MULTIPLE STREAM PCM DATA HANDLING SYSTEM FOR PROCESSING OF FLIGHT TEST DATA FROM MODERN PROTOTYPE HELICOPTERS

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1.0 Introduction

Flight test data handling system for a modern development helicopters poses several challenges in configuring, installation and development of software. The experience during the development of Indian Advanced Light Helicopter "DHRUV" was no exception. Being the first major state of the art Helicopter development programme the challenges have been further compounded.

- The system has to meet the requirements of handling large volume of high speed digital data from a variety of sources like multiple stream PCM, ARINC-429, MIL – 1553B Bus, in addition to high Bandwidth analog.
- It has to be flexible enough to handle fast rate of obsolescence in the field of computer hardware and software market.
- The software has to present user friendly and easily comprehensible processed summary fast enough so that the data processing system keeps pace with the demands of a development environment.

The data processing facility made operational during mid nineties for the development of "DHRUV" Advanced Light Helicopter has kept pace with development programme of the Helicopter and at every stage has been keeping pace with the fast changes in the computer and software technology as well.

2.0 Evolution of Data Processing

Advanced Light Helicopter programme came to the flight testing stage during early nineties with two active prototypes in the front line. Data processing systems all round the world were configured in those days around PDP-11 minicomputer, VAX-11 systems and IBM or GOULD high speed mainframes. Accordingly Flight Test Centre configured a mini computer system with RT-11 operating system for real time operations and RSX-11M multitasking operating system for post flight data handling. Medium for bulk storage of data was computer magnetic tapes with block by block recording. System had to be soon upgraded to VAX-11 platform.

At that point of time due to technology limitations of on board PCM data recording system the bulk of data emanating from on board data acquisition system had to be configured in to four streams of 250kilo bits per second. Voice IRIG time code and analog high frequency signals came on separate tracks of the recorder. It was felt prudent to have a system developed through local computer industry which can handle multiple PCM streams and also take IRIG-B time signal and provide time stamping in PCM frames as the data is streamed in to the computer. During early nineties a minicomputer based on Intel 80386 processor was developed by M/s. WIPRO in close co-ordination with Hindustan Aeronautics Limited. The configuration was with plug-in PCM frame synchronizers on the system bus MULTIBUS. These frame synchronizers were developed specially for HAL requirement. Four PC pluggable bit synchronizer cards which were imported was used on a separate personal computer AT-286. Parallel time code word input was distributed to all the four decommutator for time stamping. Fig.1 provides the system configuration. M/s. WIPRO & HAL jointly developed necessary real-time drivers, setup and application software on UNIX operating system. The whole effort was quite successful and system functioned satisfactorily for post flight data handling. The next generation system was configured using 80486 processor. The pace with which the computer industry went forward and speed of obsolescence was quite high.

During second half of nineties Pentium processors with windows operating system had replaced the earlier technology. During late nineties the entire data processing system was revamped in a networked configuration. A server was configured with Pentium – III processor, had a separate housing to take in frame synchronizer, time code formatter and high speed digitizer. This system was again jointly developed with HAL and local computer house. System software and drivers using tools of Visual C++ on windows operating system provided the comforts of user friendliness in system setup, and operation. Fig.2 provides the system configuration. Due to large volume of disc space available, the media of storage of data has been disc files with availability of local area network and wide area network, distribution of data was simplified and instantaneous.

3.0 Application software

Application Software requirements were totally evolved from the user requirements and have gone through constant up gradation, improvements and addition of features. The application software are categorized into two cases.

a) First line analysis
b) Post flight data transfer.

First line analysis assumes great importance since it decides the several critical issues and answers following major questions : -

- Have all test points been covered and completed satisfactory.
- Have relevant instrumentation parameters functioned satisfactorily
- Has there been any limit exceedence of any critical parameters requiring detailed investigation on the test Helicopter.

