Development of Modular Data Systems at National Aeronautical Laboratory, Bangalore

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ABSTRACT

The need for automatic data logging systems arise in different areas of work relating to Aeronautics. Where large quantities of data are to be recorded, an automatic system will be advantageous. Where the rate of data input is too fast for manual reading (say, 10 per second), use of an automatic system is unavoidable. In general, digital readout/printing is required. However, requirements vary considerably as to the degree of sophistication and the extent of automation required. Therefore a modular design is desirable so that systems of varying degrees of complexity can be assembled from basic components. This concept also keeps the cost of a system as well as the time for building one within reasonable limits.

NAL has developed the different components required for data logging systems. These include analogue to digital converters (both electromechanical and electronic), logic circuits, logic power drives, d.c. amplifiers etc.

The paper aims at describing these together with some possibilities using such equipment.

The need for automatic Data Logging Systems arises in different areas of work relating to Aeronautics. Typical examples are experiments on structures of aircraft utilising a 100 or more strain-gauge transducers, wind tunnel experiments on aircraft models, vibration studies etc. In some cases, automatic data logging is advantageous because of the very large quantity of data that has to be recorded. In others automatic processing is necessary because the rate of data input is too high for manual handling, (say, 10 inputs per second). The requirements on the system vary considerably depending on the particular experiment. In some cases, all that is required is a suitable indication of the measured variable in a digital form, while in others, automatic printout may be required together with punched paper tape or card for computer operation. It is also often necessary to add to the variable data certain fixed parameters which are read from manually reset switches. It is therefore desirable that Data Systems should be built on the modular principle. This enables a system with given specifications to be assembled from standard components with the minimum expenditure of time and experimentation. The cost of the system also tends to remain within reasonable limits with this method of approach to the problem.

NAL has, over the last eight years, built most of the components required for making Data Logging Systems. Several systems have been built successfully. In what follows, an attempt is made to describe various components developed in NAL together with brief specifications of the same and the overall performance of complete Systems built from these components.

I. TRANSDUCERS AND DATA AMPLIFIERS

The Instrumentation Division of NAL has developed several transducers for measurement of pressure, displacement, force, acceleration etc. It is however not the purpose of this paper to describe these devices. For our purpose it is sufficient to indicate that the output of most of these devices will be in the form of electrical voltage of no more than a few millivolts at full scale. To record this data, two approaches are possible. One is to use a d.c. amplifier to raise the voltage level to a few volts. The other approach is to use a Strip-Chart Recorder or other self-balancing potentiometric device to measure this small voltage and use the mechanical position of the instrument for further processing. NAL has worked on systems using both types of devices. In either case it is necessary to transform the continuous or analog signal in the form of millivolts or shaft position into a digital number for further processing. NAL has developed several shaft-position digitizers which can be attached to standard strip-chart recorders in order to provide digital translation of the SCR indication. These digitizers have a resolution of one part in one thousand which corresponds to the accuracy obtainable in the best SCR's. It is significant to note that since the signal handled is purely digital, there are no errors introduced after this stage. NAL has also developed an Electronic Digitizer with 0.1% accuracy aud readout time of 10 milliseconds. This means that as many as 100 samples can be read in a second to an accuracy of one part in one thousand.

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2. LOGIC CIRCUITS

The output of a digitizer is necessarily in coded form In general it will be necessary to translate this output into decimal form and also to other codes as may be required by peripheral equipment which may be used to print or punch out information at the output. Detailed requirements of these circuits vary considerably in regard to actual logic as well as the requirement of power for the output stage. In addition to processing actual data it is often necessary to have a considerable number of accessory circuits. It is essential to have a set of universal logic and power drive circuits to enable design of code conversion and drive circuits to specific requirements. NAL has developed a set of mutually compatible logic circuits in small modules. Interconnection of these circuits according to well known design methods will result in a digital circuit with required specifications. These circuits are designed using high reliability silicon transistors and other quality components made in the country. All the components are conservatively derated to ensure highest possible reliability in operation. As a concrete figure may be mentioned the fact that a sample lot has undergone 50,000 device hours of working at temperatures cycling between 60°C and ambient without any failure. Life test is still on and it is hoped to continue the test to at least a million device hours. The standard circuits include basic 'NAND', FLIPFLOPS, ONE-SHOT CIRCUITS, SCHMITT and several lamp drive circuits useful for applications requiring power drives. Full specifications of these circuits are available in the relevant data sheets. Design of these circuits is such that their input/output characteristics are fully known and therefore it is possible to design complicated logic circuits using these and it is a rule rather than exception that the circuits will work on first switching on.

3. SCANNERS

In multichannel work it is essential that several inputs are scanned and a single input—the one required alone is connected to the System. This requires the use of scanners. The essential requirement of a scanner is that it should not introduce stray voltages of a magnitude that will disturb the measurement. In other words, to measure a 2 mV full-scale signal at 0.1% accuracy, the maximum error signal from the scanner shall not exceed 2 microvolts. NAL has designed two types of scanners—one using a stepping switch which is capable of scanning any number of channels at speeds upto 5 channels per second and the other capable of speeds upto 500 channels per second (though it is very unlikely that the scanner will be used at this speed). Both the scanners introduce less than 5 microvolt stray voltage and are therefore suitable for operation at low level input stages without preamplification.

4. DIGITAL DISPLAY

To display a digital quantity, NAL has developed two different types of displays. These are (i) the edge-illuminated type and (ii) the in-line planar type. Either of these displays can be used with the standard lamp-drive circuit described above.

5. COMPLETE SYSTEMS

Two examples of complete systems developed at NAL are described. One of the systems has been designed to automatically print out the contents of a DVM along with fixed data taken from a fixed data panel. The system includes code translators to convert from DVM code to that of a teleprinter, drive circuits to operate the teleprinter electromagnet, circuits to translate the parallel information on the DVM to serial form required by the teleprinter and circuits to translate the fixed data available on switches on the fixed data panel. In addition, control circuits are incorporated which enable different circuits to operate in the required sequence. Print-out is possible in the 'manual' or 'automatic' mode as required. In 'Auto' mode, different intervals can be selected and print-out occurs repeatedly at set intervals. Each print includes the reading of the fixed data panel, along with that of the DVM.

The second Data System is a more sophisticated one which includes a 100 channel data scanner, Strip-Chart Recorder and digitizer followed by translation circuits, and a punch drive terminating in a teletype punch which can punch out 110 characters per second. This system provides for manual readout of any specified channel which can be selected on the scanner and also for automatic printout at fixed intervals. In the 'Auto' mode, the different channels are scanned serially, starting from the selected channel. Provision has been made to suppress any channel not required as well as to start scanning from the required channel. The teletype punch punches out information in a code that is acceptable to an IBM 1620 Computer.

Both the above systems are capable of operation at speeds upto 2 channels per second. NAL is now building systems with speeds upto 100 channels per second. The only problem at this speed is the data printout. Only a magnetic tape recorder (digital) can accept data at this rate. With a paper tape punch of moderate cost, speeds upto 20 channels per second are possible.