Building a Sensor Network in a Factory

By Tomihiko Uchikawa

Introduction

In the safety review following a major accident at a factory, it may be concluded that temperature sensors should have been installed. In recent years, everybody talks about the need for installing sensors of all kinds. If we take a fresh look at our daily operations, we find that there are many remote locations where we would like to gather information, and a range of equipment that it would be useful to be able to control. Establishing total management based on sensor data in the factory is not just a matter of preventing loss of assets through accidents and the like. It is also a means of protecting human life and the global environment. In addition, managing the manufacturing line with sensors can contribute to reducing the cost of products. However, when installing new sensors, building a conventional wired system involves a lot of cost and time, and these systems do not allow frequent changes to the layout of facilities and the addition of sensors as required. In the end, it may not be possible to recover the cost and the project must be shelved for practical purposes. In this situation, a wireless sensor network is called for.

Environment monitoring and line monitoring in the factory

Environment monitoring inside the factory is not only an important consideration due to local residents, it is also very important from the point of view of protecting the global environment. Environment monitoring inside the factory is the process of gathering information from sensors located in each area, then analyzing the data and implementing total management based on the results. Although the items for environment monitoring inside the factory include the facilities and equipment that are the source of general ambient noise, low frequency noise, waste water, flue gas, exhaust heat, electromagnetic noise and so on, these are related to factors such as toxic materials, offensive odours, noise, heat, light and electromagnetic waves that must never be released outside the premises. Sensor makers are focusing their efforts on developing high precision sensors in order to meet this goal.

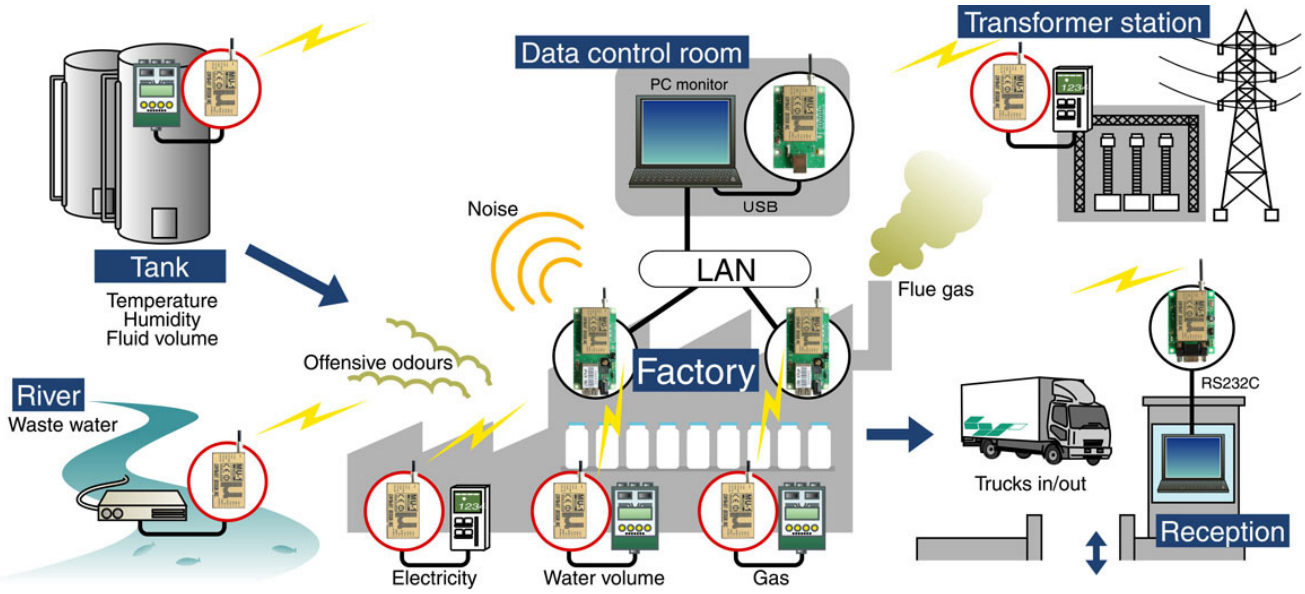
Managing these things is not only a matter of protecting the health and property of local residents. It is also an obligation to the employees. The attitude of the company towards reducing carbon dioxide and nitrogen compounds from fossil fuels is very much a concern of the public from the point of view of protecting the global environment. Up till now, this was not seen as being very important, but what the public requires of corporations these days is clearly changing.

