A Complete Layout System for the PC

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Abstract - A LAyout System for Individuals (LASI) that runs on the PC platform is presented. LASI, pronounced "LAZY", is a general use layout, DRC, and extraction program that accepts and generates layouts in both CIF and GDS formats. The contents and operation of LASI are discussed.

I. Introduction

LASI is a CAD system consisting of a main drawing program and a number of utility programs. The original but fairly limited version of LASI was written several years ago for the author's own professional use to do IC and semiconductor device layout on a personal computer. Since then, LASI has been completely rewritten, taking advantage of new hardware and software. With many improvements and the addition of several new utility programs, it has become a fairly complete design package.

A. System Contents

LASI consists of the following:

1) A main drawing program LASI.EXE that lets you do integrated circuit layout, schematics, or almost any kind of drawing with practically unlimited size and complexity.

2) A help and information program LHI.EXE that provides an online manual for overall operation and specific help for the utility programs.

3) Converter programs TLC2GDS.EXE and GDS2TLC.EXE that convert LASI drawing files to and from Calma Stream Format (GDS or GDSII).

4) Converter programs TLC2CIF.EXE and CIF2TLC.EXE that convert LASI drawing files to and from Caltech Intermediate Format (CIF).

5) A design rule check program LASIDRC.EXE that uses 2-dimensional bitmap logical operations. The operations are user programmable and therefore not specific to a particular process or technology.

6) A SPICE circuit file compiler LASICKT.EXE that works from LASI drawings, that not only does schematic capture, but also lets you make circuit files directly from a layout, allowing realistic IC simulation.

7) Plotting programs PRNPLOT.EXE and PGLPLOT.EXE and hardcopy programs PCLHCPY.COM, ESCHCPY.COM and PCXHCPY.COM that make quick and accurate prints of your drawings. The programs can either drive a printer or plotter or write plotter files.

8) A converter program DXF2TLC.EXE that imports AutoCAD (DXF) drawing files, so that LASI can be used to replace AutoCAD where LASI may be more suitable.

B. System Requirements

Although written for MS-DOS, LASI will run under Windows 3.1, Windows 95, Windows NT, or OS/2 or any operating system that has support for MS-DOS programs that use extended (XMS) memory. LASI has its own graphics and is not dependent on the operating system's graphical user interface. LASI is more or less written to operate on common hardware, and not to conform to any current operating system.

II. Uses

LASI is a basic CAD system that can be used to teach IC design techniques[1]. Anyone learning layout with LASI will easily transition to more elaborate systems. LASI is intended to be friendly and intuitively obvious, which makes it easy to learn and operate by occasional users. Once the basics are understood, the commands usually require little additional explanation. Most

commands operate on the drawing globally, so that there are no special editing procedures for different parts of a drawing. There are no hierarchical command structures with pull down menus, Figs. 1 and 2. All commands are essentially random access through menus at the side of the display and may be easily changed or aborted.
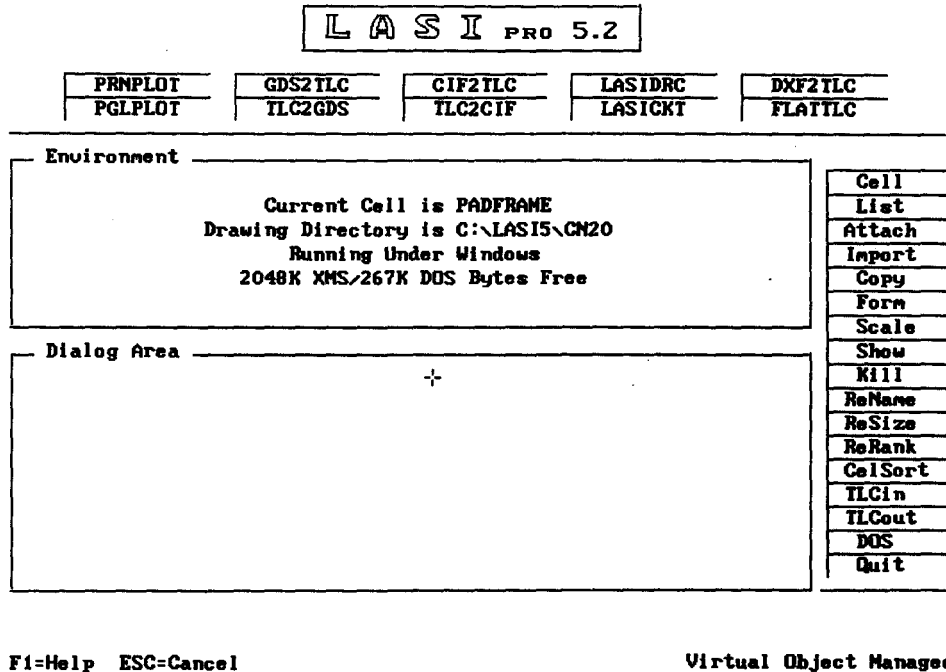
```
┌─────────────────────────┐
│  L Ⓐ S I  PRO 5.2       │
└─────────────────────────┘
```

