A REMOTE DESIGN STATION FOR CUSTOMER UNCOMMITTED LOGIC ARRAY DESIGNS

Frank R. Ramsay

Ferranti Electronics Limited

ABSTRACT

The paper describes a low cost remote design station that can be installed in customers offices, giving them the full C.A.D. facilities required to specify, design and verify an Uncommitted Logic Array. The designers can enter and check their logic, layouts and test programs via this remote station. Access is then available, via modem links, to the main Ferranti C.A.D. facility for running of design verification programs etc.

The need for such a system came after many years experience in handling customer designed circuits.

1. INTRODUCTION

Ferranti Electronics have been producing customised uncommitted logic arrays (ULA) for the last ten years. The initial aim behind the ULA concept was to produce a quicker more economical route to custom integrated circuit design than the full, all mask, custom route we had been using in the sixties. The ULA has succeeded in this area throughout the seventies when most of the custom designs were done by Ferranti's Microelectronics Design Centre based engineers. However, for the eighties, where much more emphasis of custom design is to be placed on the customer, a new approach is required. Design facilities are required in the customers laboratories and offices. Today integrated circuit design, even for ULA's is impracticle without access to specialised design automation software and therefore for the customer to do this work in his office means the DA software has to be available in his office.

The aim is that the customers will perform the logic and layout design phase in their own plant, using the large C.A.D. aids available at the design centre where appropriate, and then will enter the final layout into their design station via a drawing reading machine. From here the data can be plotted and edited before being transmitted to the design centre for full design verification and finally formatting for the pattern generator etc. While mask and prototype devices are being manufactured the customers can use their remote design station to generate, debug and verify the device test program.

2. U.L.A. C.A.D. SYSTEM AT THE MICROELECTRONICS DESIGN CENTRE

The existing C.A,D. system used by Ferranti at their Design Centre [1] consists of PDP11 and Applicon systems. A VAX is now being installed to improve capacity and performance.

The system has 3 inputs layout, logic and the test schedule (Fig 1). From these are derived the necessary pattern generator tapes and test programs along with the results of design and interconnect verification etc.

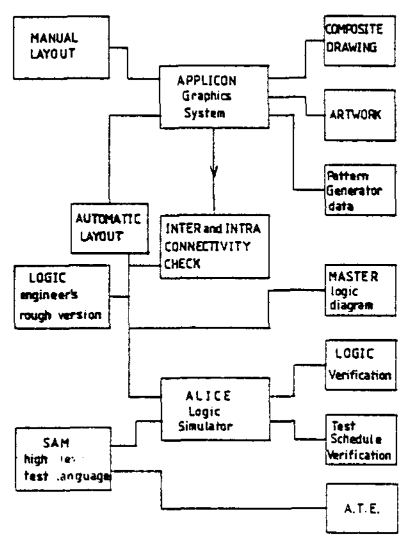


FIG 1 ERVIEW OF U.L.A. C.A.D. SYSTEM

0146-7123/81/0000-0498$00.75

The key to this system is that the various modules are all linked and relate to a master design data base - the logic diagram (Fig 2.) This link ensure an automatic complete verification of all parts of the design. Implementation is such that it does not restrict the designers ability to take full advantage of the ULA's flexibility.

