Abstract*--This paper presents a new distribution transformer monitoring system (DTMS), called Wimo, which utilizes the existing communication network, has low investment and operation costs and is easy to install and use. The system is able to provide the following benefits for utilities: warnings and alarms in real time, measured and registered data of loadings, reactive power, earth current and power quality at the transformer substation, and more reliable and effective maintenance. Also, transformer capacity can be utilized more effectively and the control of power quality can be improved.**

The field tests of the first two installations in Finland have been promising and the system is shown to be compatible with the commercial GSM networks and with the information systems used in power networks.

***Index Terms*--Monitoring, Power distribution control, Transformers**

I. Introduction

THE distribution transformer is a critical item of equipment in power systems and its correct functioning is essential to the reliable operation of the system. It is therefore, necessary to monitor the operating condition and performance of distribution transformers in order to avoid or reduce disruption due to sudden unexpected failure. It also helps to save running costs by optimizing maintenance schedules.

Several monitoring systems for power transformers have been developed, such as those described in [1] and [2], but not for distribution transformers. Generally, the trend of transformer monitoring systems (TMS) is from data acquisition to data interpretation to give clear information to the operator. The distribution network will entirely be controlled automatically.

The reliability of operation of distribution networks can be increased by using automatic monitoring systems for transformers – not only for power transformers but also for distribution transformers. Remote monitoring can provide selective sharing of data among multiple sites in the most efficient and cost effective manner. An information centre of a utility acquires information on power plants and on HV/MV substations from a supervisory control and data acquisition (SCADA) system, and information on LV energy consumption of end users from automatic metering recorders. However, on-line data on the conditions of distribution transformer substations are currently not often available for remote diagnosis. For example, the information on the loading of distribution transformer substations is not in real time, but is limited and based only on technical checks performed few times a year by visiting maintenance electricians. Not only the conventional technical data, such as current, voltage, temperature etc., but also more advanced information about the status of transformers, such as expected transformer lifetime is needed by the operators to ensure reliable power delivery. Utilities find the implementation of communication between numerous monitoring systems too expensive and thus they have been ignored entirely. However, the development of the infrastructure of wireless communication such as the mobile phone networks, gives new, cost effective possibilities to monitor distribution transformer substations.

The Wimo distribution transformer monitoring system (DMTS) described in the paper offers several advantages over more traditional methods.

II. The Wimo System

Wimo system is developed by Wimotec Ltd. [3] and it consists of a PC with proper software at the control centre, transformer monitoring units (TMU, i.e. the Wimo controllers) with a GSM module at the transformer substations and radio communication (GSM and sometimes also GPRS) between them, as shown in Fig. 1a. A reliable server is also needed for data backup.

Figs. 1b and 1c show the Wimo TMU, which has as the following main features: voltage, current and temperature measurements, other I/O ports, a real-time clock and power storage in super capacitors. The potential free inputs can be used to detect short circuits, smoke and humidity, to monitor transformer cabinet and for a temperature relay. The controller has a programmable hardware, described more detailed in [4].

The system is capable of communicating in both directions. The Wimo system not only sends messages (measuring data, warnings and alarms) from a distribution transformer substation to an operator via a mobile phone or a server, but also receives the instructions such as parameter settings of the operator via a GSM or GPRS network and Internet, as shown in Fig. 1. Use of the existing communication network (GSM network for short message service, SMS of GSM network and GPRS for data transfer)