PRNPLOT	GDS2TLC	CIF2TLC	LASIDRC	DXF2TLC
PGLPLOT	TLC2GDS	TLC2CIF	LASICKT	FLATTLC

┌─ Environment ──┐ ┌────────┐
│   │ │ Cell │
│   Current Cell is PADFRAME   │ │ List │
│   Drawing Directory is C:\LASI5\CN20   │ │ Attach │
│   Running Under Windows   │ │ Import │
│   2048K XMS/267K DOS Bytes Free   │ │ Copy │
│   │ │ Form │
└───┘ │ Scale │
┌─ Dialog Area ──┐ │ Show │
│   ⊹   │ │ Kill │
│   │ │ ReName │
│   │ │ ReSize │
│   │ │ ReRank │
│   │ │ CelSort│
│   │ │ TLCin │
│   │ │ TLCout │
│   │ │ DOS   │
└───┘ │ Quit │
                                                              └────────┘

F1=Help   ESC=Cancel   Virtual Object Managed

Figure 1 - LASI System Screen

| INV (1) | 0 Cells 43 Boxes 9 Paths 18 Vtx |
| Using Layer Table |

| W U|C|D|I|N|O|R|T |

sDrw	lDrw
Info	Show
Sort	Arc
Attr	Hcpy
cCel	cSiz
cLyr	cWth
Layr	Wdth
sWin	rWin
Fit	Xpnd
←	→
↑	↓
Zoom	Cntr
Draw	Grid
wGrd	dGrd
View	Open
Obj	Text
Add	Del
Get	Put
fGet	fPut
tGet	tPut
cGet	cPut
aPut	wGet
qMou	cMou
Mou	vStp
Cpy	pRev
pBeg	pEnd
Cut	Join
List	Cell

IN OUT (VDD ... GND ... IN OUT layout labels)

Get (Pt.1)   X=67.35   Y=46
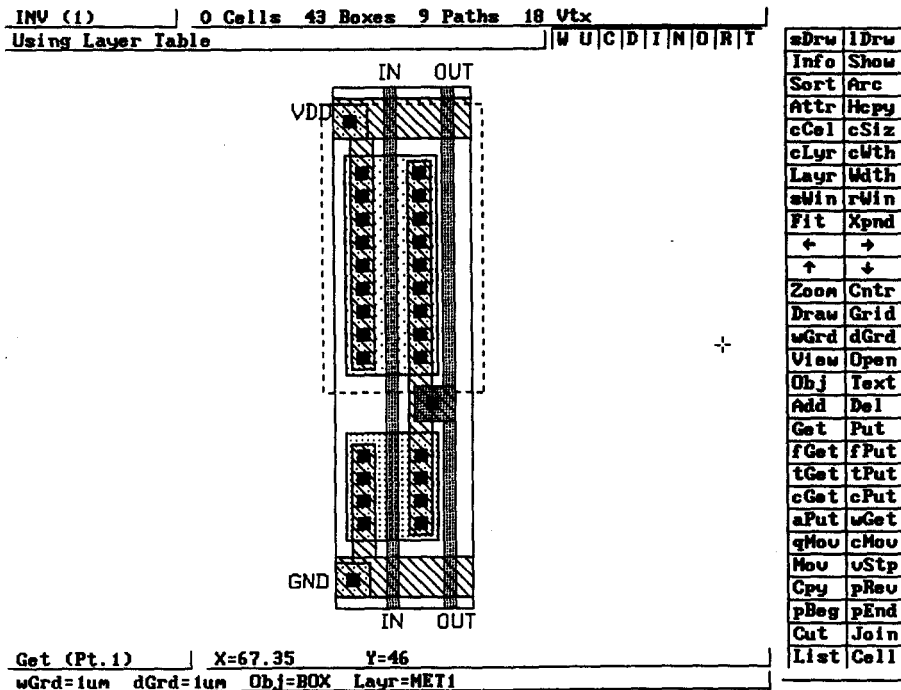wGrd=1um dGrd=1um Obj=BOX Layr=MET1