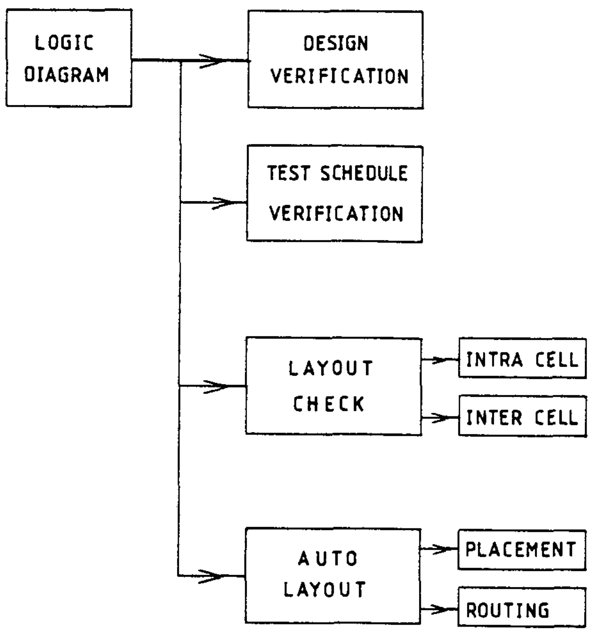


FIG 2 LOGIC DIAGRAM DATA BASE LINK

This system is specially tailored for ULA work and there are obvious advantages to any remote station if it can have access to this verification power etc.

3. EXISTING CUSTOMER DESIGN ROUTES

Before the remote design station concept customers designing their own ULA's could interface with the Design Centre in a number of ways. They could send the pencil interconnect drawing to the centre for digitising and data processing by Ferranti personnel. The main problem with this approach was in design verification. Only the designer can solve design problems and therefore the customers engineer had to schedule time to visit Ferranti to solve any problems found by the system.

Other interfaces were from customers own C.A.D. systems (Fig 3). The main problem with all these routes was the limited amount of specialised ULA C.A.D. software available to the designers on the customers own C.A.D. systems.

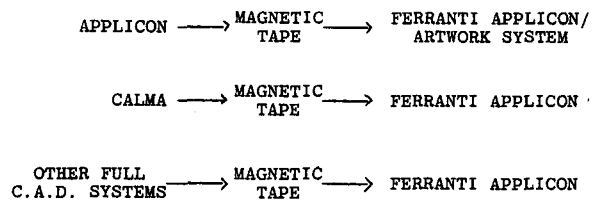


FIG 3 CUSTOMER INPUTS TO C.A.D. SYSTEM

In the case were the customer has an Applicon system they were obviously further along the line than most but would still need to purchase the required ULA package from Ferranti for their internal use.

In the other cases they would be involved in a considerable amount of effort to tailor their own C.A.D. system to ULA design and to write the specialised software needed for a complete ULA design verification system. Even a logic simulator probably, the most common electronics C.A.D. tool, takes considerable effort to tailor to the exact requirements of ULA's.

Whichever C.A.D. system the customer used they were involved in a major capital investment which required specialised support staff etc. Where ever such a system was implemented it was obviously successful but the investment level is considered too high for many design groups and therefore the concept of the remote design station was born.

4. CONVENTIONAL C.A.D. SYSTEM

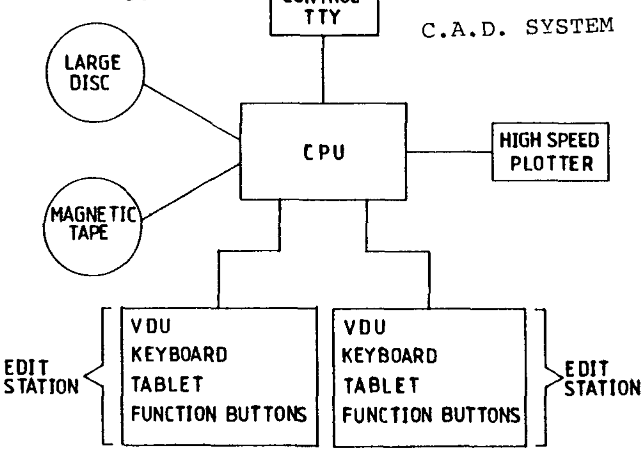
Most conventional C.A.D. systems have a hardware configuration as (Fig 4) and cost $300K to $400K for a 2 terminal system.

They are usually based around a 16 bit computer with a full complement of memory and a large disc. The terminals are fast response video displays, frequently colour, equiped with tablet, function keyboard. etc. The system is supported by high speed magnetic tape and a fast precision plotter.

