CRM: FROM THE FLY 10 TO THE FLY 30 SYSTEM

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1. Introduction

Over the last few years, the level of development in technology and informatics in the area of numerical processing of sound signals has rapidly made the latter a valuable instrument for all those disciplines, artistic and scientific, which link their method and results to the creation, analysis, synthesis and processing of sound. Because of this, vast sections of *contemporary music*, *musicology*, *ethnomusicology* and *sound restoration* on the one hand, and *acoustic physics*, *psychology of perception*, *sonology* and *organology* on the other, are discovering not only techniques and innovations for their own applications, but above all, they are experimenting with the possibility of creating spheres of interdisciplinary (or simply multimedial) research. By definition, they measure themselves against the very real opportunity of reuniting humanistic with scientific thought, the culture of the non-measurable with the experimental tradition.

In this context, in the spring of 1990 and on the initiative of a group of CRM researchers, the research project called *Fly 30* was begun. The different cultural and professional backgrounds of the members of the team (musicians, physicists, engineers and musicologists) united by a common appreciation of interdisciplinary problems and all specialising in informatic systems, produced the group's present capacity to create a digital system oriented towards the synthesis, analysis and real-time processing of sound signals. This system develops an immediate interaction with the user and is flexible and adaptable to the different scientific and artistic needs.

2. From the Fly 10 System to the Fly 30 System

The *Fly 30* system derives from the *Fly 10* system projected in 1984 by Michelangelo Lupone (first version for APPLE 1984, second version for IBM PC 1986) and is based on the high-speed processor TMS 32010.

The success that *Fly 10* has achieved in this period, in both the artistic and scientific fields, is due to the design philosophy which, by maintaining high calculating power, has also enhanced the user-interaction, facilitating all input functions and data control. The Fly system, originally planned to assist in the work of musical composition by real-time sound synthesis, has shown a much wider functional application based on flexible algorithms and general concepts such as Frequency Modulation, Additive Synthesis, Amplitude Modulation, etc.

The total programmability of the system, and therefore its adaptability to specific needs in different areas of research, has enabled it to be utilised in various fields:

- psychoacoustics: the FIAT Research Centre (C.R.F.) has tested short-burst easily identifiable semantic sound signals for use in the car industry;

- organology: instrument timbres and control algorithms have been tested and perfected, particularly as to what concerns industries of musical instruments;

- composition: since 1985, 30 works have been completed, five of which are suitable for real-time performance by a pianist.

Another important result of the research developed by CRM using *Fly 10* was the project *Musica Infinita*, commissioned in 1986 by ISMEZ (Institute for Musical Development in Southern Italy) and completed the following year.

The project, based on several studies of AI (artificial intelligence), was able to produce musical forms by computer which had the capacity for autogeneration and evolution, while keeping unchanged the rigorous structures (multiple, double, triple, reversible canons) of the counterpoint related to the armonic-tonal system.

The *Fly 30* project, based on preceding experiences such as these and particularly on the knowledge acquired through *Fly 10*, is aimed specifically at rethinking traditional algorithms of numerical calculus in order to achieve their implementation on a new high-speed precision processor (see following pages). It also aims at taking up the "challenge" posed by the latest generation of DSP processors, testing both original calculus algorithms and original real-time control systems of relative parameters, with the ultimate aim of achieving a **dynamic processing of sound signals**.

The digital system called *Fly 30* is therefore a hardware/software system with the following principal characteristics:

1 - capacity to analyse, synthetise and process real-time sound signals

2 - user-friendly interactive software complete with advanced graphic editor, examples and user's manual

3 - easy connection to a personal system (requires an IBM compatible PC-AT with a working DOS system)

4 - modularity (we predict 4 configurations to run from 1 to 4 Sonitech *Spirit 30* boards)

5 - very high precision and velocity computation (data of 32 bits in floating point, parallel processes such as multiplication and addition in 60 nanoseconds).

These characteristics are made possible by the use of the numerical superprocessor TMS 320C30 which is the heart of the *Fly 30* system. It is installed on a program connected directly to the bus of the PC-AT which gives high-speed communication and therefore the exchange in real-time control parameters set by the user.

