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by

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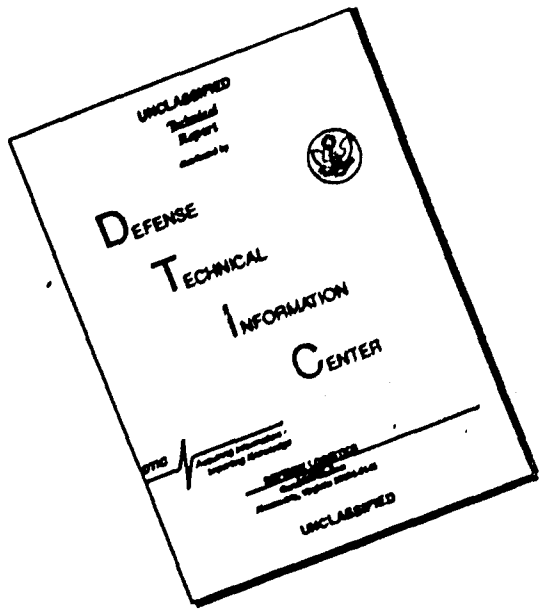

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SUMMARY

This Memorandum describes the development of a data logging system based on an IBM compatible Personal Computer (PC) which extends both the airborne and ground based data recording capabilities within Flight Management Department at RAE Bedford.

The new system supplements the existing Modular Data Acquisition System (MODAS) fitted to the research aircraft of RAE Bedford and maintains compatibility with existing recovery and plotting systems. It provides a portable record/replay capability and allows operations remote from base with immediate access to data, currently between sorties and potentially between runs in a sortie.

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1 INTRODUCTION

The Plessey Modular Data Acquisition System (MODAS) is the standard data logging system used throughout the Royal Aerospace Establishment, A&AEE Boscombe Down, and by a number of airframe and engine manufacturers. It is an expensive system and installations are limited to the research aircraft, certainly at Bedford and probably elsewhere. A 'quick look' real time replay capability is not available; the current direct system at RAE Bedford requires normally one day to replay a one hour flight tape. This is not recommended since it restricts other users. The recommended method is to convert the MODAS tape from the aircraft to a computer compatible tape (which at best takes place in real time) and to transfer to the Flight Management (FM) Department, VAX 11-785 computer where the data may be processed, analysed and plotted using the Data Analysis Terminal System (DATS) software package. In addition MODAS does not provide a portable remote site replay system and, including the transport difficulties, the turn round of the data can be three days or more which is unsatisfactory.

The requirement to record a limited number of analogue channels in a non-instrumented civil working helicopter for the Civil Aviation Authority (CAA) led to a reassessment of the recording capabilities within the Operational Systems Division, Flight Management Department at Bedford. The cost of a full MODAS recording system made it impractical to retain a palletised system for occasional trials on non-MODAS equipped aircraft. An analogue recorder, however, was available from a previous trial which had required high bandwidth recording. This system has its own preamplifiers to give a wide range of input voltage scaling and operates from aircraft 115 V 400 Hz supplies. Although this solved the aircraft recording problem it was considered a retrograde step to have only analogue traces which were inadequate for the required data analysis. This paper describes the equipment used to provide a portable, flexible data logging system.

2 DATA LOGGING SYSTEM

An IBM compatible PC with an analogue input card and data logger software was purchased. This allows the recorded aircraft data to be replayed from the same analogue recorder directly into the analogue input of the IBM compatible PC. The data files produced can be transferred at high speed on the Ethernet

connection to the main VAX computer where they may be analysed and plotted using the DATS software package in the same way as data recovered from the MODAS system.

2.1 Recording system

The system consists of a standard IBM compatible PC (Fig 1) with an analogue input/output card plugged into one of the expansion slots. An Ethernet card is required in addition to transfer data onto the main VAX computer for further analysis, but this can be in another lab-based PC using a floppy disc to transfer data from the PC acting as the logger.

2.1.1 Hardware

There are a number of analogue input cards produced for the PC that are compatible with the software package which allow the system to be used for a variety of applications. The particular card used for the logger is a general purpose version, the details of it are shown below.

ADC Inputs

Input level	±1.25 to ±10 volts dc
ADC inputs	16 single ended (SE)
	or 8 double ended (DE) differential input
Resolution	12 bits
ADC throughput	27500 samples per second

DAC Outputs

DAC outputs	2 channels
DAC resolution	12 bits
DAC throughput	33000 samples per second

Parallel I/O

The card also has 16 ttl compatible lines that may be programmed either as inputs or outputs.

There are a number of standard cards in the series compatible with the software ranging from 10 to 16 bit resolution, data rates up to 130 kHz and with gains up to 500 to allow a full scale of ±20 mV for use with low level sensors.

RS232

All PCs have at least RS232 communications port and this may be used as an additional input as part of the logging process. This is discussed further in the next paragraph.

2.1.2 Software

The software package used is "Notebook" from Data Translation Ltd.

The package is easily driven with the use of menus for real time acquisition of data, process control and analysis of data on IBM PCs, PC/XTs, PC/ATs or compatible computer systems.

