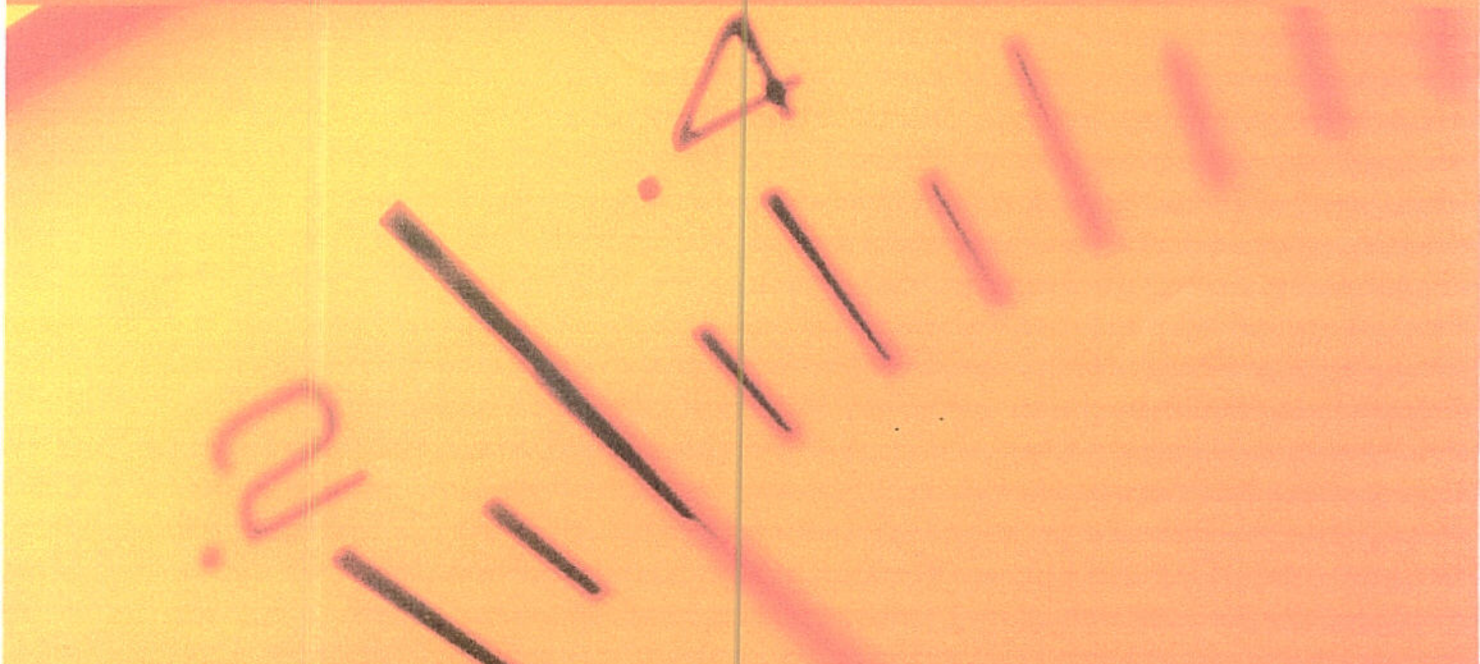
JUNE/JULY 2005

The EE

Electronics Systems and Software

RINGING YIELD BACK ROM THE LOW NUMBERS



ECONFIGURABLE SYSTEMS:
HE PROMISE AND REALITY
F FLEXIBLE SILICON

TEST-COST EXPLOSION:
COMPRESSION TO
THE RESCUE

TINY PROCESSORS:
DESIGNING PROGRAMMABLE
STATE MACHINES

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DEFERRING THE RISK OF MAKING CHIPS

Chip design has always been a risky business. You can get access to lots of processing power at a low cost of production, just as long as you can bear the one-off charges involved. Generally, the one-off costs rise with each step down the process curve, and they seem to be following the same sorts of exponentials that underlie Moore's Law in terms of silicon density.