The *Fly 30* project aims at maximising the interaction and the interdisciplinary relations on which research in the above-mentioned areas is based.

3. Hardware/Software System

The *Fly 30* system consists basically of the following hardware subsystems (fig. 1):

1 - IBM-AT or compatible Personal Computer, functioning as the host computer for the system, complete with colour monitor, a 640Kbytes memory (minimum capacity) and a 40 Megabytes hard disk.

2 - Sonitech *Spirit 30* Board, functioning as the numerical signal processor, based on the DSP TMS320C30, complete with interface logic with the host computer, serial interface for other programs and a 160x32 bits memory.

3 - Sonitech *IC 100* Conversion Board, interfacing with electronic analog devices, based on a 16 bits ADC with a maximum sampling frequency of 100 KHz, a 16 bits DAC and a serial interface logic with the *Spirit 30* board.

The system offers the following resources to users (fig. 2):

1 - Graphic Editor with "sound in line" for the creation of instruments, orchestras and forms of interactive processing.

2 - *Fly 30* Compiler for the creation of complex structures and the linkage of procedures.

3 - Analysis and debug modules of the *Fly 30* system.

3.1 Sonitech *Spirit 30* signal processing board

The *Spirit 30* processing board (fig. 3) has 160x32 bits of memory and is equipped with an interface logic for the AT computer and other similar programs. Stored in the board memory are the programs to be carried out by the TMS320C30 numerical processor, and the numerical data which carry the digitalised information of the signal.

The interface with the computer makes for a rapid exchange of information between the *Spirit 30* board and the computer itself. This allows to achieve a real time system with the possibility of modifying the signal processing while it is occurring. Further, the guest computer can check the work of the board and present in a graphic form what is being processed.

The serial interface allows parallel connection with other *Spirit 30* boards in such a way as to obtain a power system equal to the number of boards.

3.2 Numerical Processor TMS320C30

This processor was projected and built by TEXAS INSTRUMENTS especially for the work of numerical signal processing. It is the most advanced model of the whole family of TMS320xxx processors and is amongst the most sophisticated numerical processors on the market. It can carry out operations on 32 bits of data in 60 nsecs, and has an internal hardware design capable of carrying out more parallel operations and therefore of reaching a greater computing speed. The TMS320C30 processor is capable, for example, of simultaneously carrying out multiplication on different data in the same time cycle.

The assembly instructions permit the carrying out of an FFT (signal transformation in the frequency domain) with excellent results.

A specialized set of instructions allows for optimal layout of algorithms of a numerical filtering of the signals.

The TMS320C30 is internally equipped with the interfaces necessary for communication with the outside world. It has a programmable DMA for the fast exchange of data between the memories and the peripherials. It is equipped with a serial interface programmable for the exchange of information with other TMS320C30 processors or with other systems.

It is equipped with a programmable timer as well as a multifunctional clock to obtain the most complete set of synchronised sounds. It has 2 methods of access: one primary and one secondary, capable of moving as much as 32 bits of information. It has a signal system which allows either multiprogramming or synchronisation of parallel processes stored in different processors. It can address memories of up to 16x32 Mbits, divisible into one or more banks as desirable.

3.3 Sonitech *IC 100* Conversion Board (fig. 4)

The two systems DAC (Digital to Analog Converter) and ADC (Analog to Digital Converter) are used in the *Fly 30* system as interfaces to the real world of sound signals and are implemented in the *IC 100* conversion program. This allows an A/D and D/A conversion at 16 bits of information with a sampling frequency of up to 100 KHz.

The components used and the features implemented provide maximum reliability and a signal/noise ratio of over 90dB.

