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# Wireless monitor for cathodic protection in remote sites: a case study for a university spin-out company

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**Abstract.** This paper describes how a new spin-out company managed to develop a product and bring it to market. The product, a wireless monitor system for use on cathodic protection equipment, is described briefly with emphasis on the main technical challenge of ultra low power demand.

The rest of the paper is devoted to the real challenges facing a new spin-out company: ensuring that its product has a market and obtaining the finance to develop it. It shows how government grants and collaboration with an established company can help.

## 1. Introduction

In a paper to the last Sensors and their Applications conference [1] I described a shock monitor device I had just finished developing for my newly established spin-out company. It was intended for use on remote pipelines for detecting pressure surges, seismic events, explosions, etc, which could be a sign of damage in the pipe. It comprised a fast microcontroller to monitor several sensors continuously, a wireless modem to transmit data to a supervisor computer and a suite of software for analysing the data, raising alarms, maintaining a web site, etc. It was quite clever and expensive and we never sold a single unit.

This paper describes the development of its successor, a much simpler device that was developed in response to an established need in a clearly defined market. This development was undertaken in close collaboration with a company already well established as a supplier of services to the pipeline industry who can handle the marketing and sales. The new device has just entered production at the time of writing and shows promise for steady sales into the future.

This paper is offered as a case study on the development of engineering products for university spin-out companies.

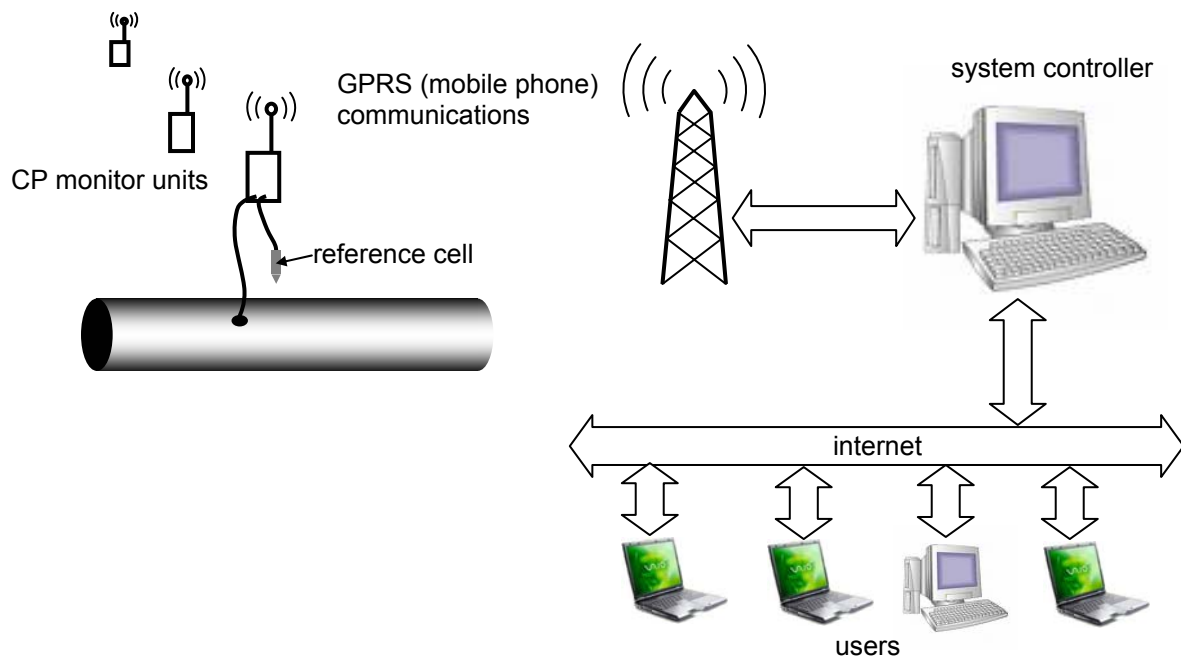
## 2. The Application

The problem with the previous device was two-fold. It had no clear market and we (the new university spin-out company) had not the time, expertise or inclination to market it aggressively.

Fortunately my university life had brought me into contact with a local company, Advanced Engineering Solutions Ltd (AESL) who have just those requisites and also the

contacts in the pipeline industry to know what is required. They had identified a need for a much simpler remote monitoring device with the same requirement for wireless communications, to provide regular testing of cathodic protection systems. They suggested we might collaborate on its development.

The problem was relatively easy technically since measurements have to be made only at predetermined time intervals rather than continuously. Our existing device apparently required only some straightforward electronics development and reprogramming. The crucial advantage was that AESL had the contacts and experience to ensure that a system we developed together would have a market, and to sell the product without significant intervention from me.