The systems are essential tools in the design cycle of modern electronics, however, it is hard for local design offices, with perhaps 2 or 3 designers to justify the cost of a full system.

Fortunately ULA's can be handled at the front end with a much smaller amount of computer power.

FIG. 4 CONVENTIONAL C.A.D. SYSTEM



5. THE FERRANTI U.L.A.

In understanding the function of the remote design station it is necessary to realise the Ferranti philosophy behind their ULA(2)

5.1. INTERCONNECT LAYER
The ULA is customised by means of a single layer metallisation layer. This achieves faster, more reliable, simpler processing than multilayer technologies. This is made possible by the gate structure used which has a pseudo second layer formed by diffusing crossunders at every cell (Fig 5.) and by the process used allowing the Vcc and GND rails to pass through the silicon thereby simplifying the interconnection problem.

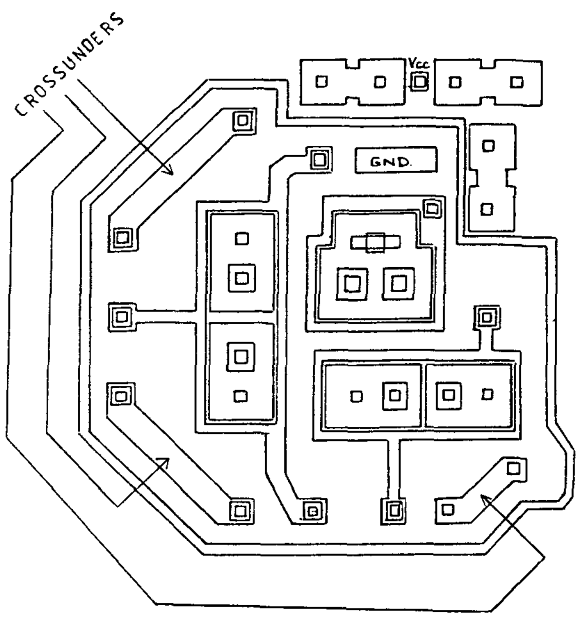


FIG. 5 TYPICAL U.L.A. MATRIX CELL

5.2. UTILISATION
Many of the Ferranti ULA's are designed as high volume production devices. For economic reasons this implies an efficient use of silicon area and therefore the ULA's are often routed to a very high density, frequently in excess of 90% (Fig 6.)

5.3. FLEXABILITY
A wide variety of functions including linear and digilin are often incorporated in layouts implemented in Ferranti ULA's.

It is the main aim of Ferranti ULA's to produce economical custom designs. Any C.A.D. system must allow the engineer to take advantage of the potentially high packing densities and flexibility available.

5.4. THE ULA TOPOLOGY
The range of ULA types varies from 100 to 2000 gates with a wide variety of speed/ power/linear capabilities.

They all consist of a matrix of cells encased in an anulus of peripheral cells (Fig 7.).

These peripheral components fall into two categories, those which have standard metallisation patterns, and those which are on a grid allowing the engineer to design his own peripheral circuits.

The standard metallisations are available for T.T.L. inputs, Tristates, Power drivers etc, etc.

The peripheral components on a grid give the engineers the flexability to design their own peripheral circuits.

6. THE REMOTE DESIGN STATIONS

6.1. Initial Design Concepts
The initial design concept for the remote design station was a low cost system ($40/50K) which would put as much of the main C.A.D. design facility as possible in the customers office. The system would obviously require a cpu with disc backings store, drawing reading machine input and some form of graphics editing facility. In practice the system becomes very similar to the conventional C.A.D. system above but the differences are in the degree of power available in the CPU setup and the lack of large peripheral support. It will have only one Design Terminal. On the final proposed system a multiuser facility will be available through a none design terminal port i.e. a teletype.

The final remote design station configuration is as Fig 8.

