Natural disaster monitoring and warning system using SRD

Based on the MU-1 embedded low power radio modem (434 MHz band)

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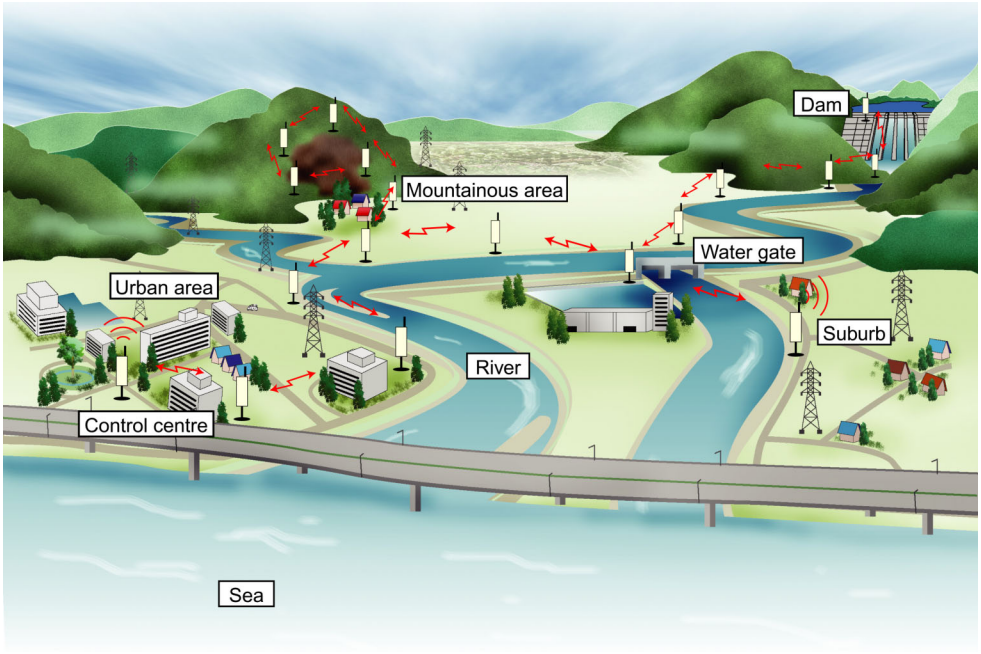
Introduction

In recent years, major flooding has occurred in all parts of Europe and in Asia, and the cause of these disasters has been identified as global warming. It appears as though the global environment is beginning to exact its toll in unforeseen ways on modern mankind for our pursuit of a convenient lifestyle. We want to be warm in winter and cool in summer, and have bright lights and round-the-clock television. We are beguiled by endless consumer products. And while our consumer appetites are fed by burning fossil fuels, these fuels emit carbon dioxide that amounts to just under 60% of greenhouse effect gases. As a result, global warming is unfortunately and undeniably getting worse. While global warming takes moisture from seas and land causing arid regions to spread, it also causes the moisture that cannot be contained in the atmosphere to fall as localised torrential rain. Since major flooding used to occur infrequently in Europe, the recent devastation was not anticipated. Clearly the global environment is changing, and floods can be expected more frequently in future.

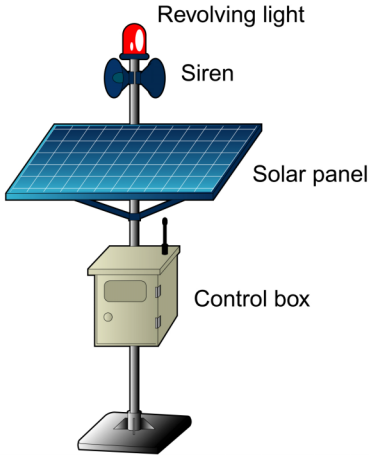
Besides causing floods, torrential rain also causes landslides in mountainous areas. Once a disaster of this kind occurs, valuable life, property and livelihoods are lost, and untold damage is caused to agriculture, industry, and infrastructure. Flooding of underground facilities in urban areas is another major problem, and the relevant agencies are studying measures to prevent it. Advance detection is important to minimize damage, and providing citizens with accurate and timely information and instructions is crucial.

Building a disaster monitoring and warning system conventionally using wiring links costs an enormous amount of money. But if a high power radio system is used instead, it is still a complicated matter to gain authorization for each part of the system regarding the transmission of radio waves. This is the problem that the agencies responsible are now facing. (In Europe, special frequencies are set aside for high power radio used for these systems.) As a solution to this problem, systems are being considered using the 434 MHz, 869 MHz, and 2.4 GHz radio frequencies that don't require a license.