In short the outcome of first line analysis gives clearance for the flight development programme to move forward and go ahead for carrying out additional test points and open up the envelope. In view of the importance of the first line analysis and the large amount of parameters that are being acquired on every test flight, method of presentation of the result assumes greater significance. This has to be concise, contain the vital information on all the acquired parameter through a quick look of the data sheet.

3.1 Peak analysis :

Majority of critical parameters have dynamic value superposed on the data. Thus the application software aims to present in a concise and comprehensive form the following elements for every parameter during every test condition.

a) Mean value.
b) Average dynamic value
c) Factor providing the max dynamic value reached during the test points.
d) Factor providing the minimum dynamic value reached during the test point
e) Period of fundamental harmonic frequency which was used as window for averaging.

By experience the above factors / parameters have been of great help in providing a concise report on large number of instrumentation parameters. A typical listing of peak analysis is presented in Fig.3.

With the usage of the algorithm to generate above parameters, a need was felt to remove wild points which occur occasionally due to data / bit dropouts.

i An algorithm was evolved over a period of time for the removal of wild points and incorporate the same in to the peak analysis. This has made the peak analysis process more robust and reliable.

3.2 Time History plots.

Selected parameters which are relevant to a test points convey more information in as a time history than any other format. Facilities have been developed and incorporated to generate a varieties of formats quickly to generate time histories. Users have found these to be extremely useful and powerful. A typical time history format used frequently is shown in Fig.4.

3.3 Spectral Transformation and digital filters.

Spectral analysis of dynamic data forms an essential part in any helicopter data handling process. Since vibration and load measurements (dynamic as well as static) forms major bulk of data acquired presentation of vital spectral lines (top ten in amplitude rank scaling) has been found to be an useful tool throughout the ALH programme.

Digital filtering of time series data have been needed quite frequently. FIR filter algorithm with a feature to deploy the same on any desired data from selected test points have been frequently used as an aid to evaluate the test performance.

4. Post Flight Bulk data Transfer:

In the earlier phase of the programme this was a major task since the entire bulk of the data acquired had to be written on computer compatible magnetic tape and sent to designer as a final process of analysis task. With the advancement of technology the medium was digital tape cartridge and then digital audio tape. However with the advent of networking this task became fairly simplified and fast. Network facility enables the end users like designers and aircraft system specialists to gather data instantaneously and employ vendor supplied software and special purpose detailed analysis algorithm on the flight test data. This task logically brings to a conclusion the responsibility of flight test center as an agency to collect and pass on the entire test data collected to the end user faithfully.

5 Conclusion

It was a challenge initially to evolve and configure a multiple stream PCM data handling system for the development testing of a modern rotary wing aircraft for the first time in the country. The system configured using indigenous know-how has been satisfying user needs at every stage of development programme. A conscious decision was taken not to hand over the task of installing a data processing system with system & application software on a turn key basis to any overseas vendor. Abundant in-house experience and expertise has been created in this field in terms of system configuration in a volatile and fast changing technology environment. Upgrading and porting in to new platforms and new operating systems were carried out easily and smoothly. The flexibility and potential to satisfying new requirements of the customer has been enormous in this approach.