It will support up to 10 analogue I/O cards, although only 4 or 5 slots are usually available, and is able to log up to 20000 samples per second.

It has true foreground/background operation under the computer's operating system with a real time graphics display of data up to 600 samples per second, which may be continuously written to disc at up to 400 samples per second.

There are basically three areas that have to be set using pages of the menu facility:

(a) Data logging/acquisition.
(b) Description of files.
(c) Description of real-time display format.

(a) Data logging/acquisition

This page of the menu (Fig 2) is used to set up the channel numbers, channel types, sample rates, and any triggering requirement to start logging. This system will accept analogue, parallel digital, or RS232 information and can time-tag data using the PC's internal clock.

As well as data acquisition, the system has an analogue and digital output capability which is also controlled from this page of the menu. Input data can be processed and output using this capability to form a process control system.

(b) Description of files

The number and type of files to be logged can also be set up with the use of another page of the menu (Fig 3). As shown, they may be integer, real or ASCII characters or may be set for displaying digital data directly on the screen. The channels of data may be stored either in one file containing all channels being recorded or in a separate file for each channel. The second

method is the one adopted, as the files produced are more easily used on the VAX computer for further analysis and plotting using DATS. The Appendix gives a brief description of the DATS software package running on the VAX computer. There is also a version of DATS called PCDATS, that will run on the IBM PC; with this the system is fully transportable for trials away from base and allows full data analysis and plotting.

(c) Description of display

The display of data is controlled using the "Windows" and "traces" facilities which are set using the menu. "Windows" is used to set up the display area of the individual plots, ie number of graphs and their positions on the display, and "traces" the colour, scaling and presentation of the curves. The windows menu page allows the display of plots either separately with individually scaled axes or as a number of plots overlayed on one set of axes using colour or line type to differentiate between them.

The information displayed may be scaled differently from that recorded onto disc to allow the information logged to be examined in more detail at particular points of interest while still retaining the ability to analyse the data fully later. These displays may also be used to view data previously recorded and so scales may be changed or channels selected for further verification of the data prior to full analysis.

There are also a number of facilities in the software that have not been assessed in this current role:

(i) Data manipulation, reduction and analysis; at present this is done on the main VAX computer.

(ii) Publication quality graphics.

(iii) Data-base management and file manipulation.

(iv) Advance curve-fitting routine for fitting collected data to mathematical models.

(v) Forward and inverse FFTs for digital signal processing.

(vi) On line help facility.

As well as data collection and analysis the system supports analogue and digital output and could be made part of a process control system for a complex system or as a testing facility for analogue systems.

2.2 Recovery System

2.2.1 Hardware

The recovery system (Fig 4) consists of a PC, with ethernet capability, and the VAX 11-785 running the DATS software analysis package.

Within Flight Management Department an IBM PC is permanently connected by Ethernet to the RAE Bedford computer complex. Data from the hard disc of the data logger is down loaded onto a floppy disc and transported to the IBM PC so that the information can be transferred to the VAX.

2.2.2 Software

The system has been configured to produce an ASCII real file for every logged channel and these files are easily converted into DATS compatible files using the DATS command "/accept". It is possible within DATS to combine a number of commands to form a "job" and so one has been written to accept and scale data from this logger. With data in this form it may be displayed on a graphics terminal for further scaling, annotating and subsequent plotting on an x/y plotter.

3 EXPANSION OF THE SYSTEM

Although the system is only capable of using cards designed to be compatible with the software it is possible to extend its capabilities by using the 16 data input/output lines as a parallel input for remotely interfaced data. For example a card could be made very easily to interface to a synchro drive signal using a synchro to digital converter. This would be compatible with the data logging system using the 16 data input lines. Similarly any serial or parallel data stream could be interfaced, probably on a card to fit into one of the spare slots of the computer itself.

With a slightly expanded logic design (Fig 5) the parallel output can be used to address the data to be gathered and so within the obvious time and addressing limits the system can be extended indefinitely.

Events such as an analogue threshold voltage being reached or a "discrete" changing state may be used to trigger the logger, or the internally generated time base may be used to trigger an external system at required time increments for synchronisation purposes.

The IBM PC can be used to perform limited analysis and plotting tasks and additional software has been purchased so that data can be scaled and plotted minutes after a flight even when the trials take place away from base.

This data logging system could also be used in reverse to form part of a system providing "Action replay of Flight Trials Data". In this situation, data recorded on MODAS is fed back into a laboratory or onto a test rig display. The analogue and digital output capabilities of the system could be utilised to replay true flight information onto the CRT displays of the Wessex "Glass Cockpit" simulator in Flight Management Department.

