Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.111 - Introductory Digital Systems Laboratory

Project Information

Introduction

The term project in 6.111 is your opportunity to specify a small digital system. You will design, build, debug, demonstrate, and report on this system. This memorandum sets forth our expectations and requirements for this project and makes a few suggestions which should help to make your project a success.

In order to accomplish all that is expected by the end of the term, it is essential that you *stay on schedule*.

Both the determination of grades and the project time requirements are inherently subjective. Lab 3 provides some guidance to the evaluation of project size and complexity. Lab 3 requires almost a full kit's worth of components. A reasonable guideline as to size of 6.111 projects is that it not require more than a kit and a proto board per person.

6.111 student projects often become too large because of a desire to effect computations in parallel and at high speed. Data paths are often unnecessarily wide and redundant. It is generally far better to minimize the type and extent of the data paths even though this results in more complicated control circuitry.

Use of microprogrammed sequencers and FSMs implemented with PALs allows implementation of complicated control with a small number of ICs. Please remember that massive data paths that enable computation at speeds far faster than needed do not represent a good design! It is almost always better to spend more time thinking and less time wiring.

Instructions

1. The first step in starting your project is to find a partner with whom you wish to work. Two-person projects are preferred, but three-person projects are permitted. Individual projects must be approved by the lecturer.

2. The second step is to decide what you wish to do. A list of project suggestions appears in this handout. This list may be helpful in this regard since it is compiled from past projects which were successfully completed.

3. The third step is to submit a PROPOSAL ABSTRACT (one for each student) using the attached form. This item and the PROPOSAL which follows are to be prepared jointly with your partner. We will use the proposal abstract to assign project teams to members of

the teaching staff. Those assignments will be posted shortly after the deadline for proposal submission.

4. The fourth step is to write the PROPOSAL. It is comprised of:

1. A description of the project in words, stating what your system is going to do and how you plan to implement it.
2. A block diagram.
3. A set of specifications that define in detail what your system is (in input, output terms) and what tests will be used to prove that it functions properly.
4. A statement of how the project work is to be divided among the partners. The block diagram should be referenced.

The project should be partitioned into two separately testable subsystems. Each subsystem is to be the responsibility of a single partner.

The proposal should be typewritten. Typically, it should be two to five pages in length, single-spaced, plus the block diagram and any figures you may need.

5. The fifth step is the Proposal Conference, which is when the proposal is to be submitted. Each project Proposal must also be presented orally to the Staff so that both you and we understand what it is you are attempting, and whether your basic design approach is sound. Each project group should sign up for a 30 minute session. Sign-up sheets will be posted in the lab in advance of the first day of proposal conferences. Be sure to bring extra copies of your Proposal with you to the presentation so that TA's can follow your talk without your having to draw your block diagram on the chalkboard.

6. The sixth step is to prepare detailed Module Designs and Logic Diagrams for each of the blocks in the block diagram, and have these approved by your project TA at the Block Diagram Conference. This approval is a prerequisite to your adding 6 extra units of 6.905.

You and your project partner(s) are to present your project design to the rest of the class. You are encouraged to use an overhead slide to show the class the block diagram. Do not count on drawing it on the board as there is not enough time for this. The presentation day will be chosen by the teaching staff and communicated to you by email and also posted on the web.

7. The seventh step is to build, debug and test your system. Project CONSTRUCTION may not begin until you have:

1. Completed and handed in all problem sets and assigned lab exercises and,
2. Had your detailed logic diagram approved by your TA.

8. The eighth step is to demonstrate your project to a member of the Staff. It is likely we will want to videotape your presentation.

9. The ninth step is to complete and submit the PROJECT REPORT. Material from the proposal can be used. The report may be prepared jointly:

- The Introduction and Summary sections can be joint efforts of the project team, but
- it must contain separate sections, individually written, describing subsystems for which each partner is responsible. Each section of the report should indicate the responsible author.

See the *Report Guide* handout for general requirements for the Final Project Report.