Figure 2 - Cell mode in LASI showing the layout of an inverter.

A. LASI's Construction

LASI's construction is fairly modular and is designed for programming simplicity. Some procedures or command sequences may appear somewhat primitive to someone experienced with other CAD systems. Because of its structure however, LASI usually can be modified easily, and new features and commands can always be added. This allows good ideas from users to be incorporated into future versions of LASI.

LASI is intended to be propagated by software alone. The programs are constantly being updated with improvements and new features. A printed manual would soon be outdated and would add an expense that would require charging everyone for LASI. There is therefore no printed manual. The LASI Help and Information program, LHI.EXE, displays the documentation, and individual topics can be printed if desired. If a printed manual is needed, a program MANUAL.EXE is supplied that prints a manual complete with index from any LASI help file. The manual is also available by pressing F1 while LASI is running.

B. Design Verification

In addition to layout, LASI can be used for schematic capture, Fig. 3, and design verification. This inverter schematic is labeled for netlist generation and comparison with the layout of Fig. 4. Some comments should be made regarding the schematic of Fig. 3. To begin with, notice that a dotted line is drawn around the individual MOSFET cells. This line is simply used to indicate the MOSFET schematic cell outlines and can be turned off by pressing "i" on the keyboard. Also notice that the ports of the MOSFET cell are labeled as 1D, 2G, 3S and 4B indicating the drain, gate, source and body connection of the MOSFETs. The MOSFET cells are drawn with a rank of one while the inverter is drawn with a rank of 2.

The utility program LASICKT, shown as a command button in Fig. 1, is used to generate a SPICE netlist from this schematic. The layout in Fig. 4 can be used to generate a SPICE netlist. Comparison of the netlists provides a heuristic design verification that the layout and schematic match. This comparison can be performed with LASICKT. The simulation results for the SPICE netlist generated using the layout and the schematic provide another method to verify the schematic and design match.

In summary, the LASI layout system provides a complete PC based system that can be used for layout, design, simulation and verification of integrated circuits.
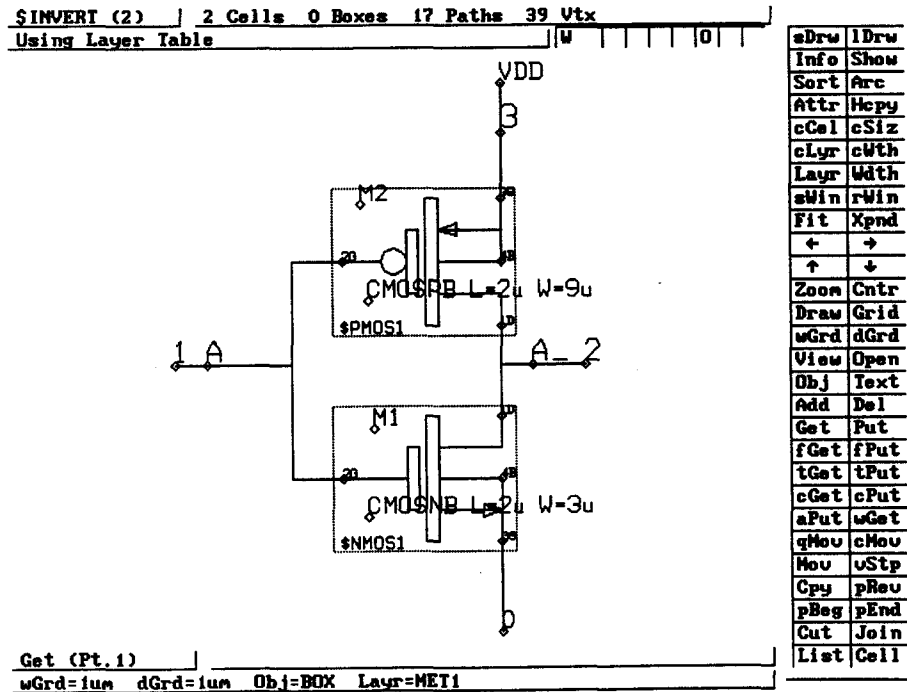