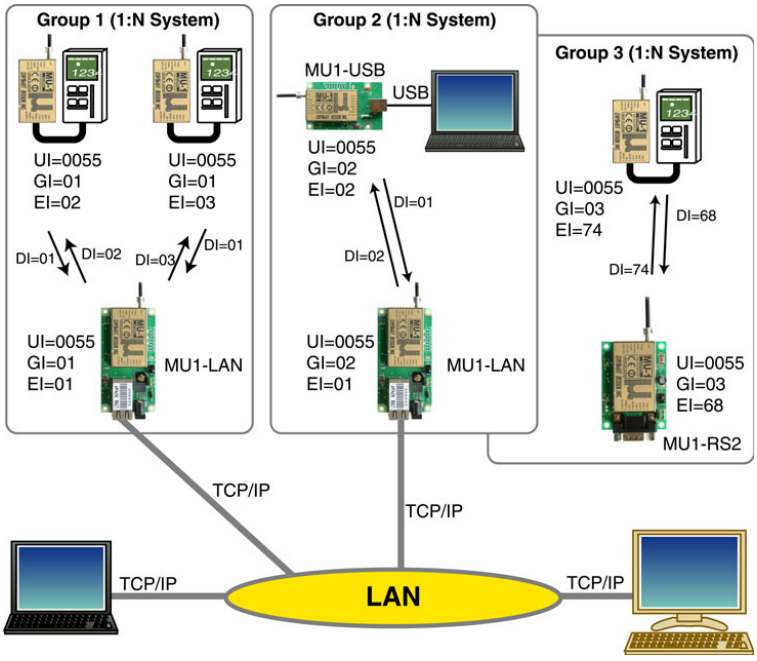
The purpose of production line monitoring is to cut energy losses, and if corporations and individuals do not take account of the earth's resources, they will eventually be exhausted. Fortunately line monitoring also leads to reduced product costs. And there is no good reason to ignore this aspect.

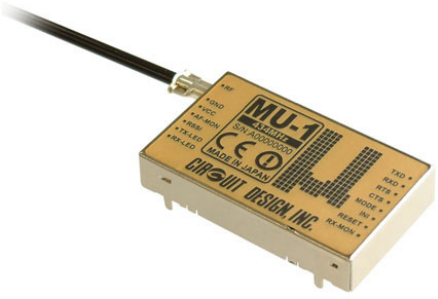
Networking with Wireless

Some of the facilities inside the factory were previously controlled as a block such as temperature and humidity data for the equipment, pressure, rate of flow data and so on. The sensing devices were provided with an RS232C or RS485 interface, and the signals were sent by wire to the control room. But when repairs were required or installation of new equipment is considered due to obsolescence of the equipment, it is necessary to consider the method of data collection. Every year there is a greater requirement to gather information from facilities that are spread out over a wide area on the premises, including data from equipment, temporary installations, and moveable machinery. But attempting to obtain all this data with a conventional wired system involves all of the problems noted above. For these reasons, systems that use wireless are increasingly being built. There are several merits to building a wireless sensor network, but perhaps the most important of these is the flexibility it allows in the layout of the system devices. In future if it is necessary to change the locations of the sensors or the layout of the data control PCs, this can be done relatively quickly, easily and at low cost. In fact there are many aspects that can only be handled using radio.

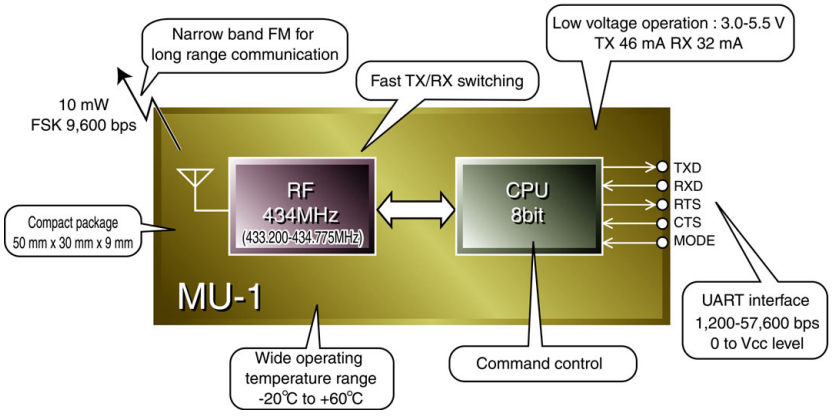
The diagram below shows an environment and line monitoring system inside a factory that uses Circuit Design's embedded radio modem MU-1. Ethernet LAN systems are already in place in many existing factories, and as the diagram shows, even where the sensors are installed at locations remote from the data control room, data can be received from the sensor nodes connected to the LAN by the MU1-LAN. The data is then gathered and analyzed in the data control room. In addition, it is possible to connect an MU1-RS2 or MU1-USB to the PC in the data control room, and receive data directly from each sensor node. Since the data transmission and control of the MU-1 is performed entirely with commands, systems can be developed relatively easily without any particular knowledge of radio modem hardware control.