I'd like to introduce an example of a monitoring and warning system using Circuit Design's short range device MU-1 radio modem that doesn't require a license. The MU-1 can be used as the basis for an entire system, or for handling sensor and actuator data as a single part of a larger system. The MU-1 has a relay function that enables it to perform direct 1:1 communication as well as 1:N communication using relay units. This allows it to be used flexibly in many applications.

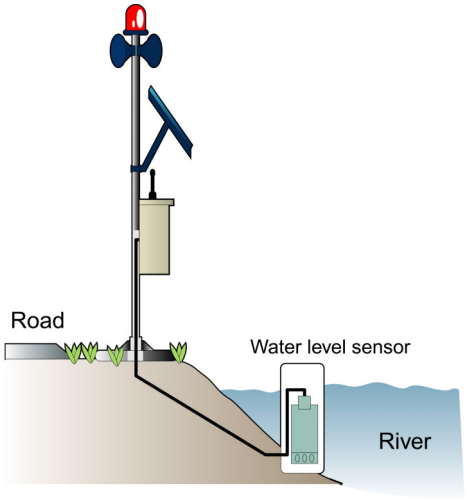


Natural disaster monitoring and warning system visualisation

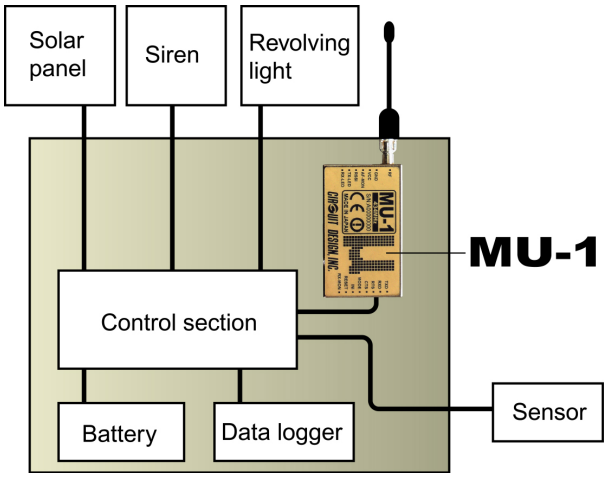


Monitoring and warning apparatus

The monitoring and warning equipment



Installed configuration



Block diagram

Viewed as systems, there are large scale systems that involve transmitting video using monitoring cameras as well as sensor information, and relatively small scale systems where sensor data alone is sufficient. Recently, 2.4 GHz band wireless LAN has become more accessible, and video monitoring is also in demand. However, images alone are insufficient, and measurement values from sensors are very useful for making judgments. Normally the data gathered is transmitted to a control center using public communications infrastructure (fixed networks, satellite circuits and the like). This article presents an example of a river monitoring and warning system using the MU-1, but since the data speed is too low for sending image data, this system uses only sensor and actuator data.

Monitoring and warning equipment for floods must include sensors for water level, rainfall, strain, temperature and so on, while the actuators required will include warning sirens, revolving lights, and electronic signboards. Basically citizens should be provided with as much information as possible, but there's a trade off here with the power consumption of the overall system. The system diagram provisionally includes batteries charged with solar panels, a data logger, and radio component, but the total power consumption will be rather high, so a larger solar panel than is shown will be necessary, and the battery also needs a large capacity. Whatever is used, the power supply of this kind of standalone system is the most significant problem.

The monitoring equipment transmits the continuously changing water level and rainfall data to the control center via the relay stations. If the water reaches the warning level or the evacuation advisory level, the control center promptly sends instructions to residents using the warning equipment. Email can be sent by mobile phone to administration staff, and they can go to the location of the emergency, checking the continuously changing information on a special homepage on their way. Other relevant agencies are notified at the same time.

Since the system presented here is intended as a key system for warning of emergencies over the whole region, the control program must be designed with great care. As this radio frequency range doesn't require a license, third party radio waves may interfere with the system, so the operating status of the overall system must be checked continuously, and the channels switched if necessary. Because the overall system must use the same channel, how to change between frequency channels is the most significant issue here, and this must be decided at the system design stage. As explained later, the MU-1 has convenient commands for changing system channels.

The system may become unstable in some cases due to the status of the radio waves. In this case you can issue an MU-1 command to acquire the RSSI level of the target station. System maintenance is very convenient using the test MU-1 connected to a notebook PC. With the air monitor function of the Evaluation Program, you can display a bar graph of the received signal level for all channels of the target station.

The system required for monitoring landslides in mountainous areas is the same, although strain and incline sensors are used. Because the equipment may sometimes be destroyed by falling soil, the system must be designed to permit use of alternate routes, so that the flow of information is not cut off when using relay communication.