The one thing you could count on was that, by shrinking the overall area of a given design, you would get improved chip yield as well as a faster part. With that, you could expect to get better margins. The only problem today is that better yield for a smaller-geometry process is not necessarily a given. And you would be hard-pressed to get a good prediction of the yield you would have with a 130nm or 90nm process before you get very close to the point of production.

Yield is no longer down to the fab alone. It has to be designed in because of the way that features put onto a chip can interact with the process steps in ways that are often difficult to predict. That is why part of this issue is dedicated to some of the techniques that are now appearing to let chip designers tune their designs to make them more manufacturable.

However, as we move towards 90nm and 65nm processes, there are big question marks over whether we will see the same sorts of yields that became possible with 250nm and 180nm processes. It seems that for those processes, many of the techniques that had been pioneered during the early 1990s finally fell into place. Moves to change the basic materials used for chip manufacture have changed that picture to the point where the kind of on-chip redundancy used for memories and FPGAs may prove necessary for logic.

This is where the adoption of reconfigurable-hardware approaches may prove to be cost-effective. By deploying multiple, identical cores across a die and programming them using firmware, it is possible to build on a few spares to account for possible yield problems. The technique has been applied by a couple of companies active in this space.

Another big project cost lies in verification, to avoid paying the price of a verification failure. Reconfigurable systems promise deferred verification. Whether this is a good thing or not depends on whether developers choose to adopt the same techniques as those used for a lot of software: let the user find the bugs rather than a lengthy verification process. That may be a step too far from today's reasonably rigorous approach to electronics system design.

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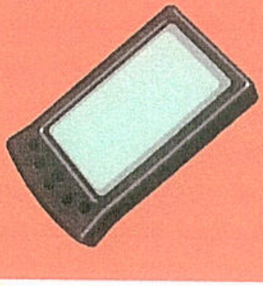

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by John Ferguson

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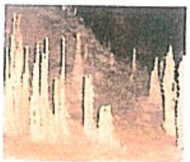

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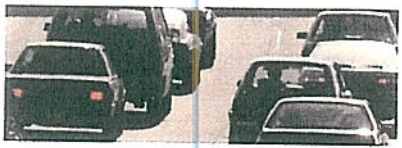

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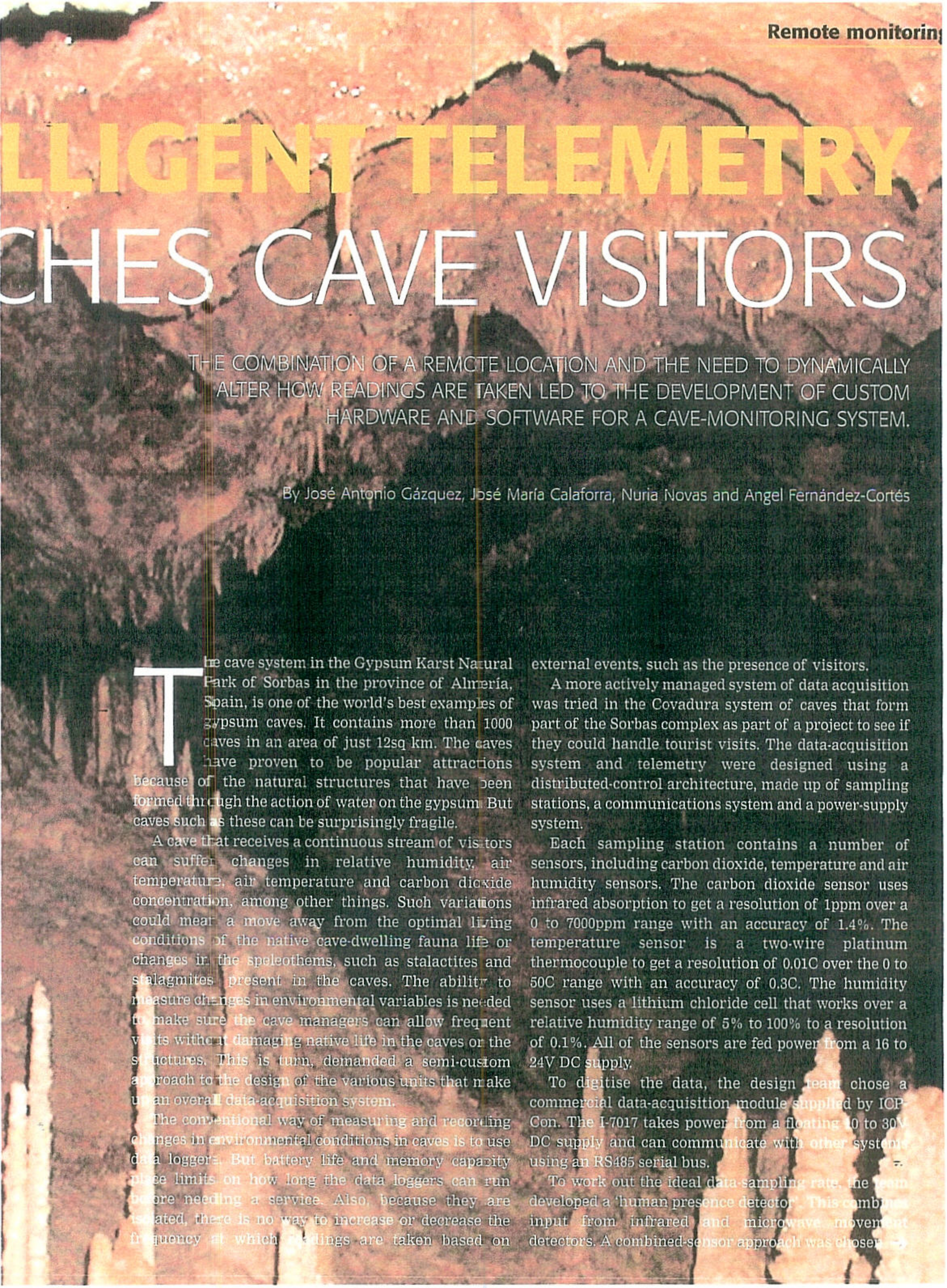