**Figure 1.** Schematic Representation of the Cathodic Protection Monitor System

Numerous monitors at widely dispersed sites communicate with a central controlling computer using the mobile telephone network. This computer stores all measurement data and publishes it on a password controlled website so that customers can see only the records for their own monitors.

### 3. Cathodic Protection

The type of cathodic protection (CP) used on pipelines is known as “impressed current”. This is an active device that differs from the passive “sacrificial anode” CP in that it has a power source that holds the pipe at a negative potential with respect to the ground. For effective protection, this potential must be greater than 0.8V and 1.2V is normally considered the target.

In the UK and other developed countries there is a regulatory requirement on the operators of high pressure gas pipelines to install this equipment and, crucially, to test it regularly. In the UK the rule is that there must be a thorough examination every five years and a monthly operational check. This monthly testing is currently undertaken manually by a technician, and this is a time consuming process because many of the measurement points are in remote locations in the countryside. The operators are well aware that they could save a lot of money if the testing could be automated, but no suitable equipment existed at the start of the project.

The monitor system is shown schematically in Figure 1. The main components are a monitor unit located at each measurement point and a central computer to handle the data from all the monitors. Communication between the computer and monitor units makes use of the mobile telephone network and communication with customers (owners of the pipelines being monitored) is via the internet using a password protected web site.

#### **4. Cathodic Protection Monitor Specification**

Talks with a major gas distribution company, a current customer of AESL, clarified the requirements for a monitor system. The main features required were:

- measurement range 0-2.5V with 10mV resolution,
- the ability to operate without manual intervention for five years,
- small size to fit inside an existing enclosure,
- wireless communication using mobile telephone network,
- a computer to control a potentially large number of monitor units, providing data archiving, data analysis to detect faults, and automatic alarm generation.

The measurement range and resolution presented no difficulty since an 8 bit analogue-to-digital converter (ADC) suffices. However, 10 bit ADCs are widely available and this was seen as preferable since the least significant bit, which is suspect in any measurement, could be discounted.

Similarly, communications using a GSM/GPRS modem was proposed since these devices are readily available in very small packages from a number of suppliers at low cost. However, programming the modem and integrating it with the measurement and control software was recognised as a job for an engineer experienced in this type of work.

The long period between services was seen as a serious challenge. The main power drain in the system is the modem, but this could be switched off when not in use so the net power averaged over a month would be small. However, the power drain of any microcontroller, even in its deepest sleep mode, would drain the highest energy density lithium primary cells of sufficiently small size well before the five year period was complete. The proposed solution was to make use of the CP potential, “stealing” a small current to charge a battery or super-capacitor over the month between measurements to provide sufficient energy for a relatively high power discharge for the few seconds required to perform the measurement and communication task. Again, this was clearly a task for an experienced electronics engineer.

The programming of the central computer involved communications, database and web site development. AESL has an excellent programmer with experience of all three types of programming. It was agreed that he would undertake this work.

#### **5. Financial Modelling**

AESL had previously undertaken the monthly CP testing as a contractor to a major gas distribution company and so knew exactly the cost of this service. Using this information, I undertook some financial modelling to investigate the costs and payback time for both the supplier and customer of the monitor. This enabled me to calculate the range of prices that could be charged for the monitors under various combinations of initial sale and recurrent rental/service charge while giving the customer a substantial saving and short payback time.

I also investigated the potential income for both my company and AESL under various supply arrangements, charges and costs. From this it was clear that reasonable profits could be expected for both parties under any reasonable arrangement, but cash flow could be a serious problem for my company, a new start-up, if we undertook manufacture of the hardware.

It was thus agreed early on that the devices would be made for AESL directly by a manufacturer that we would agree between us. AESL would supply and install the units, and

also provide an on-going service for hardware maintenance and all data management. The customer would be charged for this service and AESL would pay us a licence fee.

By this arrangement, our income would be modest but fairly well assured over the life of the product. AESL would get a considerably larger income, but would provide the initial investment on each unit with a payback time that could be a year or more depending on the combination of initial and recurrent charges made to the customer.

## **6. Development Funding**

The cost of developing the monitor was estimated initially at £10,000, not including my time and the contribution of AESL for software development and general commercial advice.

To fund it, a DTI R&D award was obtained. These grants are made to small companies to develop new products and so encourage innovation leading to industrial growth. They are given for projects with a total budget up to £40,000, which can include salaries, reasonable overheads, etc. The grant pays half of actual outgoings, claimed quarterly in arrears, so there is still a substantial investment required by the company.

Two important criteria for justifying a grant application are “adventure”, by which they mean significant innovation with a risk of failure, and realistic forecast of commercial success if the innovation is successful. The second of these requirements was met quite easily by reference to the thorough financial modelling outlined above and by emphasising the collaboration with AESL, whose knowledge of the market and good relations with potential customers would ensure ready sales of a technically successful product.