4 ADDITIONAL APPLICATIONS

4.1 CAA trial

(a) The trial

In 1986 the Civil Aviation Authority (CAA) raised the poor weather approach minima from 300 metres Runway Visual Range (RVR) associated with a Decision Height (DH) of 200 feet to 600 metres RVR with a DH of 200 feet pending a reassessment of the operational procedures, lighting requirements and helicopter handling qualities. To this end a Dauphin helicopter (Fig 6) is being chartered when fog is forecast and a number of flights have already been made at Bedford where the aircraft's position is monitored and logged using the Bell tracking radar. These results together with the guidance error signals measured in the aircraft are used to assess the aircraft's performance, and positional accuracy at decision point, during manual, flight directed and autocoupled approaches.

(b) The Aircraft recording system

A block diagram of the aircraft system is shown in (Fig 7). The aircraft was modified to allow access to certain aircraft parameters. These were wired to a socket which is stowed during the helicopters normal operations. On a when required basis the rest of the recording equipment is added, which includes an interface unit to ensure that there is no adverse effect on normal aircraft performance. Three signals, radio height, ILS localiser, and ILS glideslope are available and after buffering are routed to the Frequency Modulated (FM) analogue tape recorder.

(c) The recovery system

The FM tape recorder is also used for the recovery of the aircraft data. The event marker recorded on the analogue recorder can be used to start the data

logger so that the process is virtually automatic. A real time display as shown in (Fig 8) is produced as the data is logged and stored on the main files on the hard disc for subsequent analysis. This gives great confidence in the system both in terms of system operation and validity of data.

After a run has been logged the files produced are transferred to the main VAX computer using Ethernet, so that another run may be logged.

The system is flexible and, if desired, information may be stored locally on the hard disc by renaming the files for each run, or may be copied to a floppy disc.

4.2 Sea trials

Trials away from base are always at risk due to the inability to replay MODAS tapes away from base. On ship trials to be conducted by the All Weather Operations section using the MADGE guidance equipment this will be less of a problem in the future by making more use of the ground monitoring system. MADGE is a ground derived system, ie the aircraft position is measured on the ground and this information is available to any monitoring system. The aircraft height and range data is sent down over the MADGE data link and so the majority of data required from the trial is available on the ground. Outputs may be logged in real time and re-run into the logger display programme.

As a prelude to the proposed ship trial, flight trials have taken place to look at propagation effects over water and this logger system has performed a major role in the collection of the data.

4.3 Bell radar tracking system

The logging system has also been lent to the Bell tracking radar to log analogue data representing the position of the tracked aircraft. The logging system used for the radar is at present being upgraded from an increasingly unreliable punch paper tape system to a modern magnetic tape system. During the change over period it was suggested that the logger based on an IBM PC would form an adequate stop-gap.

This requirement meant that the logger had to be interfaced to the radio clock used for the correlation of data between aircraft and ground. Time from the radio clock system is available on RS232 which can be linked to the standard communications port of the PC. Two methods of synchronising have been tried; the first was to output a pulse from the PC to interrogate the radio clock. This then sends the time to the nearest millisecond of the interrogation on a

serial RS232 link. The second method was to use the pulse train from the radio clock to start data logging. This again was successfully implemented but being a sampled system had a 50 millisecond uncertainty on the trigger point, the same rate for this test.

The logging system has been used for a series of flight trials and works satisfactorily within the environment of the Bell radar caravan. Data has been recovered and plots produced on the VAX computer using DATS.

5 DISCUSSION

During the first 2 months that this low cost data logging and replay system was operational it provided all the airborne data for seven flights for the CAA. It showed its capability for logging tracker information and as a ground based monitor for trials.

Many of the facilities of the software have not been examined to date. With some of these additional facilities and the local analysis and plotting using PCDATS which will be available in the future, this system will provide a very useful and versatile stand-alone capability. The ease and speed of the transfer of data from the logger to the main Bedford facilities VAX computer using the Ethernet link is again a great attraction allowing data from a variety of sources to be brought together for further detailed analysis, comparison and plotting.

The one area where this system has not been used is on board an aircraft. The system, in its present form, will be compatible with operations in a passenger type of aircraft but not in helicopters or fast jets. There are two possibilities that could overcome this limitation. The first is to operate solely from floppy discs which should survive a harsher environment, and the second is to produce a system with a storage system designed for aircraft applications, either a Winchester disc or bubble memory.

Although it does not in any way replace the MODAS system there are a great number of applications both on the ground and in the air where this cheap data logging system (less than £3K) can be used to advantage. Simple interfacing, for instance to synchro or parallel digital signals can be accomplished but more consideration must be given to longer term recording requirements before interfacing to more complex digital signals.

6 CONCLUSIONS

This Memorandum has described the development of a data logging system based on an IBM compatible PC to extend the air and ground based recording capabilities within Flight Management Department at RAE Bedford. This low cost data logging system supplements the existing MODAS recording system and provides a self contained portable record/replay capability while operating away from base.

At present the system allows recording of up to 16 channels of analogue data at rates up to 20000 samples a second. Lower rates of sampling allow the data to be displayed graphically in real time while still recording.

The system is capable of expansion using a range of analogue and digital cards available from PC card manufacturers. Further expansion is possible by introducing custom built interface cards for special requirements and by fully utilising and extending the present software.

The system was assembled quickly, worked well and has provided the All Weather Operations Section of Flight Management Department with a very useful additional tool for monitoring and acquiring data.

