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INTEGRATED ACOUSTIC SYSTEMS

P M DORE

BELL ELECTRONICS

1. INTRODUCTION

The Bell Subsea Control and Navigation System (SCANS) has been developed to satisfy the operational requirements of subsea operators by functionally combining a truly remote ranging and telemetry system within a single unit. The standard package is designed to cater for a wide range of applications where telemetry, control and navigation are involved. Some applications will require special interfaces or software and as a result of the highly structured and modular design approach, such requirements are readily facilitated. The main configurations offered by the standard unit are outlined below:-

(a) An Acoustic Positioning Transponder

It has always been a design requirement that the traditional and more commonly used methods of undersea navigation are maintained with the minimum overhead being imposed by the necessarily more sophisticated SCANS hardware/software package. In situations of deteriorating propagation conditions, data telemetry is more likely to falter before single pulse ranging becomes inoperative. The ability to configure SCANS to be indistinguishable from the standard transponder, means that logistic costs can be minimised. As a transponder the unit is required to detect an interogation pulse of one frequency and after a small time delay, transmit a reply on a second frequency. By this method, the operator can always fallback on direct ranging methods.

(b) A Remote Ranging System

In this configuration, the system is capable of simultaneously measuring the relative displacement between itself and other transponders (other SCANS units or standard transponders) in a seabed net. In this mode of operation, SCANS takes over many of the tasks conventionally handled by the surface equipment as well as offering vastly increased performance and flexibility. This is because the remote (from the surface) inter-transponder ranges are measured directly and as the ray paths are nearly horizontal, the errors due to ray bending and measurement of ranges indirectly from the surface are minimized. The direct ranges thus measured will be telemetered to the surface Control and Display Unit (CDU).

(c) A Telemetry Link

A SCANS unit may be used as an upward telemetry link for monitoring of sensors or externally derived data. Data acquired from analogue and digital sensors are digitised and conveyed to the surface with no loss of accuracy. A complete underwater instrumentation system can thus be built up using temperature, depth, conductivity and current sensors together with gyros, twin axis inclinometers etc.

(d) A Remote Control System

The telemetry link is fully bidirectional with data and commands being sent from the CDU to an underwater unit which subsequently replies with data and command acknowledgements. Tasks involved may vary in complexity from a low cost release unit to a wellhead controller.

2. INCORPORATING MICROPROCESSORS

In the context of this application, incorporating a microprocessor is the key to flexibility, commonality and improved reliability. It is reasonable that for a specific application, special-to-type hardware can be assembled whose performance parameters such as size and power consumption will represent a marginal improvement over the microprocessor based solution. However, cost and lead time to the market place counts out this approach for dedicated systems (e.g. twin axis inclinometers) where the challenge is essentially one of interface alone. Unfortunately over sophistication can have a detrimental effect on system performance. When production quantities are sufficient, dedicated hardware can be produced which is optimum in terms of size, life expectancy and unit replacement cost.

Flexibility of purpose offers two real advantages, first in minimizing deployment costs and subsea unit count and secondly it facilitates speedy responses to differing customer requirements by allowing an economic solution to the maintenance of a store of 'off the shelf' modules requiring only hardware and software interface definition. The microprocessor leads to a minimal hardware configuration as the control and processing potential of the technology allows each module of hardware to be used for a multiple number of applications. For example a simple counter will provide time of day status, act as a reference for range time, provide the time base for the delayed trigger of a transponder as well as the sampling intervals used with most sensors.

The SCANS approach takes the conceptual step of not basing the undersea unit on the acoustic interface. Indeed, the acoustic interface is configured simply as a peripheral giving the realtime output of the acoustic channel. This step is essential in realizing the next generation of undersea instrumentation and control packages as the tasks to be performed are not always reliant upon activity in the acoustic medium. The ensuing generation will be in position to use the intelligence afforded by the use of microprocessor technology.

The subsea unit used not simply as a remote extension of any surface electronics but as a truly remote, autonomous node in the control and instrumentation networks. Data will no longer be simply acquired and echoed to the surface as there is now the ability to process acquired information. Indeed, the much publicised Hutton Field Tension Leg Platform (TLP) operated by Conoco (UK) Ltd involved the use of a Bell Acoustic Telemetry system to monitor any pull-out of the seabed templates during installation of the platform and the longer term monitoring of storm performance.

The telemetry units were coupled to displacement gauges produced by the Soil Mechanics department of Imperial College London. On command from the oil platform, the units powered the gauge during an initial warm-up followed by a period of data collection. The data is statistically compressed with only the minimum, maximum and mean data points together with the standard error of the distribution being transmitted to the surface.

The development of a remote microcomputer for the marine environment identifies the engineering requirement in the systems design:-

(a) Size and shape of unit for ease of deployment and installation.

(b) Packaging to protect against the effects of temperature, shock and vibration.

(c) Power consumption must be kept to a minimum.

(d) Fail-safe power shutdown.

(e) Fail-safe reinitialisation on power up.