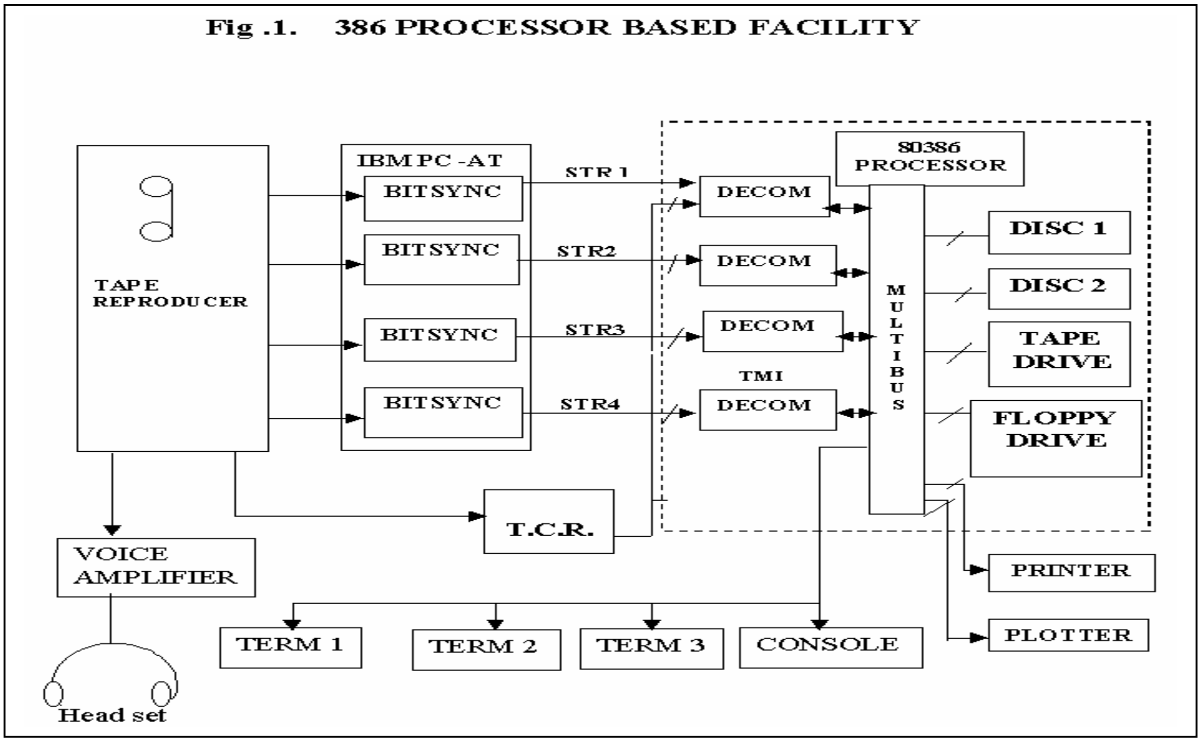
Fig .1. 386 PROCESSOR BASED FACILITY
TAPE REPRODUCER
IBM PC -AT
BITSYNC
BITSYNC
BITSYNC
BITSYNC
STR 1
STR2
STR3
STR4
DECOM
DECOM
DECOM
TMI
DECOM
80386 PROCESSOR
MULTIBUS
DISC 1
DISC 2
TAPE DRIVE
FLOPPY DRIVE
T.C.R.
VOICE AMPLIFIER
PRINTER
PLOTTER
TERM 1
TERM 2
TERM 3
CONSOLE
Head set