LLIGENT TELEMETRY CHES CAVE VISITORS

THE COMBINATION OF A REMOTE LOCATION AND THE NEED TO DYNAMICALLY ALTER HOW READINGS ARE TAKEN LED TO THE DEVELOPMENT OF CUSTOM HARDWARE AND SOFTWARE FOR A CAVE-MONITORING SYSTEM.

By José Antonio Gázquez, José María Calaforra, Nuria Novas and Angel Fernández-Cortés

The cave system in the Gypsum Karst Natural Park of Sorbas in the province of Almería, Spain, is one of the world's best examples of gypsum caves. It contains more than 1000 caves in an area of just 12sq km. The caves have proven to be popular attractions because of the natural structures that have been formed through the action of water on the gypsum. But caves such as these can be surprisingly fragile.

A cave that receives a continuous stream of visitors can suffer changes in relative humidity, air temperature, air temperature and carbon dioxide concentration, among other things. Such variations could mean a move away from the optimal living conditions of the native cave-dwelling fauna life or changes in the speleothems, such as stalactites and stalagmites present in the caves. The ability to measure changes in environmental variables is needed to make sure the cave managers can allow frequent visits without damaging native life in the caves or the structures. This is turn, demanded a semi-custom approach to the design of the various units that make up an overall data-acquisition system.

The conventional way of measuring and recording changes in environmental conditions in caves is to use data loggers. But battery life and memory capacity place limits on how long the data loggers can run before needing a service. Also, because they are isolated, there is no way to increase or decrease the frequency at which readings are taken based on external events, such as the presence of visitors.

A more actively managed system of data acquisition was tried in the Covadura system of caves that form part of the Sorbas complex as part of a project to see if they could handle tourist visits. The data-acquisition system and telemetry were designed using a distributed-control architecture, made up of sampling stations, a communications system and a power-supply system.

Each sampling station contains a number of sensors, including carbon dioxide, temperature and air humidity sensors. The carbon dioxide sensor uses infrared absorption to get a resolution of 1ppm over a 0 to 7000ppm range with an accuracy of 1.4%. The temperature sensor is a two-wire platinum thermocouple to get a resolution of 0.01C over the 0 to 50C range with an accuracy of 0.3C. The humidity sensor uses a lithium chloride cell that works over a relative humidity range of 5% to 100% to a resolution of 0.1%. All of the sensors are fed power from a 16 to 24V DC supply.