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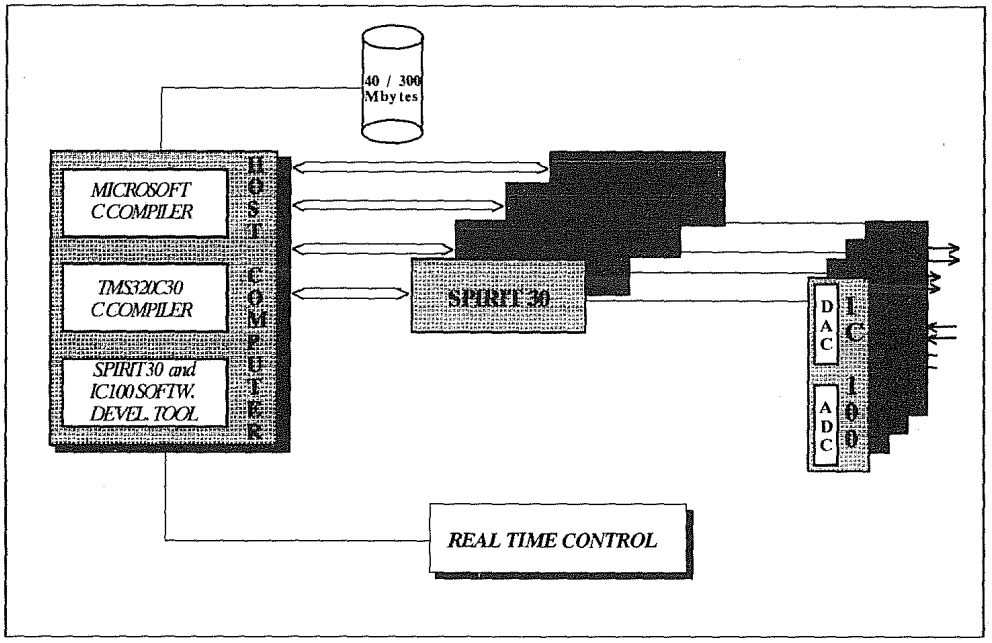

