70/18

BRITISH ACOUSTICAL SOCIETY

Microelectronics and its influence on Underwater Acoustic Systems.

25th February, 1970.

RECENT DEVELOPMENTS IN THE USE OF MULTICHANNEL TELEMETRY FOR FISHERIES RESEARCH

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1. Introduction

Acoustic telemetry has for some time been an established tool for underwater research and development. The art has advanced in recent years from simple single channel devices, to the multichannel systems carrying out more complex measurements which are now available. The principal factors which have limited the scope of acoustic telemetry are reliability, physical size and power consumption. The development of more compact integrated circuits has had a direct impact on underwater telemetry by raising the limits of these factors, so that it is now possible to design systems of a complexity which would have been unrealisable only a few years ago.

2. Application to fishing gear research

At the Marine Laboratory, Aberdeen, an acoustic telemeter system has been developed to provide real-time information on the performance of full scale fishing gears[1,2] The complexity of such gears means that a wide range of parameters have to be monitored underwater. These include geometrical factors like the spread of the net, and height of mouth opening, together with physical quantities such as towing loads in the wires, water depth etc. Accordingly, the gear telemeter was designed to accommodate up to sixteen separate measuring instruments on the net connected with it by cable, and to transmit data from these via an acoustic link to a towed receiver at the ship.

Apart from the main data transmitting link, acoustic pulses are also used for some of the distance measurements about the net, transmitted between a pair of hydrophones separately cable connected to the telemeter. The design of the underwater electronics was considerably simplified by standardising on this type of signal (a time delay). Thus tension meters, for example, which essentially operate a pressure transducer giving an analogue output, had additional circuitry built in so that on interrogation via the cable connection with the telemeter a response pulse was returned, the delay between the two pulses providing the required information.

The prototype equipment has now been in use at sea for over a year. A number of design and operating problems have had to be overcome, but the value of the system to the research effort has been decidedly proved. The experience gained has been applied to the preparation of a new design for future models. The logic of the system remains practically unchanged, but advantage has been taken of latest developments in component technology, particularly the advent of MSI elements. This development is detailed further below.

3. Underwater electronics

Circuits for timing, sequencing, encoding and data transmission are all incorporated into one "control unit", which is the subject of this section. Two timing oscillators are independently used to control channel stepping rate (variable, 0.1 to 3 channels per second) and acoustic link frequency (50 KHz) respectively. A time division multiplexer linked to a preset patchboard determines the sequence in which the instruments will be interrogated. Instrument time delay data are digitised by gating the 50 KHz oscillator into a 3-decade counter. Each decade then contains a 4 bit BCD number, in a special code. When these data are complete, a 4th "decade" is loaded with 4 bits given the channel number corresponding to the data. The full 16 combinations of 4 bits are possible in this last case, so it is not a true decade module like the others. Switching of a logic level now causes the 4 "decades" to be logically connected as a long shift register. The stored bits are now sequentially presented via a Morse-type encoder to the power amplifier driving the acoustic link transmitting transducers. Thus a binary '1' is sent over the link as a pulse 3 times as long as that for a binary '0'. Additional logic is used to properly space each pulse, and each group of 4 pulses.

The control unit logic circuits use a mixture of TTL and DTL elements. The additional speed, which is one of the features of TTL, is not necessary in this application. In fact fast switching times can be an embarrassment due to radiation, and TTL elements are also liable to cause noise spikes on power lines should the two output transistors overlap in switching with both 'on' together momentarily. However, it is the case at the present time that TTL systems offered by manufacturers generally include a wider range of functions than other types. Particularly in relation to the recently available MSI elements, the advantage of simple logic design and correspondingly improved reliability is paramount, and so the advanced design which has been prepared for future units uses TTL exclusively. The problem of circuit interaction will therefore require special attention through the use of proper screening and power line filtering techniques, bearing in mind the overall size limitation on the equipment which means that circuits cannot be spacially separated to any great extent.

The "first generation" microelectronic elements used in the prototype telemeter are mainly dual-in-line (DIL) packaged. Of the alternatives, TO5 cans are now out of date (except perhaps for operational amplifiers). Flat packs do offer a saving in space, but this is to some extent lost through the more complicated constructional procedures which are necessary. Maintenance of flat pack circuitry is better carried out at the sub-assembly rather than component level. For prototype equipments, and small runs of prototype copies, DIL packages are therefore likely to remain the favourite for some time to come.