To digitise the data, the design team chose a commercial data-acquisition module supplied by ICP-Con. The I-7017 takes power from a floating 10 to 30V DC supply and can communicate with other systems using an RS485 serial bus.

To work out the ideal data-sampling rate, the team developed a 'human presence detector'. This combines input from infrared and microwave movement detectors. A combined-sensor approach was chosen →

The presence of visitors changes cave conditions

to make the detector less susceptible to false alarms. An 8051-architecture microcontroller running custom software was used to process the data from the sensors and feed data to the other systems using the RS485 bus. The board carrying the microcontroller was designed to support remote stations using a relay or pulsewidth modulation for control. These options may be used if the project is extended to include a wider range of sensors that need intervention during operation. A block diagram of the microcontroller board is shown in Figure 1.

THE TEAM OPTED TO USE TWO POLLING PROCESSES TO ALLOW SAMPLING TO CHANGE

The data packets provided by the data-acquisition systems attached to the RS485 bus go to a local computer that sits in a hut near to the caves. This computer formats the information and relays it using a radio-modem link that runs via an antenna tower at the Calar Alto seisomological station to a central computer in the University of Almería. The RS485 bus used in the caves is split into main segments, each less than 1000m long. Low-capacity twisted-pair wiring was used for communications and was joined to a 1sq mm thick wire for the power supply. Because of the risk of rodents gnawing at the cables, they are put into spiral steel tubes and then buried to avoid any visual impact on the caves.

The RS485 bus allows only one station to transmit at one time so a polling protocol was used to control access to the bus. To allow sampling to change with the presence of visitors, the team opted to use two polling processes. One records the time at which people are detected at any of the stations and operates every 30 seconds. The other collects the environmental data. If people were in the cave system less than an hour ago, the environmental data is collected every minute. Otherwise, the data collection rate drops to once every hour. The intervals can be varied if necessary.

SOLAR NEEDS

As the remote stations are some distance from power lines, a photovoltaic supply is needed to provide power. The total power consumption of the local computer, radio modem and four remote stations sitting on one of the sampling lines in the cave is about 24W. That means a daily energy supply of 576Wh. The average daily