10. The final step is to turn in your kit and other components. Remove all wires from the socket strips and return the chips to their places in the box.

Schedule
Pertinent due dates are as follows:

Formation of Project Teams	Monday, April 1, 2002
Project Abstracts	Wednesday, April 3, 2002
Proposal Submission and Conferences	starting Monday, April 8, 2002
Block Diagram Conferences	starting Thursday, April 18, 2002
Last Day to ADD 6.905 (Drop Date)	Thursday, April 25, 2002
Project Design Presentations	starting Friday, April 26, 2002
Project Demonstrations	Tuesday, May 14–16, 2002
Vide-taping of Project Demonstrations	Wednesday, May 15, 2002
Project Reports	Thursday, May 16, 2002 (5:00 PM)

Extra Units for "Large" 6.111 Projects

Most 6.111 students spend more hours per week than warranted by the 12 unit rating. Primarily this is due to large final projects. It is now possible to register for an additional 6 units of credit for 6.111.

Our motivation for enabling the availability of these extra units is two-fold. Foremost is our desire to convince 6.111 students that they need NOT do a project which is bigger and more complicated than ever done in the past. Secondly, recognizing that many students will continue to do ambitious projects, we would like to credit 6.111 students with units appropriate to work expended.

We are concerned that the availability of extra units may be taken as a signal to escalate the size of 6.111 projects. Indeed, if we perceive this to be the result, we may discontinue this procedure. While a large project is not required for the extra units, timely completion of course work is. Before you can register for the extra units, you must have completed all of the labs, submitted your proposal, had your design conference and received clearance to begin construction from your project TA.

Procedures for adding six extra units (as 6.919) are described on an attached page, together with additional information.

Project Resources

Project resources are allocated on a per student basis. This means that a two-person project has twice the resources that an individual project has, etc. You have already been issued a kit and a quantity of ICs. The following items are available on an individual sign-out basis. Note that the quantities listed must suffice for the entire class.

Quantity	Item	* Indicates a buy to replace breakage
*200	Proto-boards which do not have switches, lights, or power supplies. Suitable 5 volt power supplies are mounted on the lab benches. Each proto-board will hold about one-half the number of ICs that can be mounted on your kit.	
*100	50 pin 3M ribbon cables for kit to kit connections	

The following items may have to be shared. Cables for the TVs, Z19s, and HP Displays must be signed out and returned daily.

several	VT100 Video Display Terminals with RS 232 cable
15	Monochrome TV Monitors with BNC cable
15	Color TV Monitors with cable

1	HP Pen Plotter with RS 232 cable
25	Speakers (with built in amplifier)
15	Microphones
2	Television Cameras with sync inputs
2	Digital shaft encoders
6	Stepper Motors

The following items may be signed out from the instrument room. Data sheets are available from the instrument room.

*30	AD775	Flash A to D Converter
*50	LM386	Low Power Audio Amplifier
*50		10 Mhz Crystal Oscillator
50	MC6847	Video Display Generator
*50		3.575945 MHz Crystal
*50		2K Pot
50	AY 1015D	UART
*50	741	Op Amp
*25	LF357	Op Amp
*25	LM311	Comparator
*50	AM26LS32	Line Receiver (Comparator)
*50	AD558JN	D to A Converter
*100	AD670JN	A to D Converter
*50	898-1-R5.1K	(or 898-1-R4.7K) resistor pack
50		LED Assembly
150		HEX LED
40	AM25S557	High Speed 8 x 8 Multiplier
20	AM25S558	High Speed 8 x 8 Multiplier
50	AM29C509DC	High Speed 12 x 12 Multiplier Accumulator
50	6850	Asynchronous Communications Interface Adapter
*10	6N138	Opto-isolater plus 1N914 diode
*10		5-pin DIN cables (female cable to wires)
small		misc. resistors and capacitors
100	74LS00	Quad 2-input NAND gate
75	74LS02	Quad 2-input NOR gate
75	74LS03	Quad 2-input NOR open collector gate
160	74LS04	Hex inverter
100	74LS08	Quad 2-input AND gate
120	74LS10	Triple 3-input NAND gate
50	74LS14	Hex Schmitt Trigger INVERTER
50	74LS20	Dual 4-input AND gate
50	74LS30	8-input NAND gate