FIG. 1 - Fly 30 System

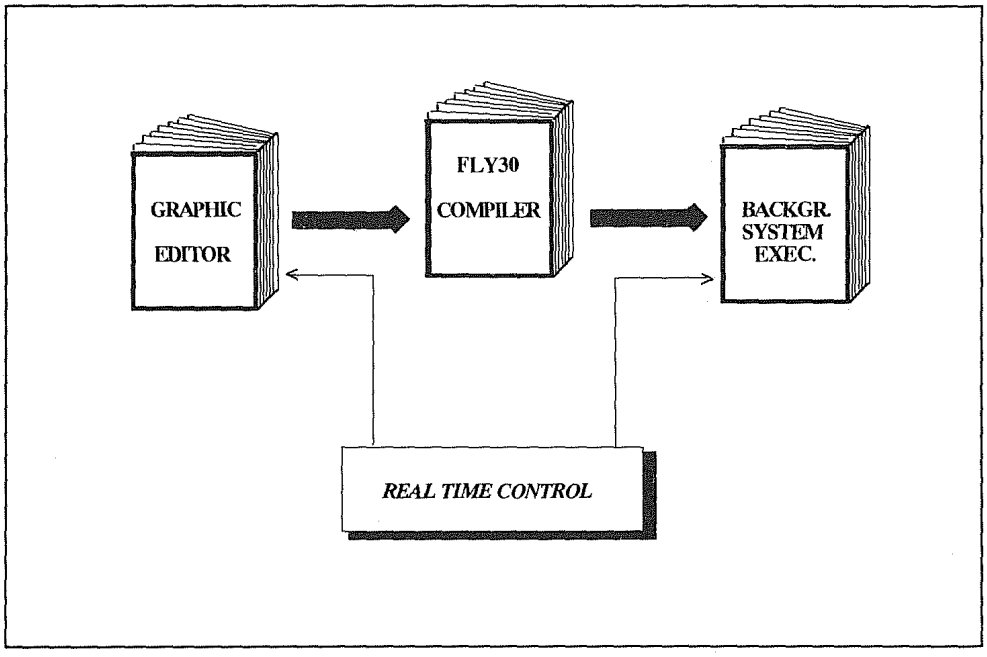

FIG. 2 - Fly 30 software system

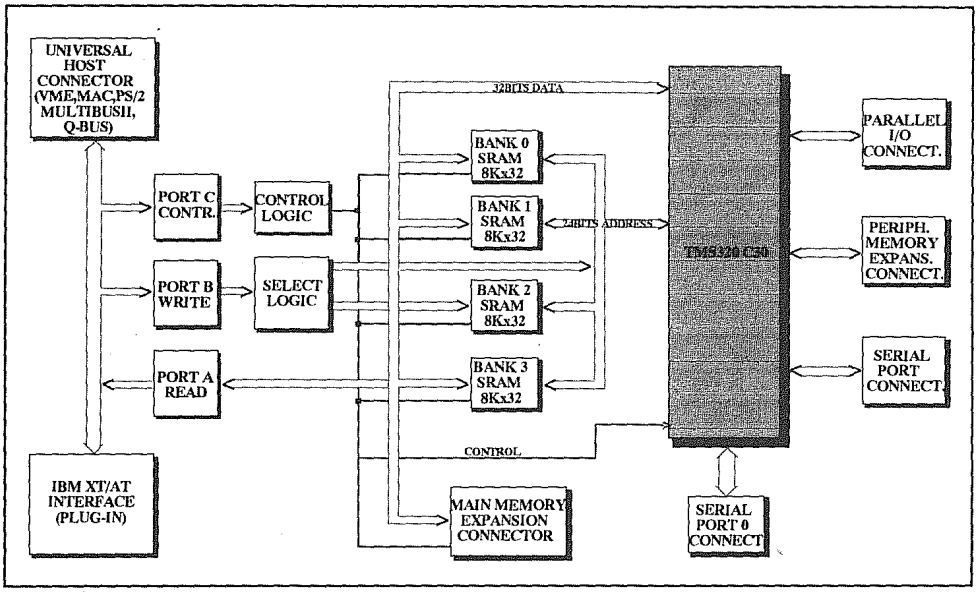

FIG. 3 - Spirit 30 architecture