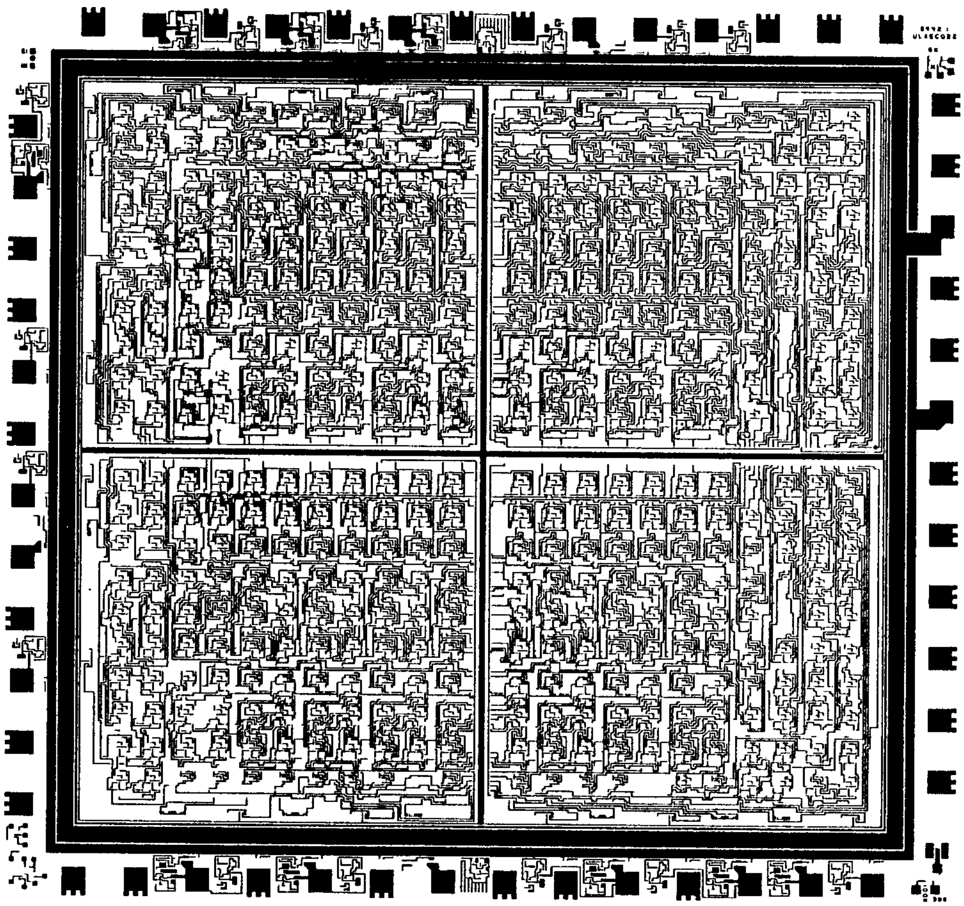


FIG. 6 A U.L.A. METALLISATION MASK

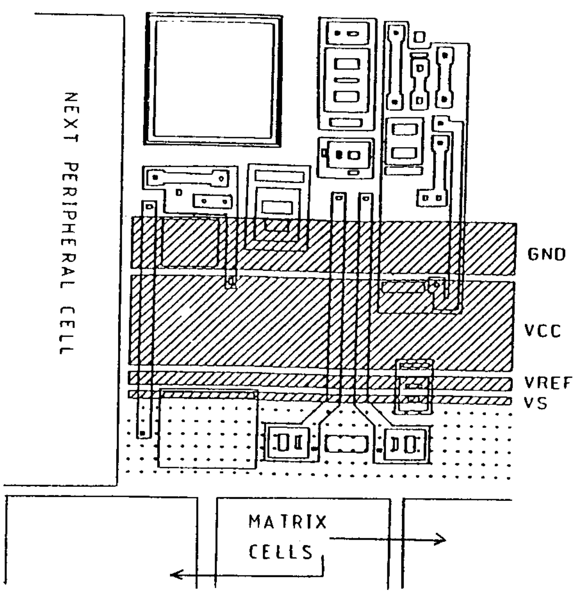


FIG. 7 U.L.A. PERIPHERAL CELL ARRANGEMENTS

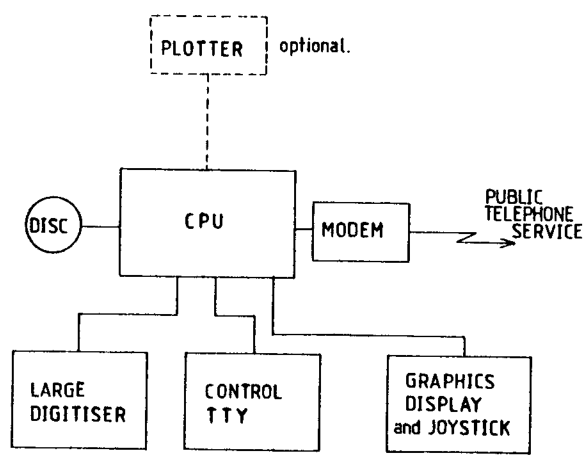


FIG. 8 REMOTE DESIGN STATION CONFIGURATION

Full facilities are available in the PDP11/23 for entering scaling, plotting and editing the ULA layout. Facilities also exist for writing of the test program and entry of the logic description. Access is then available to the main C.A.D. system via the Modems and DECNET to run this data on logic simulation and design verification programs.

6.2. HARDWARE CONSIDERATIONS

6.2.1. Computer

It was decided to have the system around a PDP11/23 for 3 main reasons:-

(a) It was the smallest of the PDP11 family that would support the RSX(3) operating system in a multiuser situation.

(b) It was reasonable cost.

(c) The learning cycle for our engineers understanding it and its software would be minimum.

The last consideration is probably one of the most important factors and a factor often over looked in new system design.

6.2.2. Disc

The disc was an important consideration because initial estimates showed that the required data structure would not fit into a 32K word block and therefore data paging was going to be essential.

Floppies were dismissed, partly due to speed, but largely due to concern that they may not perform reliably enough in the field. Not all engineers appreciate the importance of floppy disc backup and replacement.

Consideration was given to Winchester discs. The main problems here were the difficulty of system backup on a system without magnetic tape and our lack of support/knowledge on a Winchester based RSX11M system