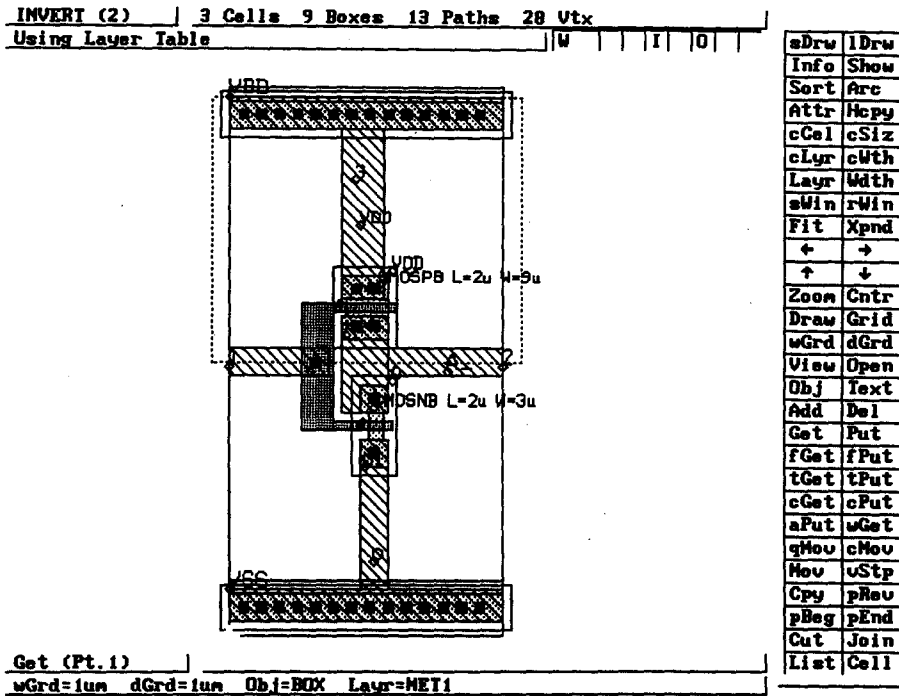Figure 3 - Schematic capture using LASI.

UDD

OSPB L=2u W=9u

DSNB L=2u W=3u

VSS

Get (Pt.1)
wGrd=1um   dGrd=1um   Obj=BOX   Layr=MET1

aDrw	lDrw
Info	Show
Sort	Arc
Attr	Hcpy
cCel	cSiz
cLyr	cWth
Layr	Wdth
aWin	rWin
Fit	Xpnd
←	→
↑	↓
Zoom	Cntr
Draw	Grid
wGrd	dGrd
View	Open
Obj	Text
Add	Del
Get	Put
fGet	fPut
tGet	tPut
cGet	cPut
aPut	wGet
qMov	cMov
Mov	vStp
Cpy	pRev
pBeg	pEnd
Cut	Join
List	Cell

Figure 4 - Layout of an inverter used to generate a SPICE netlist.

III. A Textbook

A textbook [1] has been written that incorporates LASI with the design, simulation and layout of CMOS analog and digital integrated circuits. Some outstanding features of the text are; 1) Software for layout of integrated circuits 2) Information and directions on submitting chips to MOSIS 3) tutorial presentation of material suitable for self study or as a University textbook 4) a broad range of topics 5) numerous examples and homework problems.

This text has been used at the University of Idaho for two courses; 1) a second semester junior level course covering CMOS digital circuit design, IC layout and SPICE simulation, 2) a senior/ first year graduate course introducing analog CMOS circuit design.

COMMENTS

The LASI layout program can be **downloaded** at http://www.engboi.uidaho.edu/lan-group/jbaker/wwwbook/lasi.htm

REFERENCE

[1]   Baker, R.J., Li, H.W. and Boyce, D.E. "CMOS Circuit Design, Layout and Simulation," IEEE Press, 1998.