The former requirement, for “adventure” was met by undertaking to develop a second wireless monitor unit whose main feature is an extremely accurately synchronised switching facility. This device will complement the low power monitor that forms the subject of this paper, but at best will be sold in much smaller quantities and so will be of limited commercial significance in the short term. I undertook to do the development work on this device myself, requiring microcontroller programming and integration of communications, GPS and logic modules at board level, all new technologies to me.

Including this “adventurous” component to the project fulfilled three important requirements: it satisfied the rules for the grant; it provided me with an interesting technical challenge to make up for the project management that was my main task; and it increased the total project budget to a level where the grant paid for the whole external cost (contractors fees, electronic components, consumables, etc).

## **7. The Development Process**

Having set a specification and obtained funding, the next task was to find a suitable contractor to do the main electronics development. I found four possible companies in the north-east and organised a tender competition. In the end three of the four tendered, and we were fortunate that one of the two that had particularly impressed me in initial discussions quoted the lowest price so that selection was not difficult.

The development went pretty much to plan, with no major mishaps. An important feature of the development was that the electronics contractor and the programmer at AESL worked closely together from the start to ensure the compatibility of the GSM/GPRS communications.

The only feature that changed significantly was the power supply, and it was here that the selected contractor made a big contribution. I had proposed to use the technique known as charge pumping to produce the necessary DC voltage for battery charging from the low voltage cathodic protection current. It turns out that no commercial charge pumping devices are available for input voltages less than 1.5V and, although the contractor thought a “special” might be made to work at the 1.2V CP potential, it would not be self starting and might not be reliable if the CP voltage drooped.

Fortunately, the contractor had previous experience of very low power applications (that was one of the things that had impressed me about him at our first meeting) and was able to suggest an alternative strategy. Instead of running the microcontroller in its deepest sleep mode for the hibernation period between measurements, it could be switched off completely and a separate real time clock (RTC) used to trigger the wake-up sequence. He found a RTC with a continuous current drain of only  $1\mu\text{A}$ . This completely changed the power budget for the monitor unit, which had previously been dominated by the low but continuous drain during the hibernation period. This continuous drain became so small that the short monthly measurement and transmission events became the major drain, and this could be accommodated by advanced lithium primary cells small enough to fit into the space available.

The development was completed with the delivery of the pre-production prototype monitor unit delivered just two weeks behind schedule, and thanks to the interaction with the AESL programmer, with no remedial work required.

### **Exploitation**

It was agreed at an early stage that the monitor system (monitor unit, installation and servicing, and all data handling) would be marketed as a system by AESL. This would save potential customers having to buy hardware and services separately and so make the package more attractive. It would also allow AESL the option of supplying the hardware free and putting all the charges into a recurrent rental, which they believed would be attractive to many pipeline operator companies.

As the scale of likely sales started to emerge it became apparent that the “up-front” cost of the monitor units would be considerable and too much for a small company such as ours to handle without a significant cash injection. It was also clear to me that running a manufacturing operation, even with the work contracted out, would be a significant drain on my time that would interfere with my academic research.

It was thus agreed that my company would not be involved directly in the exploitation at all. I would find a suitable manufacturer and then allow AESL to buy from them direct and pay us a licence fee.

This arrangement has worked well so far. I arranged for the electronics developer to supply the monitor units, using a printed circuit board made by a much larger electronics company with whom he has a close working relationship. This has the great virtue that if a problem should appear there will be no doubt who is responsible. If sales take off as hoped, it is understood that the manufacturing arrangement will be reviewed in the expectation of obtaining a better high volume price elsewhere.

### **Conclusions**

From the point of view of an academic, the following important lessons can be learnt from this project.

- A clear market is vital for sales; far more important than a very clever product.
- Identifying a market niche and assessing it realistically is much easier for a company already operating successfully in a field than for an academic looking out from a university.
- DTI (government) grants are available for small companies doing “adventurous” development. Work that does not seem particularly difficult to us will often seem so to industrialists and DTI assessors, so these grants are relatively easy to obtain and are extremely useful for developing a commercially viable product.
- Exploitation of even a simple product requires significant capital and is best left to industrialists.
- Industrial development work of this type is time consuming and does conflict with academic research.

These points can be summarised in one. University spin-out companies are supposed to be vehicles for exploiting our clever research. This has worked in a few well publicised cases, but a new company is much more likely to succeed if it addresses a real need with a simple solution rather than trying to create a market for a clever new technology.

At the time of writing (March 2007) the marketing operation is starting. The customer website, where customers will view the on-going performance of their CP units, is operational. The first batch of production monitor units has been bought and a field trial established by installing a monitor on a CP test point on a gas pipeline in Northumberland.

#### **Acknowledgements**

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#### **References**

**[1] Structural Monitoring for Rare Events in Remote Locations**

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