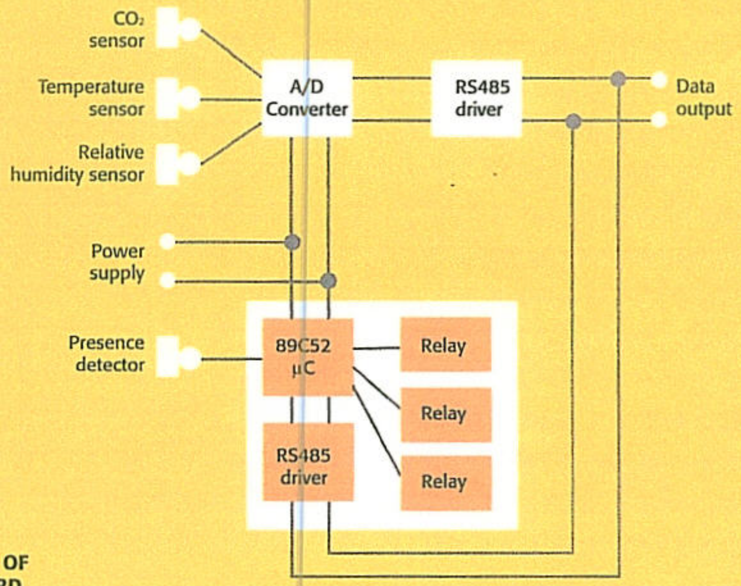


FIG. 1 BLOCK DIAGRAM OF THE REMOTE UNIT BOARD

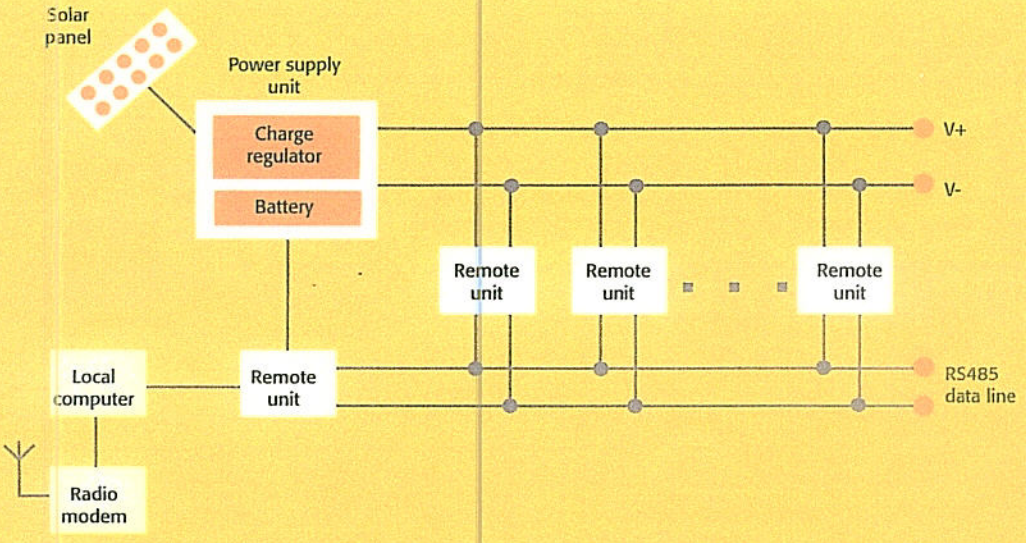
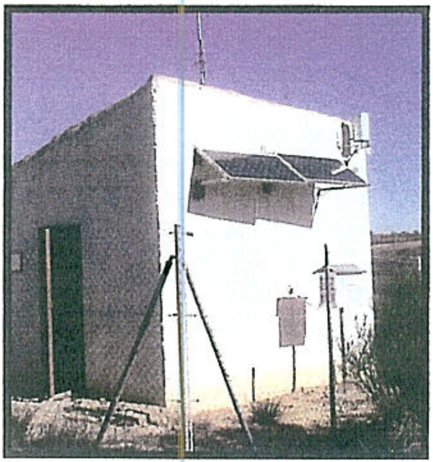


FIG. 2 OVERALL ARCHITECTURE OF THE DATA-COLLECTION SYSTEM



solar radiation in the area is about 3900Wh/sq m for the least favourable month of December. Using 200W solar panels at the optimal inclination of 60 degrees, it is possible to obtain 800Wh per day. The batteries used have a capacity of 200Ah at 24V, giving an operational life of more than one week before charging. This ensures that battery discharge between cycles is kept low, helping to improve the batteries' lifetimes.

The battery-charge regulator used for the cave network is an experimental system developed by the team and is based on direct current transformers using pulsewidth modulation. It is more efficient than typical commercial systems, which use repeated connection and disconnection cycles under the control of a microprocessor.

The radio-modem link needed a specialised design to deal with the specific requirements of this kind of remote-monitoring application. A radio-modem design intended for solar-powered system had already been developed at the University of Almería and this was used as the basis for the cave-monitoring system's modem. The modem is managed by a microcontroller to allow software to be adapted to optimise the link parameters.

The modem uses four-way frequency-shift keying and supports detection and error correction. The design allows for variable-length packets and can filter out 'foreign' frames. Special attention was paid to this part of the design to prevent the manipulation of the system by external personnel. The overall architecture of the system from solar panels through to the radio modem link is shown in Figure 2.

The system at the Sorbas caves has been operating for more than a year under the surveillance of researchers at the University of Almería and has generated a large quantity of data. The automatic increase in data-collection frequency has allowed detailed time-series analysis of the monitored variables for different types of visit. This continuous record will enable the ideal visitor regime to be determined as a function of the impact of the types of visit on each environmental parameter.

By developing specific hardware for key parts of the data-acquisition system, it was possible to produce an overall system that was better suited to the remote nature of the Sorbas cave system.

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