Issues with the system

- Because the system introduced in this article uses radio equipment that doesn't require a license and is susceptible to radio interference, it is necessary to make a robust system, and to check it continuously to ensure that it doesn't go down.

- The data handled is very important, so the communication protocol must be reliable.

- It is also necessary to consider alternative routes for communication for when a problem occurs at a relay station. Parallel operation may be required.

- Since the equipment must run year round, the power supply is an issue. Where there is no commercial power supply, a combination of solar panels and secondary batteries or fuel cells can be used.

- The equipment itself is located in a disaster prone area, so it must be physically robust.

- To conserve the batteries, a longer data sampling interval can be used under normal conditions, but then it is necessary to shorten the data sampling interval during emergencies to gather up-to-date information.

- Measures are required against interference signals and vandalism by malicious third parties.

- Systems located in mountainous areas may be vulnerable to lightning. Parallel operation may be required.

About the MU-1 radio modem used for the system

Radio modems for the 434 MHz band that don't require a license can communicate at long range even though their power is limited to 10 mW, 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 is a half-duplex transceiver that uses the 434 MHz band. Suitable for applications such as data transmission, telecontrol, and telemetry, it employs a command control system.

Its biggest feature is its data relay function, and a maximum of 10 relay stations can be used. Also, the MU-1 achieves the low power consumption (46 mA when transmitting) required for sensing applications.

Other features include a communication range of 600 m (1 line-of-sight leg), a 9,600 bps wireless bit rate, narrowband FM with a channel span of 25 kHz, and a SAW filter with sharp filtering characteristics, providing good resistance to radio interference.

The most important and convenient functions are listed below.

- Since a maximum of 10 relay stations can be used, with a communication range of 600 m for each straight line leg, long distance communication of around 7 km can be achieved. When the data is sent from the source station to the target station, an ACK response is returned if it is received normally making it possible to determine whether the data arrived.

- In radio systems, problems specific to radio equipment arise frequently, but the cause can be difficult to investigate when the equipment is located inconveniently. However the MU-1 comes with a function for acquiring the status of radio waves (received signal level) in the vicinity of the target station, and this function is extremely useful for system maintenance. Using the air monitor function of the Evaluation Program, you can display the received signal level of all channels as a bar graph.

- The MU-1 can send 255 bytes of data per packet, which is quite sufficient for sensing applications. Of course data that exceeds 255 bytes is also taken into account. When data sent from the source station arrives normally at the target station, a receive acknowledgement (ACK) is returned as a response to the source station, so that the source station can start sending the next data packet.

- If one of the relay units in a relay system operating in a certain channel is subject to interference, the system goes down. In this case, channels must be switched, and the MU-1 can change all the channels in the system at once. Of course changing channels must be timed so that there is no radio interference, but it is very convenient to be able to switch wirelessly without having to go to where the equipment is located. The MU-1 has a total of 64 channels.

- The function for acquiring the status of radio waves in the vicinity of the equipment should also be used extensively at the equipment (system) design stage. It is important to use this function to optimize equipment performance in order to build a reliable system.

  The circuit board on which the MU-1 is mounted for the application will include noise sources such as the user CPU and other logic circuits, and various noise will also be emitted from the main device that encloses the circuit board. With the MU-1 embedded in the system, you can test the effects of changing the placement of the unit, adding shielding, adjusting the ground pattern, installing noise filters and so on. This is done by wirelessly obtaining the status of a measurement MU-1 connected to an external PC.

- It is useful to know the packet success rate in the environment of use during actual operation, and the MU-1 comes with a convenient function for measuring the packet success rate. The actual form of this function is a data transmit command, where data of a set size is sent from the source station, and the target station simply returns the data without change. If 1,000 packets are sent, errors can be detected with accuracy of 0.1%. (The success rate must be calculated for one way communication.)

- Since it is possible to attach the received data packet signal level to the front of the data output to the user CPU, this can be used to catch real time changes in the radio wave environment, allowing for countermeasures such as changing routes and so on

Conclusion

This article presented an outline of the benefits and functions of the MU-1 used in telemetry and monitoring applications, using a natural disaster monitoring system as an example. The applications of the MU-1 are unlimited; it can be used for emergency warning devices as a measure against intruders in schools, management information systems for agricultural produce, weather information systems, in-car information display systems, sports score displays and so on.

Although a ubiquitous information transmission environment is taking shape based on the Internet, wireless LAN equipment and so on, short range devices that extend the reach of data equipment will increasingly play a part. Although there are issues to be resolved with integrating the infrastructure with the Internet and mobile phones, there is a clear demand for this kind of equipment, and we invite you to consider developing your own applications.

Circuit Design accepts technical questions by email via our website for European readers who are interested in the MU-1. Responses are in English only, but our specialist staff will be very happy to help you.

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