50	74LS32	quad 2-input OR gate
50	74LS37	quad 2-input NAND buffer
50	74S38	quad 2-input NAND open collector gate
25	74LS42	BCD to Decimal decoder
100	74LS47	BCD to 7-segment decoder driver
150	74LS74	dual D flip flop
150	74LS85	4-bit comparator
50	74LS86	quad 2-input XOR gate
50	74LS107	dual JK flip flop with clear
50	74LS112	dual JK flip flop with preset and clear
50	74LS123	dual retriggerable monostable
75	74LS126	quad tri-state non-inverting buffer
50	74LS133	13-input NAND gate
75	74LS138	3 to 8 decoder
75	74LS139	dual 2 to 4 decoder
50	74150	16 to 1 multiplexor
150	74LS151	8 to 1 multiplexor
100	74LS153	dual 4 to 1 multiplexor
150	74LS157	quad 2 to 1 multiplexor
300	74LS161	binary 4-bit counter with direct clear
500	74LS163	binary 4-bit counter with synchronous clear
100	74LS169	4-bit up/down counter
100	74LS175	quad D edge triggered FF with clear, Q, /Q
50	74LS181	4-bit ALU
25	74LS193	binary dual clock up/down counter with clear
100	74LS194	4-bit bidirectional shift register
300	74LS244	Octal tri-state non-inverting buffer
100	74LS245	Octal tri-state bidirectional bus buffer
200	74LS257	quad 2 to 1 tri-state multiplexor
100	74LS259	8-bit addressable latch (positive output decoder)
150	74LS273	Octal D edge triggered flip flop with clear
100	74LS283	4-bit adder
100	74LS367	Hex tri-state non-inverting buffer
100	74LS368	Hex tri-state inverting buffer
75	74LS373	Octal D tri-state latch
100	74LS374	Octal D edge triggered tri-state flip flop
200	74LS377	Octal D edge triggered flip flop with enable
100	74LS393	dual 4-bit binary counter
100	74LS399	quad 2-input multiplexors with storage
25	74LS670	4 by 4 register file
small	Misc.	Crystal Oscillator

Many	28F256A	FLASH Memory
100	Am28F010	131,072 x 8-Bit CMOS Flash Memory
100	Am28F020	262,144 x 8-Bit CMOS Flash Memory
100	Am28F512	65,536 x 8-Bit CMOS Flash Memory
100	6116-3	2K by 8 SRAM
200	6264-15	8K by 8 SRAM
50	62256-12	32K by 8 SRAM
200	22V10 PAL	
400	16V8 PAL	
400	20V8 PAL	
*25	MAXIM 233	RS 232 level converter
25	Am29C517APC	16 bit multiplier
*25	54ACT/74ACT715	Programmable Video Sync Generator
*25	GS4981	Monolithic Video Sync Separator
*25	CD22204	Harris 5V Low Power Subscriber DTMF Receiver
25	AD8402/3	Dual/Quad Digital Pot
in kit	CY7C374i	CPLD
60	1408	DAC
8	P9931	small speaker/microphone

Project Suggestions

In past years, a great variety of projects have been successfully completed. A list of some completed recently is attached. The project reports for these are filed in the digital lab.

All the project reports are on file in 38-684. You may sign out any one for an overnight loan or for reading in the lab. You are free to make a copy of part or all of a report if you want to keep it for a longer time. The best and most interesting of your project reports will be used to augment this list for future terms.

It is often more satisfying to have projects which do something in addition to blinking LEDs. Examples are audio output, TV monitors, or VDT terminal displays.

Be careful – most unsuccessful projects were too complex. We will help you to size your project appropriately.