Appendix

DATA ANALYSIS TERMINAL SYSTEM (DATS)

DATS is a software package produced by Prosig Computer Consultants which is particularly aimed at the analysis, correlation and display of time series data. Within DATS are a collection of 'modules' which perform individual functions such as filtering a time history, arithmetic functions with two or more files, probability and statistical analysis, graph drawing and plotting.

Most of the modules read and/or write files of a particular form but modules are available to convert to and from standard ASCII format.

ABBREVIATIONS

A&AEE	Aeroplane and Arm Experimental Establishment
ADC	analogue to digital converter
ASCII	American Standard Code for Information Interchange
CAA	Civil Aviation Authority
DAC	digital to analogue converter
DATS	Data Analysis Terminal System
DE	double ended - differential two wire input
DH	decision height
FM	frequency modulated
Hz	hertz
I/O	Input/Output
MODAS	Modular Data Acquisition System
PC	personal computer
RAE	Royal Aerospace Establishment
RS232	serial computer communications
RVR	runway visual range
SE	single ended - single wire with separate earth
VAX computer	digital VAX 11-785 computer
kHz	kilohertz
mv	millivolts
ttl	transistor transistor logic

FIG.1 STANDARD IBM COMPATIBLE P.C. WITH ANALOGUE I/0

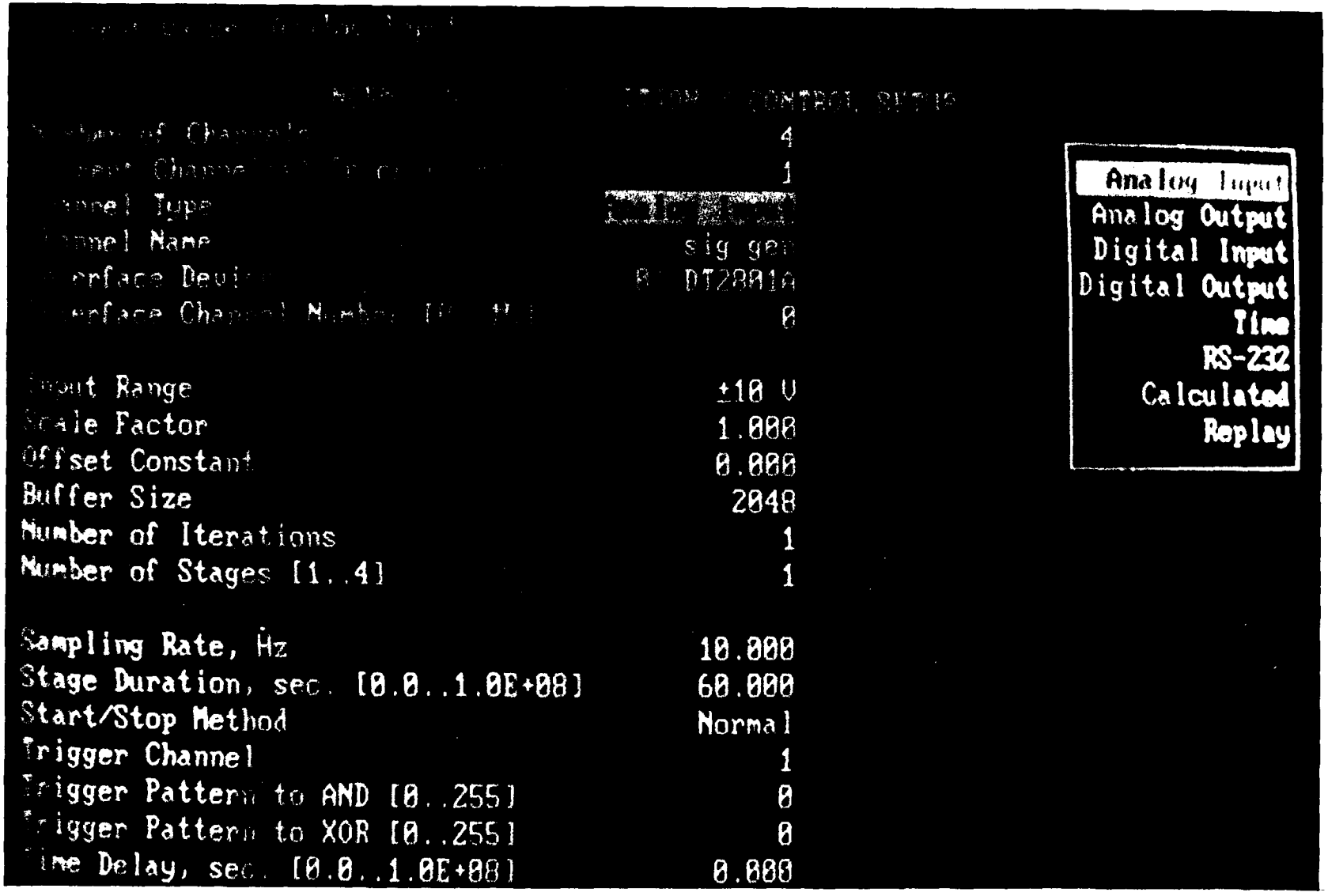


FIG.2 DATA LOGGING & ACQUISITION MENU

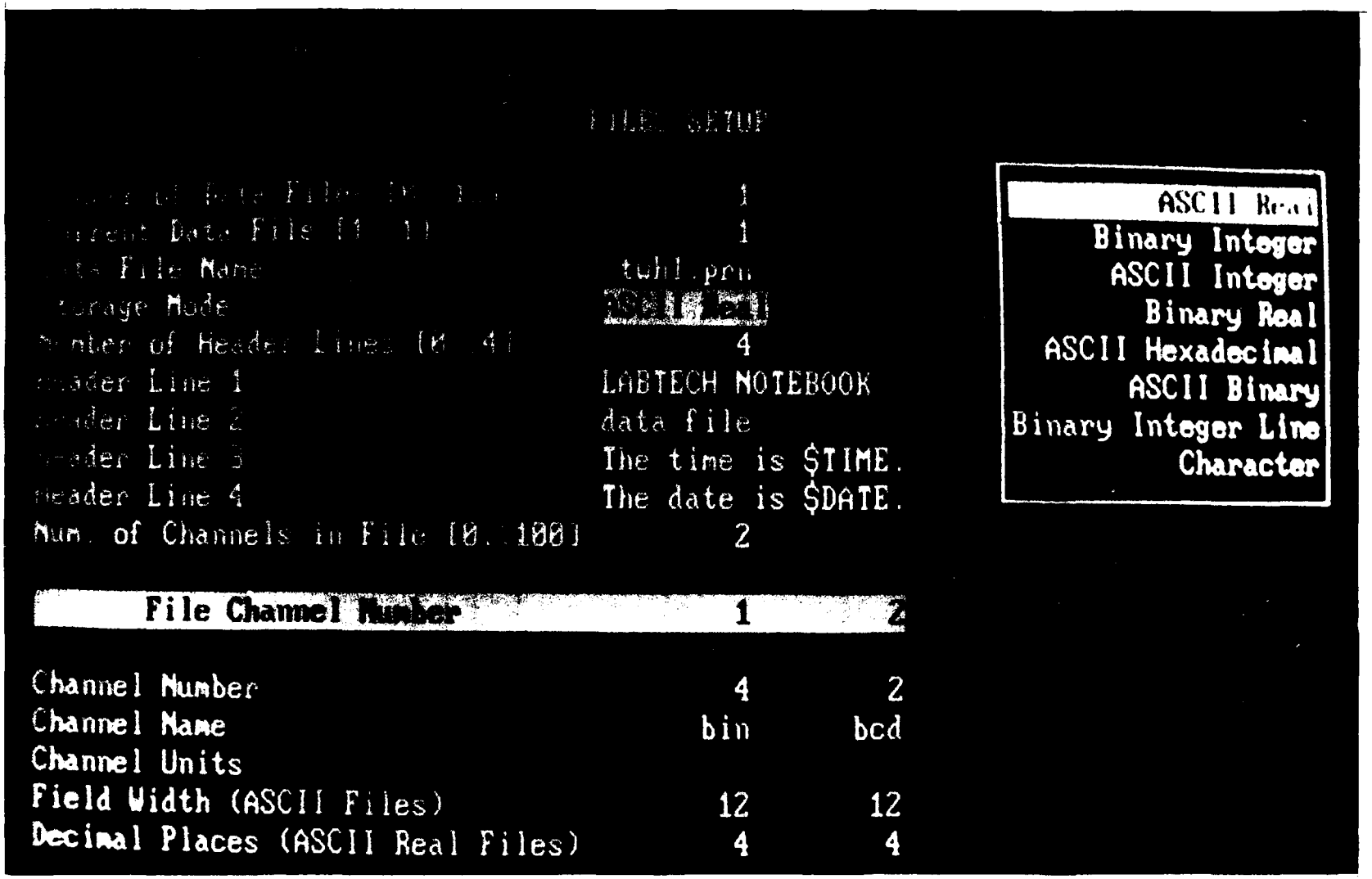


FIG.3 DESCRIPTION OF FILES MENU