MU-1 internal block



Radio Modems for Data Sensing Applications

We are now seeing the emergence of a market for a variety of radio modems and modules for data sensing. Wireless chips aimed at standardization are close to the delivery stage, but how they will be received is as yet unknown.

The radio frequencies that can be used for sensing in Europe are the 434 MHz, 869 MHz, and 2.4 GHz bands. Radio modems for the 434 MHz band can communicate at long range, achieving a link even where there are occasional obstacles. There are many products available that use this frequency band, and with good design, they can be used to build satisfactory user systems. Circuit Design's MU-1 uses the 434 MHz band, and it achieves a communication range of 600 m (line of sight), a bit rate of 9,600 bps, and power consumption of 46 mA (when transmitting) using a command control system. Through use of narrowband FM with a span of 25 kHz and a SAW filter with sharp filtering characteristics, good resistance to radio interference is one of its features.

The 2.4 GHz band is used for wideband, multifunctional wireless LANs with high speed communication. But it is also used for relatively narrowband multi-channel SS modems (spread spectrum communication) which are marketed for low data capacity communications. Circuit Design also plans to market a low power consumption product. With a greater number of channel frequencies, the communication range becomes shorter and communication is more prone to the effects of obstacles. However, by choosing a channel with good communication quality from among the many channels available with a 2.4 GHz band radio modem, it is possible to build a stable system. In addition, from the point of view of frequencies, it offers the merit of being usable nearly all over the world, including Japan, Europe and America.

Sensors are often located out of doors, and this often raises problems of power supply and environment. In other words, radio modems for sensor nodes are required to have low consumption current, and to be small, light and resistant to secular and environmental variation (temperature, humidity, vibration and so on). There is an abundance of information on the Web concerning how to solve problems of power supply with fuel cells or solar panels. These are excellent developments, and while they may not be immediately available, they suggest interesting possibilities.

When using radio modems for industrial applications, it is necessary to decide the specification after careful investigation of system safety. For example, since wireless errors always occur they must be addressed, and if a third party is emitting radio waves nearby, there will be radio interference. With important systems, even parallel operation may not be sufficient from the point of view of safety. It is necessary to ensure that the system functions safely under any circumstances. Besides safety, security must also be considered. Since anybody can receive radio waves within the frequency band, systems must be designed bearing this in mind.

The Future of Data Sensing

As I described above, one of the merits of building a wireless sensor network is the flexibility it allows in adding sensors and changing the layout of the system. But approaches to sensor networks are evolving daily, and recently new ideas such as the fusion of sensor networks and ad hoc networks and so on are being studied. As an example of a new network, if one sensor node among several located over a wide area should malfunction (communication error, dead battery, failure and so on), the network has a protocol for finding another route automatically and getting the data to the control node. This enables users who are not very familiar with electronics or networks but who need to use sensors to add additional sensors to the network easily, which is a very important consideration.

In future sensing applications, sensors will likely be attached to many things, so that the number of sensor nodes will increase. Therefore radio modems will be required that are equipped with protocols that can coordinate between the nodes. Current radio modems for data sensing applications achieve low power consumption through a trade off with data capacity. They are also slow and allow no margins. In the near future, modems that achieve both requirements are likely to become available in response to the new networks.

Conclusion

The requirements of users who seek to take an environmentally friendly stance are self perpetuating, and users continually convey their wishes to radio manufacturers and vendors who design radio system applications. For many years, Circuit Design has been providing the sensing market with embedded radio modems and general purpose radio modules for industrial use. Circuit Design's radio products are built with highly reliable basic components for industrial use, and they are more than capable of meeting the system requirements of the sensing field in which long term operation is required.

Although you may have gained the impression that anybody can easily build a wireless sensor network, for industrial applications, the system must resolve the problems unique to radio that we looked at above.

If you are considering a sensing system using radio modems, please ensure that you implement a solid and reliable application design. And be sure to mention the benefits of using a radio sensing system in all your corporate communications.

CIRCUIT DESIGN, INC. 7557-1 Hotaka Hotakamachi Minamiazumi Nagano 399-8303 Japan
Phone: +81 263 82 1024 Fax: +81 263 82 1016 e-mail: info@circuitdesign.jp Web: http://www.cdt21.com