Turning now to the further development now in progress on this telemeter system, centred on the use of MSI elements, these have a number of advantages over earlier IC techniques. Principally, the incorporation of a larger number of functions within one package greatly simplifies system design and construction. In consequence, the reduced number of mechanical wiring connections which have to be made enhances reliability. A good example is presented by the multiplexer logic of the telemeter control unit. This is essentially a 16-stage ring counter, made up by a 4 bit binary counter whose outputs are decoded by 16 NAND gates. The prototype telemeter uses for this 8 dual 4-input NAND plus 4 JK flip flop chips, a total of 12 circuit components, and 132 solder connections (including power supplies). Dual JK elements cannot be used, as switching of the counter must be synchronous thereby requiring a number of independent J and K inputs. The same logic, designed in MSI (Figure 1) has only 2 circuit elements and a corresponding 32 solder connections.

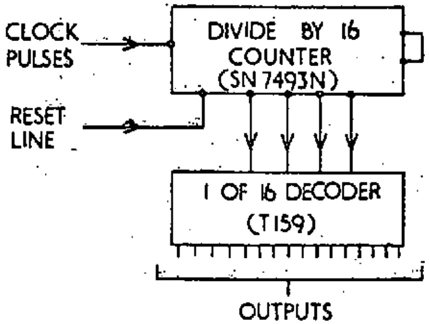

FIG. 1. 16-STAGE RING COUNTER

Standard applications like the ring counter are the obvious ones to benefit from MSI. On the other hand, more specialised circuits are not so easy, because the limited turnover will be unlikely to induce the manufacturer to enlarge the scale of integration. Thus the encoder logic requires various connections to be made between registers, so that the binary counter can be switched to a shift register mode, and vice versa. There are MSI counters on the market, and MSI shift registers; but, alas, no element which can be both. So first generation IC's must still be used in cases like this.

4. Shipboard receiving equipment

The prototype telemeter has been used at sea mainly in conjunction with an on-line computer for signal processing. In this situation the receiving hardware is minimal; a pre-amplifier built into the towed receiver housing, a main amplifier on the ship and a detector which provides the unchanged Morse type signals, at TTL voltage levels, to the computer interface. Further decoding is then done by software.

Linear IC's can be used in the amplifier circuits, but present some problems. Those operational amplifiers with a well controlled roll-off do not generally have enough gain at 50 KHz, while devices with a higher frequency limit but worse roll-off characteristics can give stability problems. This is particularly so where AGC has to be built around the system, as is the case here, to compensate for fading and other irregularities in the acoustic signal.

The computer is not an essential part of the telemeter system, but without it decoding circuits must be provided to drive a display. A unit is now being developed for this purpose. Full use is being made of MSI components for bit storage, decoding and the detection of fail conditions. The recovery of signal space and pulse length information is done by timing circuits based on the 710 type comparator, which has proved to be a most useful component for a variety of applications in this field.

5. Concluding remarks

Reliability of equipment is undoubtedly the key to the successful use of telemeters of the type described here. In a fishing gear development exercise, all instrument data from the net are channelled through the one telemeter control and transmitter unit. If that fails, all is lost, in contrast with previous techniques where the failure of one self-contained recording instrument did not affect the data contained in the other independent instruments. But multiple acoustic links are not a practical proposition at present, so to obtain data in real time, which is the principal advantage of telemetry, particular attention must be paid to the reliability question. Considering the severe vibration and shock to which this equipment is subject in use, one would expect mechanical connections, e.g. solder joints, plugs and sockets, to be a dominant source of failures. This has indeed been demonstrated by experience. The use of IC and MSI components will therefore contribute to system reliability through the reduction in number of such connections.

Even the best engineered systems fail sometimes, and assuming that financial considerations prohibit the use of "throw away" telemeters, proper provision must be made for maintenance in the field. If replaceable modules or cards are used, then there is an optimum size of module which depends both on cost and component considerations. Looking to the future, technology may well advance to the stage where all the circuitry for a multi-channel telemeter might be built on to one silicon chip, leaving but one electronic component to replace in the event of failure.

References

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