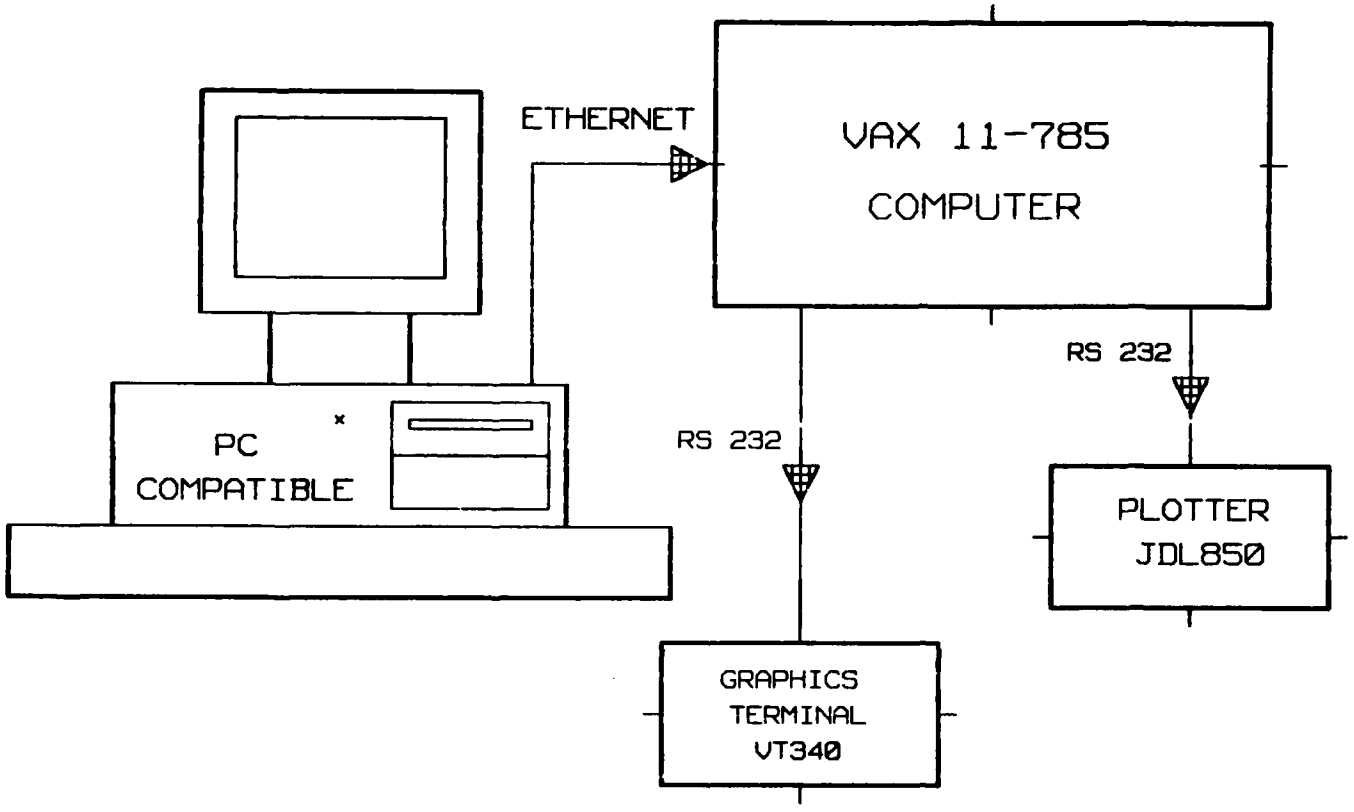


FIG.4 RECOVERY SYSTEM

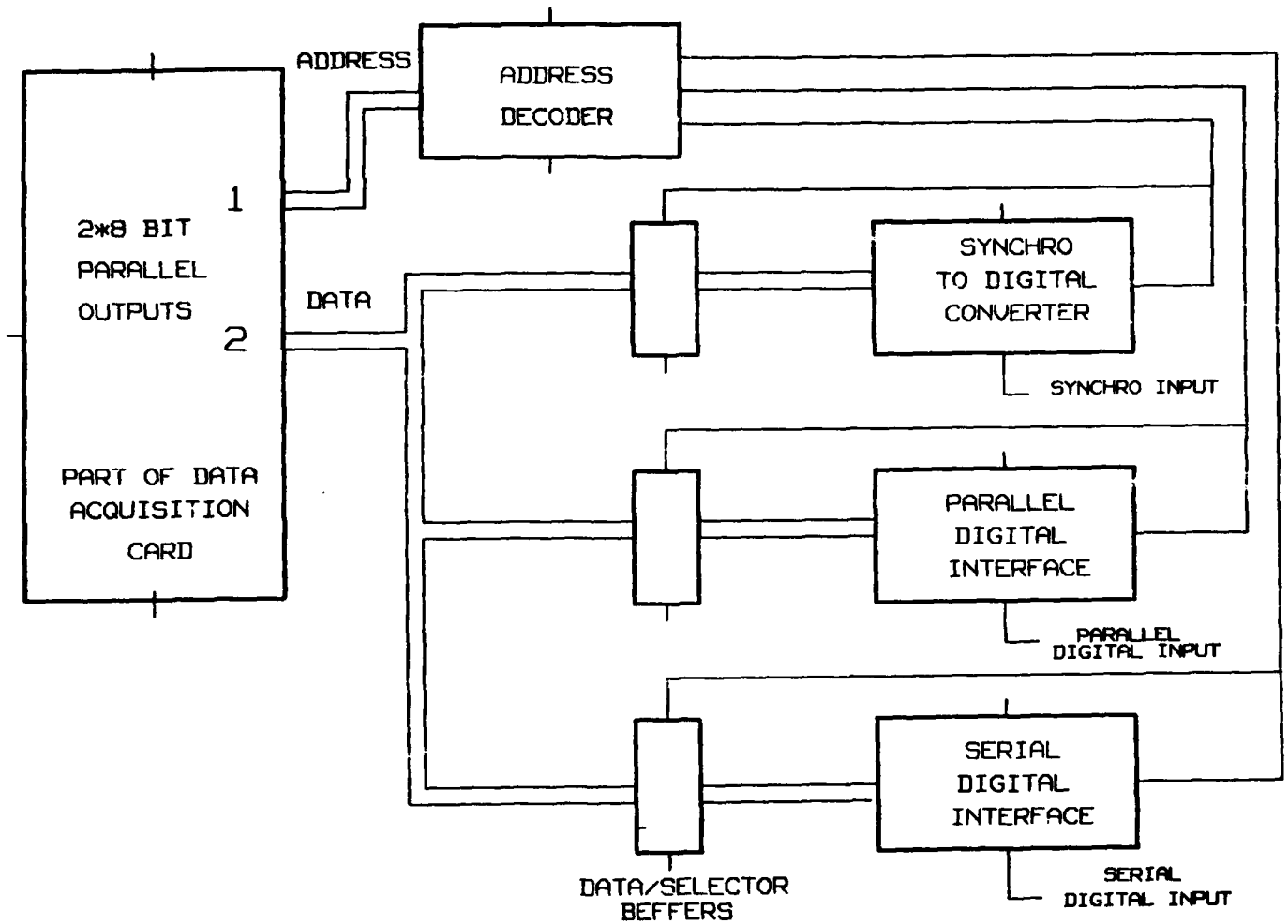


FIG.5 MORE COMPLEX LOGIC DESIGN

Fig 5

FIG.6 DAUPHIN HELICOPTER

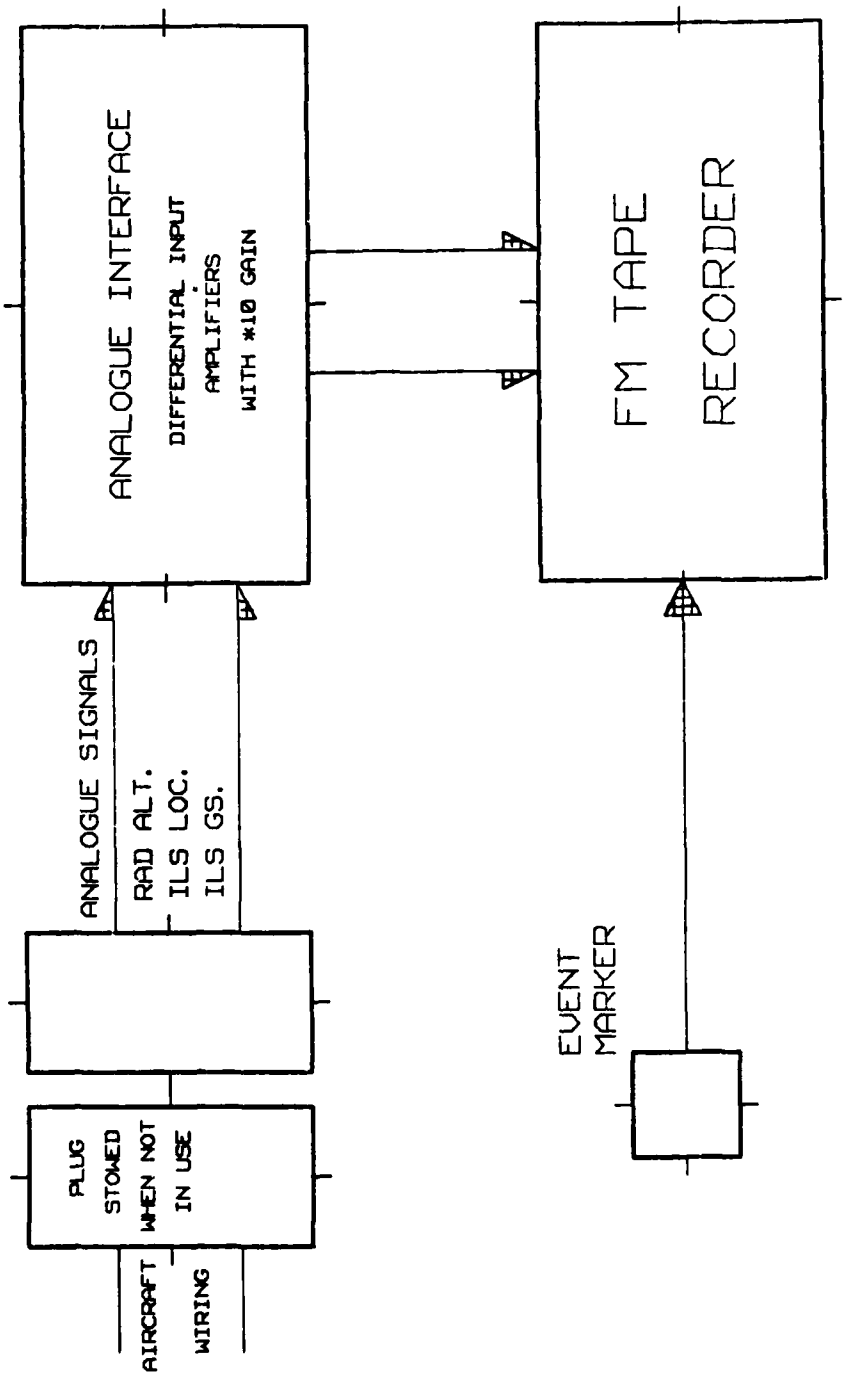
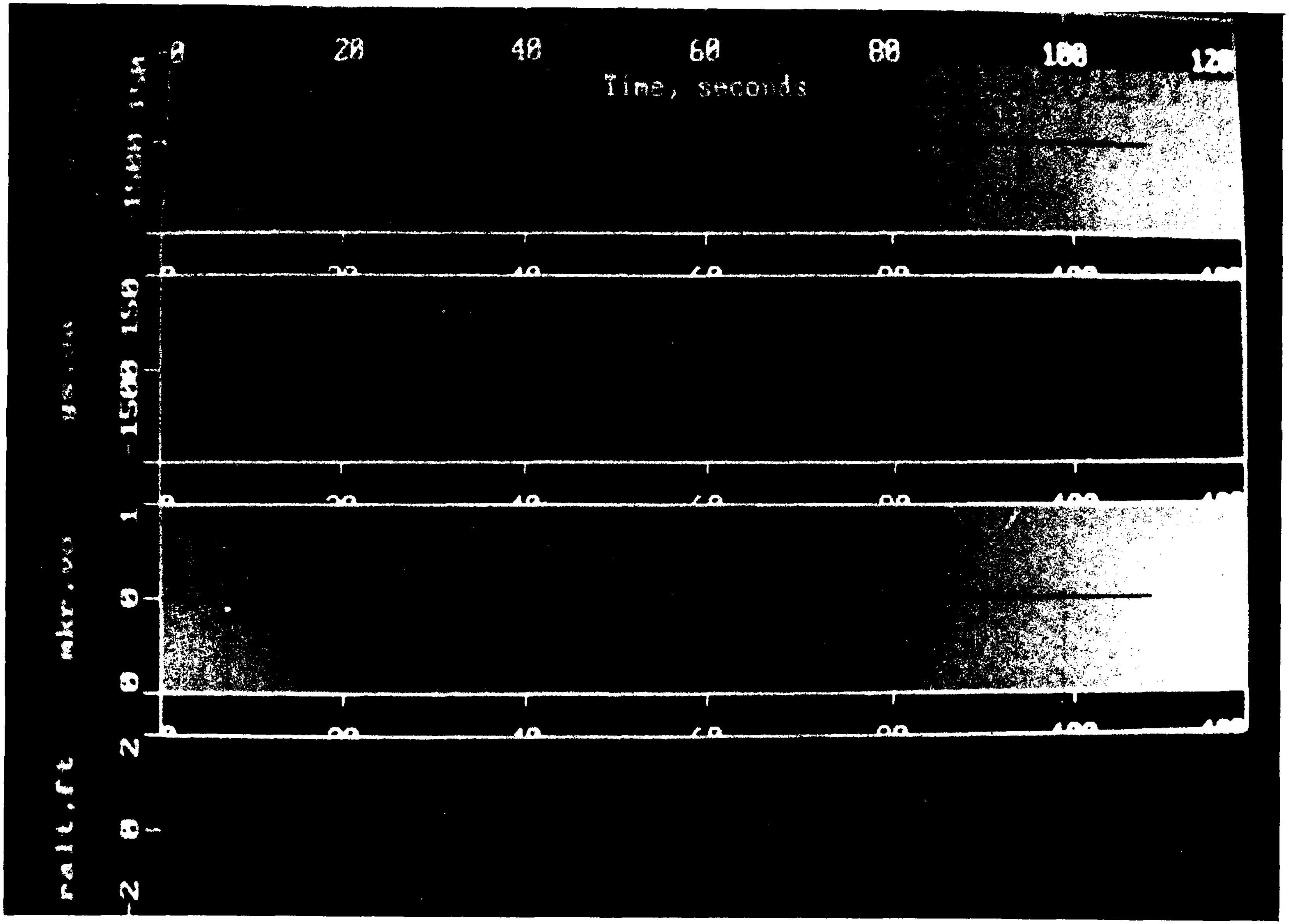


FIG. 7 BLOCK DIAGRAM OF AIRCRAFT SYSTEM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16. Descriptors (Keywords) (Descriptors marked * are selected from TEST)

Data logging. Portable recording. Replay. Data analysis plotting.

17. Abstract

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The new system supplements the existing Modular Data Acquisition System (MODAS) fitted to the research aircraft of RAE Bedford and maintains compatibility with existing recovery and plotting systems. It provides a portable record/replay capability and allows operations remote from base with immediate access to data, currently between sorties and potentially between runs in a sortie.

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