The system was eventually based around twin 5MB hard discs (RL01's), one fixed and one removable.

6.2.3. Edit Terminal

Although a colour display with equivalent speed of response of the major C.A.D. systems seemed desirable, a mono display was chosen on grounds of cost.

Colour, although effective, was not considered the economical for single layer metal ULA's. It was felt that if designers had their own terminals they would live with a screen repaint time of a few seconds.

Initially the Tektronix 4010 display was chosen but later a compatible raster screen with joystick control was substituted.

6.2.4. Digitising Tablet

This was an area in which that there could be no compromise on what was offered with a full C.A.D. system.

Although working in the area of automatic layout and automatic layout aids the manual layout is still important. If a ULA is being designed for high packing densities then manual layout or manual layout completion will still need to be used. This will result in a large drawing and therefore a large digitising tablet will still be the most effective way of handling the layout.

6.2.5. Plotter

Plotters are expensive but plots of drawings are essential. Although Ferranti are now using automatic layout interconnection checking of all their ULA's a plot of the layout is always required. ULA layouts are usually drawn at the traditional 200 or 250 x size which results in plots of up to 52 inches square. Due to resolution even crude metallisation plots at this size need to be drawn reasonably accurately (better than 10 mil). This results in a requirement for a large accurate plotter or a smaller plotter with the added complication of windowing software etc.