- Computer/Editor/Graphics

94-8 Video Editing in Real Time
94-11 OSCAR, Optical Character Recognition Machine
94-16 Digital Oscilloscope
95-7 A Digital Parrot
96-3 Visually Controlled Pointer Device
96-7 An Object Tracker
97-4 Stretch
97-9 Digital Postscript Imager
2000-2 The Design and Implementation of a Digital Oscilloscope
2000-3 6.111 Digital Pet Student
2000-4 Brushfire: A Hardware Platform for Running a Modern Operating System
96-15 A Personal Location and Navigation System at MIT

- Games

90-1 Video Jigsaw
90-5 MEMRUC – The Game
90-7 Digital Othello
90-8 Connect Four Machine
90-10 Master Mind – A Video Game
92-9 Nerd Kit Asteroids
93-16 Tetris
94-18 The 6.111 Pinball Machine
95-1 Virtual Kaboom
95-6 B-n-B Space Invaders
96-4 Battleship
96-6 The Pinball Project
97-1 The Amazing Maze
97-7 Ninja Master Fighting Game

98-1 Core Wars
98-9 Main Battle Tank
98-12 Sign Language Hangman
98-16 Automated Foosball
99-9 Electronic Talking Battleship
99-11 Pac-Man
99-14 Wireless Marksmanship Trainer
99-17 Air Connect Four
99-21 3-D Maze Navitgation
2000-5 Stoplight Pitch Nintendo Shifting Controller Entertainmenet System
2001-3 CTF.111 (Capture the Flag)
2001-5 Super Mario Brothers
2001-8 Monkey Box: an 8-bit Video Game platform
2001-13 Mole Dance Revolution – A 6.111 Interactive Workout

- Music/Audio

90-3 A Digital Music Synthesize
90-4 A MIDI Controlled Digital Music Synthesizer [MIDI]
90-12 The Magic Music Machine
90-14 Γ: The Musical Project
90-15 The MIDI Transceiver
91-1 Air Piano
91-4 Elevator Music
91-7 Optical Music Recognition
92-4 Playing the sax, or whatever you want
93-4 Programmable Multi-Channel Sound Synthesizer
94-5 The Digital DJ
94-9 The Multi-Mode Windowing Subtitling Machine
94-10 Super Sampling Sound Sequencer
94-13 The Digital Graphic Equalizer
95-4 Self-calibrating Audio Equalizer
95-13 The Accompanist
95-14 Bach's Napkin
96-11 BPM 2001: A Digital Odyssey
97-2 The Virtual Conductor
98-6 Digital Surround Sound Processor
98-17 Humanoid Robot Ear Sound Localization
99-22 Digital Air Band
2001-7 Programmable Symphony
2001-9 The Digital DJ

- Video

90-9 Video House of Mirrors
91-5 The MCG-30 Raster Image Processor
91-6 Smart Vision
92-5 Video Tracker
92-8 Digital Darkroom

93-5 Video Edge Detection System
93-9 Digitial Video Mixing Board
93-10 Air Sketcher
93-11 Killer Crayons!
93-15 Recursive Picture Manipulation
94-2 Digital Poisson Engine
94-7 Video "Go"
94-12 Video Chromakeying
95-11 Picture in Picture
95-12 Intelligent Picture-in-Picture Video
96-1 Design and Implementation of a PONG Game
96-2 Relatime Video Motion Detection
96-5 The Digital Conductor
96-8 Video Phone
96-14 Real Time Sky Navigation Aid
98-3 Downtown Traffic Control Simulator
98-4 3-D Vector Graphics Engine
98-5 The Speed Detector
98-10 Design and Implementation of a Target Finding and Termination system
98-14 GEORDI: Generalized Enhancement of Real-time Digital Imagery
98-18 S.I.M.A.E.D. Still Image Magnification and Enhancement Device
99-10 RC4 Video Encryption
99-13 Touchscreen Phone
99-20 A Closed-Caption Decoder
2001-6 Mr. Etch-a-Sketch
2001-2 A Digital Video Security System
2001-10 Visual Target Tracking System