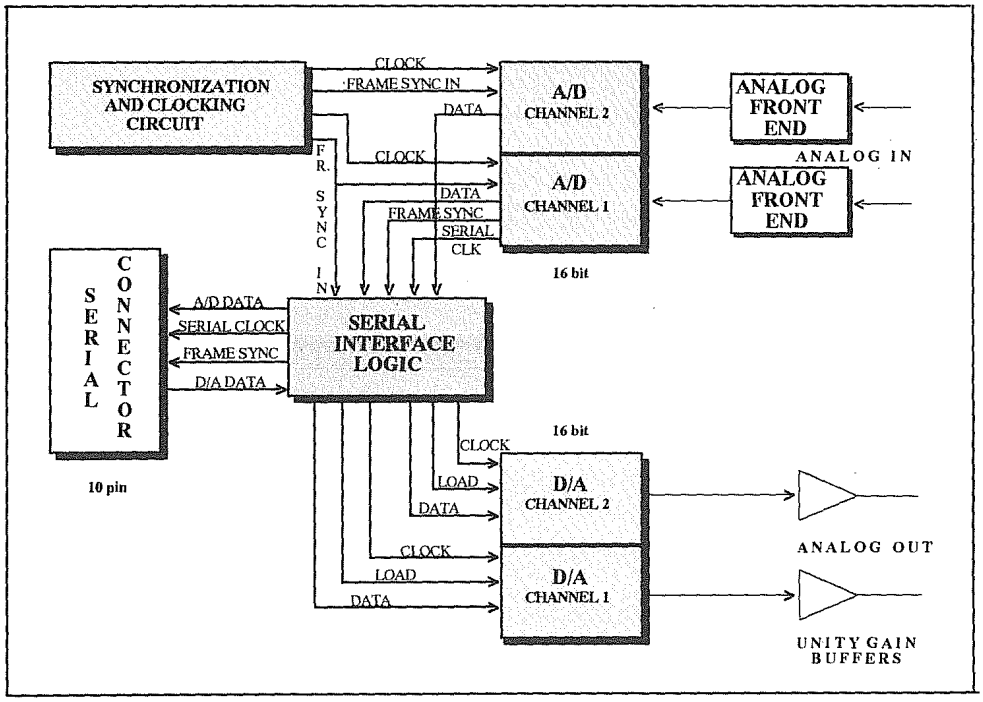

FIG. 4 - IC-100 block diagram

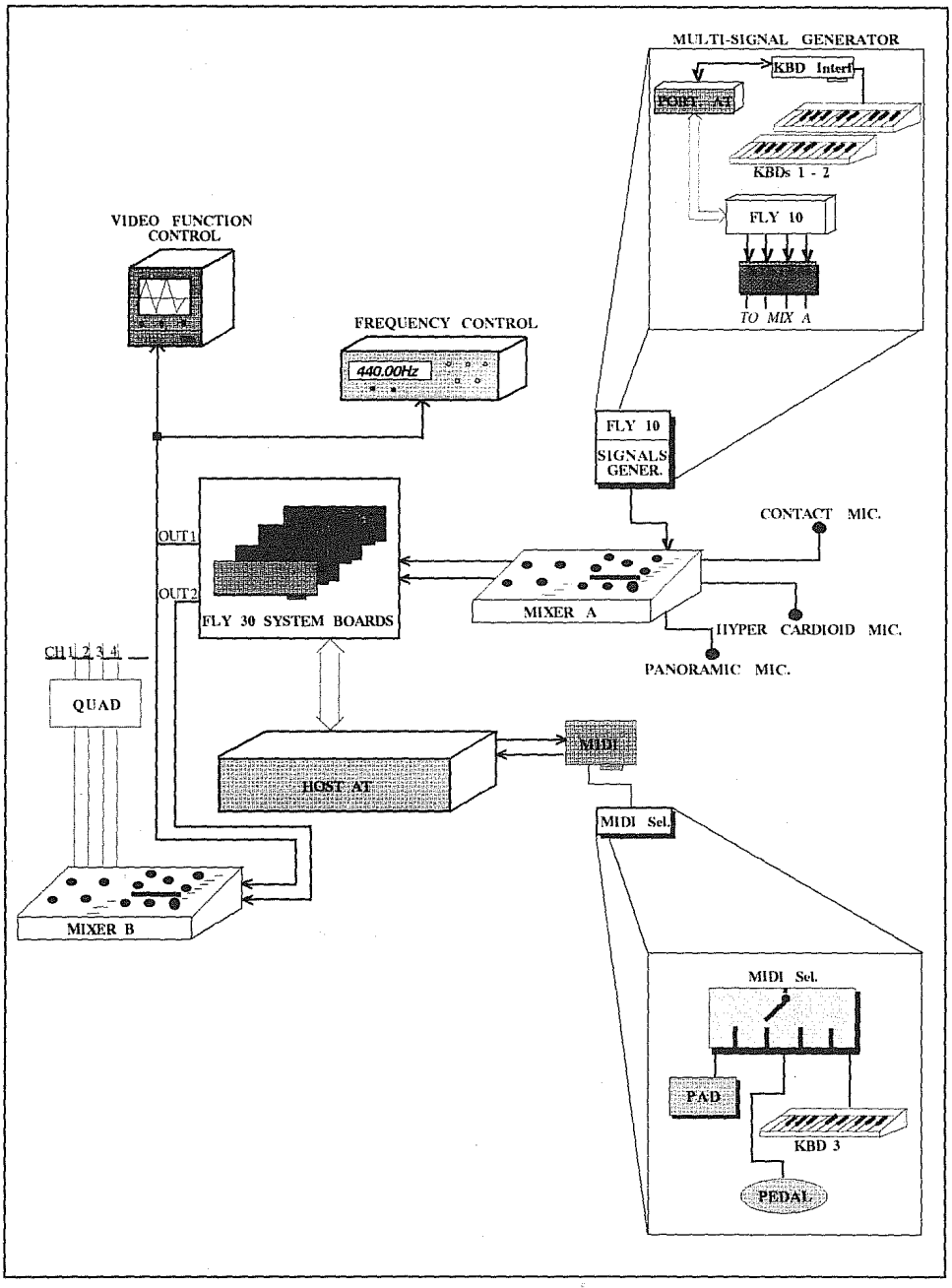

FIG. 5 - Fly 30 System: a CRM complete workstation