(f) The need for a large number of I/O points and its effect on internal wiring and mechanical packaging.

(g) A system modular enough so the designer only has to use the functions he needs thus minimising operational overheads. To the operator this ensures simple configuration procedures.

(h) The electronics must be designed with a high degree of power supply and noise rejection due to the close proximity of switching logic, sensitive analogue circuits and acoustic transmitters all in one small package.

(i) The accuracy of any digital and analogue interfaces determines the overall system specification.

Ensuring effective communication is crucial to the solution for the next generation of underwater systems. The acoustic medium severly constrains the data channel capacity, especially when prevailing conditions include long time-constant reverberation and localised external noise sources. Like diseases, noise is never eliminated, just localises, quantified and endured. As will be shown in the succeeding section, incorporation of a microprocessor will assist in the unit's endurance and tolerance of noise.

3. COMMUNICATION

Higher data rates are normally achieved at the expense of data integrity. If activity in the acoustic medium is reduced, the error performance of the data transfer will improve. Hence given that errors will always occur, the aim of the systems design is to achieve effective error free transmission by ensuring that the decoders are tolerant of them. This can be achieved by first avoiding recurring geometric errors for, no matter how many times the telemetry message is sent, the errors will occur being a function of the reflections and reverberation of any particular geometry. Secondly the designer must bear in mind that the only degrees of freedom are frequency and time, and to make full use of both to maximise the bit rate as well as the baud (or symbol) rate, that which is adjacent in time should not be adjacent in frequency.

To further optimise the discrimination between signal and noise, microprocessor driven scanning enables the telemetry unit to detect the presence of frequency components in short time periods usually insufficient to trigger conventional verification circuits.

4. HARDWARE

The hardware design has a direct effect on the more basic aspects of the systems design, namely size, cost and life expectancy. Fundamentally the hardware defines the battery requirements both in the number of cells required and the type of cell used. The problems posed in minimising power consumption are usually handled by one or more of the following methods:-

(a) Total shutdown of the system, with the exception of the acoustic receiver and the memory which can be backed up with negligible quiescent current.

(b) Partial shutdown which involves the shutdown of all CPU clocks and activity, Processor activity is effectively frozen. This mode is very effective when the processor would otherwise be idling during a timed period.

(c) Varying the frequency of the system clock dynamically thereby adjusting the CPU throughput to a rate suitable for the specific task, whether it be processor intensive as required by performing statistical calculations or non time critical activities such as interrogating sensors.

(d) Powering of modules by requirement ensures that no operating overhead is carried by the batteries and that minimal current is always drawn.

(e) Use of low power electronics hardware.

(f) Optimization of the hardware/software compromise to minimize power consumption and maximise system performance.

(g) Make minimum use of the microprocessors bus as low power devices consume by far the most current when transitions occur.

After ensuring that correct engineering principles have been followed the biggest problem remains to be addressed, "what happens if the CPU fails?". There are two ways in which this possibility can be guarded against.

First there is reliability. Apart from inherent component reliability (MTBF figure) there are also the problems imposed by time and environment to be guarded against. Emphasis in these circumstances is upon high noise immunity, wide power supply range and wide range of operating temperature. Protection against these factors can, with the increased system complexity, lead to a lower MTBF. Initial specification of high standard components thereby becomes a cost effective aid to reliability.

The second way failure can be guarded against is to introduce a specific signal using as much of the system as possible which can only be generated if the system is functioning correctly. One of the worst failures which can occur is if one of the system elements starts to function only marginally incorrectly, since this is most difficult to detect. For most modules, this can be guarded against by the CPU, but what happens if such a defect occurs in the CPU? This possibility can be prevented by use of a two level fail safe timer, at the lower level a timer runs totally independently of the microcomputer to ensure that the processor has powered up correctly. At a higher level, a timer interrupts the CPU at regular intervals and performs various status checks.

Together with the afore mentioned safeguards, reliability rests with the overall engineering within the systems.

5. SOFTWARE

Software costs money. Modularisation must be a key feature of the software design allowing the states and modes of operation to be easily separated and their interfaces redesigned facilitating simple expansion or modification.

It is by the software that the more sophisticated functions are performed e.g. data compression, collation or scaling. Programmability is a key feature of the SCANS concept enabling the fine tuning of operational parameters to suit the varying acoustic conditions and requirements of different applications (i.e. reply frequency and turnaround delay).

CONCLUSION

Bell Electronics is committed to planning for the applications market with an expanding set of available application sensors and modules, both software and hardware. Efficient interfacing not only simplifies adaption for future requirements but also streamlines the performance in existing operations. User friendliness is more than simply a selling phrase in the market place, it means that the equipment is as useable in the North Sea on a diving support vessel as it is on a jetty in the Bahamas.

The development of microprocessor technology over the past decade has opened up a wide variety of opportunities for the design engineer. In the field of sub-sea engineering this ability has been used to develop both reliability and flexibility into systems so enhancing the operational performance of existing equipment and opening up the market place to new generations of instrumentation and systems.