The plan for the remote design station is to make the plotter an option. If no plotter is available on the system files will be transferred down the line to the Design Centre for plotting. These can then be despatched to the customer by one of the courier services.

6.3. System Software

The remote design station is a tool for ULA design and not a general purpose graphic system. Its operation is based around a number of specific tasks, all of which will be run in the RSX11M operating system. They will be controlled by indirect command files to make the computer operation invisible to the user.

6.3.1. Layout Design Entry

This is the entry via the drawing reading machine of the layout designers pencil interconnect pattern.

All operations related to the topology of the ULA are controlled by a table of geometry characteristics of the array. This table contains information on cell pitch, track density etc. (Fig 9.)

NUMBER OF BLOCKS IN MATRIC

NUMBER OF X + Y CELLS PER BLOCK

X + Y TRACK PITCH

STANDARD PERIPHERALS ALLOWED

PERIPHERAL CELL LOCATIONS

MATRIC CELL BLACKCLOTH PATTERN

PERIPHERAL BLACKCLOTH PATTERN

CALIBRATION POINTS

ETC

FIG. 9 TABLE OF TOPOLOGY INFORMATION FOR REMOTE DESIGN STATION

The system extracts the ULA type from the first part of the job number and from this determines which table characteristics to use.

Calibration points and deadband zones are also set up via the table.

After calibration the only data entered into the system at this stage is track centre lines and special matrix cell links etc.

Because digitising is time consuming the system allows all other operations, such as data editing to be performed simultaneously at the edit terminal while digitising.

6.3.2. Layout Editing

This is performed at the graphics terminal in conjunction with a joystick control of the curser. All the usual commands to add and modify data exists. Two interesting features are the window and backcloth facilities.

As on all systems it is necessary to window into the area required in order to obtain sufficient resolution for easy editing. As this system is designed to edit the ULA matrix and all cells are identified by reference numbers (rows 1-columns A-Z) the operator can call up any given cell area by typing its reference number. The area then displayed is centralised on that reference cell. Scale and therefore number of cells displayed depends on the version of the window command used with the cell reference numbers.

A 'backcloth' is available to help operators determine locations of contact holes etc, on a given matrix. This is a symbolic representation of the ULA diffusion and contact holes. It can be switched on at half and full levels. Half level is for experienced users and has less information than displayed on the full backcloth.

6.3.3. Logic Diagram Entry

The key reference document or data base in the Ferranti C.A.D. system for ULA's operating at their Microelectronics Design Centre is the logic diagram. At the centre this is entered into the system through the Applicon system as a complete graphical drawing.

The same logic data is to be entered at the remote design station but initially this will be typed in as a network list, rather than entered as a diagram to save the complication of data structures with arcs and text etc.

This logic diagram will then form the reference tables for layout and logic checking routines.

6.3.4. Test Program Entry

As on the main system the designer will enter the device test program.

This is in the high level language SAM[4] and is used for both logic verification and production of the final A.T.E. program.

7. COMMUNICATIONS

The most important feature of the remote design station is its communication link with the main Ferranti C.A.D. system at their Microelectronics Design Centre.

This link will be at 2400 Baud on the normal dial up telephone networks. The communications will be controlled by DECNET [5].

The engineer at the customer site will transmit to the centre 3 main files:-

(a) layout
(b) logic
(c) test program

In addition he will send message files requesting runs of the logic simulator, interconnection check program etc. The output of these runs, error messages etc, will be sent back later the same day or the following day by the same links.

In this way the customer engineer will have full access to the specialised ULA software necessary for complete design verification.

REFERENCES

1. Automation of Design for Uncommitted Logic Arrays. - F.R. Ramsay D.A.C.80
2. ULA Technical Handbook Issue 1 - Ferranti Electronics Limited.
3. RSX11M Digital Equipment Corporation
4. SAM Integrated Circuit Testing Language - Ferranti Electronics Limited. - Internal Document.
5. DECNET Digital Equipment Corporation.