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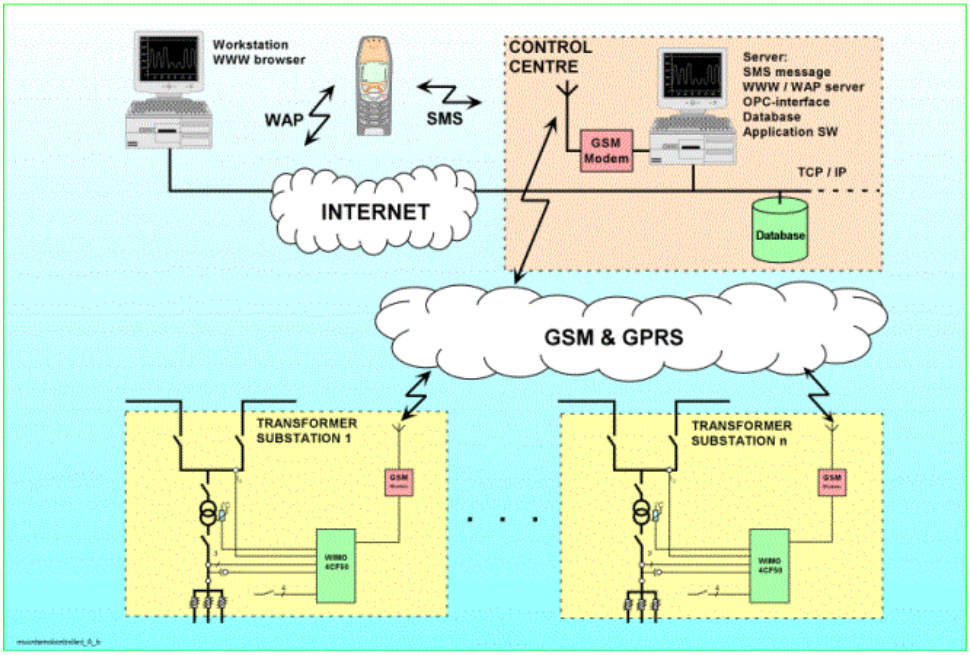
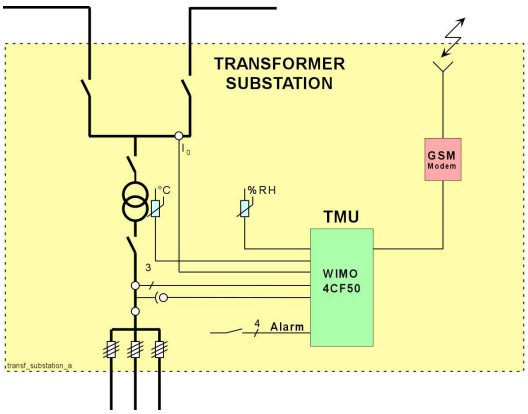


(a)



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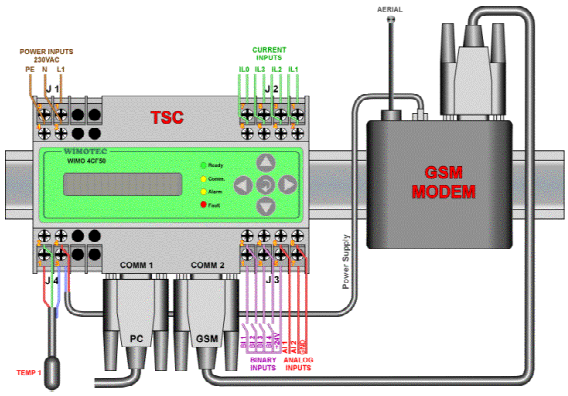

(c)

Fig. 1. The Wimo monitoring system for distribution transformers (a), the Wimo controller (TMU) with a GSM module in a transformer substation; schematic diagram (b), and layout (c).

keeps investment and operation costs low.

To monitor a transformer substation an operator needs the Web browser such as Microsoft Explorer or Netscape in a PC or in a PDA device or a mobile phone, and central station software (CTS); the main functions of which are alarm management, reading and storing of measurements to database and production of reports, online monitoring, parameter setting, production of a communication log, and system administration in general.

The system takes measurements and provides reports to the operator concerning overload conditions, power outages, voltage disturbances, earth faults, current unbalance and increase of reactive power etc. Fig. 2 shows a sample view seen by the operator. The operator sets the alarming limits for parameters such as currents, voltage, temperature, reactive power, imbalance, voltage peaks and drops, and receives the information of alarms, their location, time, event and measured value.

Wimo system is compatible with the other commercial IT systems for power systems, like a remote control and operating system for networks developed by ABB Ltd., a network data system of Tekla Ltd. and a remote metering system of Enermet Ltd., see [5]-[7], respectively.