- Speech and Communications

93-3 Telephone Switching System with Voicemail
93-17 Speech Synthesis Using Linear Predictive Coding
93-18 A Single Phone Line Demultiplexor
95-2 Time Multiplexed Single Line Communication System
96-12 Interactive Tic-Tac-Toe with Speech Recognition
97-5 Robotic Dog with Speech Control
98-2 A Flexible Dual Tone Multi Frequency Filter
98-11 A Voice Based Data Acquisition System
98-21 Home Security System with Telephone Interface
2001-4 Magnetic Card Reader

- Robotics

90-2 2-D Robot Arm Solving the Shuttle Puzzle Mechanically
92-6 Robothello
94-6 Seeing, Object-collecting Robot
96-13 The Digital Duck Terminator
98-15 Robot See, Robot do
98-20 To Mars and Beyond

99-12 Bipedal Walking Robot
2000-1 Theseus
2000-6 Writing Robot
2000-7 OJ Rover
2001-11 Writing Robot

- Miscellaneous

87-1 A Real Time Spectrum Analyzer with FFT
87-12 The Life Machine
92-2 ASPIRE Audio Signal Processor Ideally Realm Exclusive
92-3 Digital Patchbay
93-2 MAP (Map Algorithm Processing)
93-6 6.111 Lab 3 Sights and Sounds Unlimited: A Laser Light Show
94-4 The Conniption Machine
94-15 Dream Machine
94-17 Elevator Control System
95-3 Attitude Control System for a Small Satellite
95-5 Infrared Security System
95-8 Chaotic Scrambler/Descrambler
96-9 Internet Message Board
98-13 Sonar with Pulse Compression
99-15 Digital Pet Parrot
99-16 Digital Billboard
99-18 Barrier-clearning Video Controlled Electronic Target-seeking Car
2001-12 Power Wheels: An Autonomous Driving Machine

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6.905 SUPPLEMENTAL PROJECT CREDIT
Permission Form for an extra 6 units for 6.111

- Written proposals and logic diagram conferences must be completed by the posted deadlines.
- The deadline for registration for extra units is DROP DATE. Deviations from this deadline will NOT be made.
- An ADD card must be filled out. The **student is responsible for** securing Prof. Troxel's signature, his/her advisor's signature, and delivering the ADD card to the Registrar on or before DROP DATE.
- You must present to Prof. Troxel the following, at least one day before DROP DATE:
  - ADD card for 6 units of 6.905
  - Permission Form (this page) signed by your project TA

NOTE: Prof. Troxel keeps the Permission Form.

- You may, if you wish, leave the filled-in paperwork (listed in 4. above) at the Instrument Room desk at the entrance to the 6.111 lab (38–601). After signing your ADD card, Prof. Troxel will leave it there so that you may conveniently get your ADD card and take it to the Registrar.
- Your grade for the extra 6 units will be the same as your 6.111 grade.
- The extra 6 units may <u>not</u> be used to satisfy either the Institute or the departmental lab requirement.

Your Name _____ Course _____

Class _____ Phone _____ Term _____

Term Address: _____ No. of Units _____

Electronic Mail Address _____

Attach your 6.111 Project Proposal to this Permission Form.

6.111 Instructor's Agreement: The project described above is suitable for 6 Units of 6.905 credit.

TA Signature _____ Date _____

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PROPOSAL ABSTRACT FOR TERM PROJECT

(Submit one copy per project team.)

NAME: _____
(last) (first) (initial) (Term residence phone)

_____
(Address)

NAME: _____
(last) (first) (initial) (Term residence phone)

_____
(Address)

Title of Project (nine words or less): _____

_____

ABSTRACT

(One paragraph description)

_____

_____

_____

_____

_____

_____

_____

_____

_____

TENTATIVE DIVISION OF WORK

(One paragraph statement of how work is to be divided between partners.)

_____

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(Continue on separate sheet if necessary.)