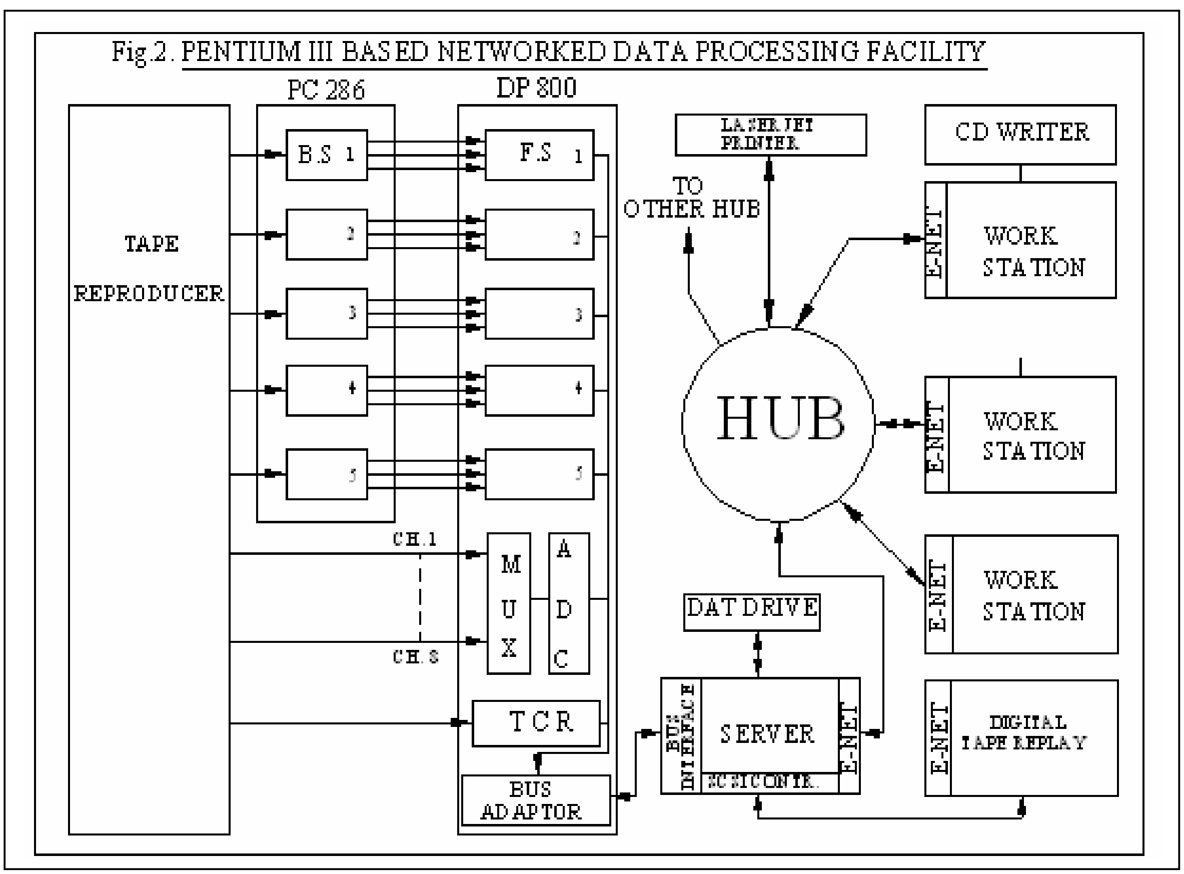
Fig.2. PENTIUM III BASED NETWORKED DATA PROCESSING FACILITY
PC 286
DP 800
TAPE REPRODUCER
B.S 1
2
3
4
5
F.S 1
2
3
4
5
CH.1
CH.8
MUX
ADC
TCR
BUS ADAPTOR
LASERJET PRINTER
CD WRITER
TO OTHER HUB
HUB
E-NET
WORK STATION
E-NET
WORK STATION
E-NET
WORK STATION
DAT DRIVE
BUS INTERFACE
SERVER
E-NET
E-NET
DIGITAL TAPE REPLAY