The benefits of the WIMO system to power utilities can be summarized as follows: 1) effective management of the capacity of the transformer 2) fast fault clearance 3) automatic and reliable recording of outages and events including the time stamps, 4) authentic energy quality information through registration of voltage dips and spikes according to IEC standard 61000-4-30, 5) measurements to provide relevant data for enhancing maintenance and operating functions and predictability in various power network situations, 6) several communication options with the control centre including SMS based protocol for GSM, industrial protocol for control LANs, communication over GPRS, and OPC server for integration with external appli-

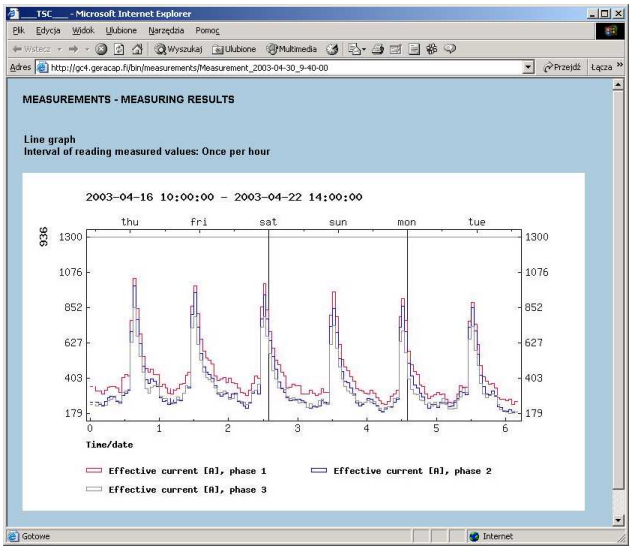

Fig. 2. Sample view of measured phase currents of a load as a function of time for an operator as shown on the PC screen.

cations, and 7) a financially advantageous solution both at purchase and operation.

III. Experiences in Finland

The first Wimo system has been operating in Finland for about two years. The system has shown to function properly and fully compatibly with the GSM and GPRS radio networks of the largest commercial mobile phone operators in Finland, i.e., Radiolinja Ltd., Sonera Ltd, and Dna Finland Ltd., introduced in [8]-[10].

In practice, the benefits of the monitoring system have shown to be useful in giving accurate and real-time information on distribution transformers such as loading and conditions of their rooms. Power quality can now be registered remotely without visiting the transformer substation for transferring physical measurement devices. In general, it is expected that the importance of the advanced features related to power quality will still increase in future.

Further development of the Wimo system will be in the production of devices for outdoor use and translation of the central station software which is now only in Finnish, Swedish and English to other languages. Total harmonic distortion (THD) will also be available soon.

IV. Conclusion

The reliability of operation of distribution networks can be increased by using automatic monitoring systems for transformers – not only for power transformers but also for distribution transformers. At present, operators do not have either much measured data or advanced information on transformer substations for maintenance and control. This paper describes an advanced remote monitoring system for distribution transformers which utilizes the existing communication network, has low investment and operation costs and is easy to install and use. Experience in Finland has shown that the commercial infrastructure can successfully be used in monitoring of transformer substations.

V. Acknowledgements

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VI. References

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VII. Biographies

Timo T. Vekara was born in Kokemaki, Finland, in 1959. He received MSc (El Eng), Lic. Tech and Doctor of technology degrees from Tampere University of Technology Finland in 1984, in 1993 and in 2001, respectively. He has worked several years with R&D of hoists and cranes first in Kone Corporation and then in KCI Konecranes. Since 1997 he has worked as an acting professor and has also been the Head of Electrical Engineering at the University of Vaasa, Finland.

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Seppo Pettissalo received MSc degree in electronics from the University of Oulu, Finland in 1970. He has worked several years with Strömberg Ltd, ABB Ltd., Vaasa Electronics Ltd., Vacon Ltd. and Vamp Ltd. in Vaasa. In 2002 he started Wimotec Ltd. where he currently works as the technical manager.

His interests are R&D in electrical engineering and electronics.

N. Rajkumar graduated in electrical, electronic and control engineering, and has worked in electricity distribution for several years. He received the MSc (Sys Eng) and PhD (El) degrees from the City University, London.

He was with the Singapore Polytechnic for 15 years, where he was a Senior Lecturer and has been the Section Head of the Electrical Power Section. He worked for two years as a Professor of Electrical Engineering at the University of Vaasa, Finland.

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