Fig. 3.PEAK ANALYSIS RESULT

CH	VALUE	UNIT	NAME	SR	KU	WTMEAN	MEAN	AV-PK	WT-AV-PK	AMAX/AV-PK	AMIN/AV-PK	STD.DEV	FREQ	SFREQ
11	9759.30	NM	MB1MR1	0	1	2301.47	2301.72	1108.26	1163.59	1.64	0.45	60.76	5.25	735.29
49	4314.00	N	FNR31	0	1	-205.69	-205.70	136.37	141.25	1.29	0.68	3.96	5.25	735.29
14	42170.00	NM	MOSTUB	0	1	124.76	124.31	3740.44	3951.00	1.87	0.49	232.01	5.25	735.29
2	10412.00	N	FDAMP1	0	1	1244.95	1245.72	1899.96	1971.18	1.33	0.82	51.76	5.25	735.29
17	15962.00	N	FRCR1	0	1	2068.53	2070.08	2505.94	2602.92	1.24	0.76	51.08	5.25	735.29
18	16034.00	N	FRCR3	0	1	2354.45	2353.02	2574.22	2670.33	1.25	0.75	52.45	5.25	735.29
20	21236.00	N	FNRLO	0	1	2181.49	2181.54	998.94	1031.60	1.24	0.83	19.56	5.25	735.29
21	14546.00	N	FNRLA	0	1	1417.62	1417.52	859.38	888.40	1.35	0.70	25.75	5.25	735.29
22	22749.00	N	FBCRLO	0	1	-3541.76	-3541.40	1144.81	1186.19	1.25	0.72	29.94	5.25	735.29
23	24902.00	N	FBCRLA	0	1	1689.58	1689.78	780.18	805.02	1.23	0.77	20.59	5.25	735.29
24	24556.00	N	FBCRCO	0	1	7325.27	7324.90	1048.44	1081.51	1.30	0.62	30.10	5.25	735.29
25	21550.00	N	FNRLV	0	1	7164.90	7164.79	813.17	848.48	1.62	0.65	31.22	5.25	735.29
27	33911.00	NM	MZOTB	0	1	12280.68	12282.37	1431.43	1475.13	1.55	0.46	72.88	5.25	735.29
28	38672.00	NM	MBTB	0	1	-7163.01	-7162.96	1059.42	1088.04	2.08	0.52	60.83	5.25	735.29
34	42590.00	N	FLRRHR	0	1	10881.46	10881.63	1317.04	1358.92	1.32	0.70	42.92	5.25	735.29
35	44346.00	N	FLRRHF	0	1	7670.71	7670.32	1031.88	1065.62	1.45	0.52	44.32	5.25	735.29
52	44337.00	N	FLRLHR	0	1	13534.66	13535.21	805.81	833.59	1.70	0.52	47.34	5.25	735.29
53	42758.00	N	FLRLHF	0	1	13448.49	13448.41	1247.11	1284.80	1.40	0.49	49.22	5.25	735.29
61	12.00	G	VZTGB	0	1	xxxx	xxxx	1.06	1.10	1.53	0.73	0.03	5.25	735.29
62	11.20	G	VYTDS2	0	1	xxxx	xxxx	1.28	1.33	1.12	0.86	0.01	5.25	735.29
72	10.80	G	VYIGB	0	1	xxxx	xxxx	2.48	2.58	1.22	0.83	0.04	5.25	735.29
541	6.00	G	VYPSF	0	1	xxxx	xxxx	0.33	0.34	1.44	0.63	0.01	5.25	735.29
542	2.90	G	VZPSF	0	1	xxxx	xxxx	0.18	0.19	1.50	0.69	0.01	5.25	735.29
547	31760.00	N	FSTVLF	0	1	27732.61	27732.53	1639.29	1686.27	1.65	0.53	77.38	5.25	735.29

Fig.4.TIME HISTORY PLOTS

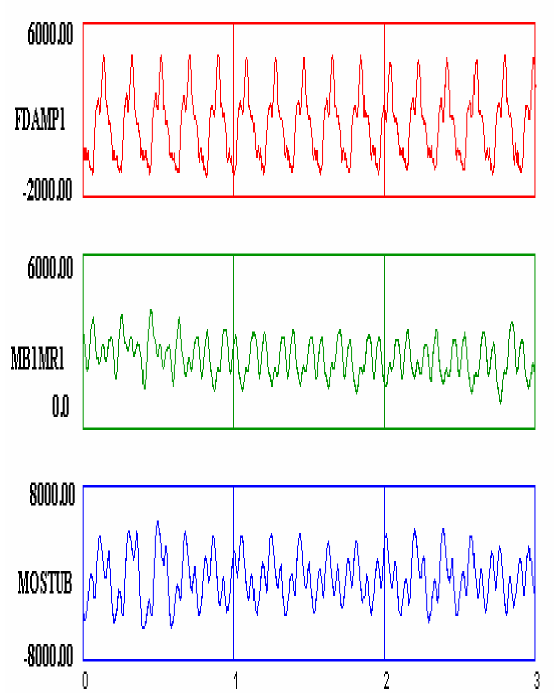

Fig.5. SPECTRAL PLOTS