INDEPENDENT PROJECT (3 WEEKS)

In this laboratory you have three weeks to construct a device, typically digital, of your own choosing. You are expected to continue to work in pairs. The project will count as the equivalent of 3 laboratories. At or before the first laboratory period you must submit your plans to the instructor for review. The object of the review is to attempt to determine whether the proposed project is feasible, the design is practical, and that completion of it is realistic for the time available. An early start is desirable to determine parts availability, both from UCSD and from external suppliers. During the three week period the TA's will be available for consultation and parts checkout; the instructor will be available for consultation during the first hour of every laboratory period, in the laboratory. Additional consultation can be arranged on an individual basis.

The project report is not to be included in your notebook as in previous laboratories. It should be printed or written on regular letter size paper. It should include:

a) An introduction with a brief description of the function, purpose, or objective of the project device as appropriate.
b) For the devices which were constructed or used in the project, provide the relevant specifications. For example; power requirements and input and/or output signal requirements.
c) Include a circuit diagram of the device. A sample is appended. In general the circuit should be organized in logical blocks and accompanied by a block diagram showing signal flow or logical interrelation of various blocks of the circuit. Also include a sketch of the physical layout of the IC's and other major components such as controls, displays and/or input and output connections.
c) Instructions (where appropriate) to a potential user as to how to use the device and/or how to repeat the measurements and analysis of the results.
d) A discussion of the theory of operation of the device.
e)Suggestions for additions, modifications, and alternate methods which could improve or add to the functions of the device. It is almost impossible to design and use a device without becoming aware of limitations and possible improvements.

It is important to be clear and concise. No report should exceed 10 single spaced pages and most should be shorter. Higher grades will be given for more efficient use of words rather than for long reports. The grades will be based on the difficulty of the project, the quality of its execution, and the quality of the report. Satisfactory operation must be demonstrated to your TA during or before the last scheduled lab session. The report must be turned in by 7PM of the scheduled lab session during the week ending May 18. Late reports are penalized 5%/day.You may write your own individual reports if you wish or you may turn in a single report for two partners. In the latter case, both partners receive the same grade.

The device should be as close to stand-alone as possible. Use the bench power supply for power. Function generators may be used for test or clock signals, but making your own from a 555 or other timer is preferred. Some parts may be temporarily signed out from the supplies of the lab but do not expect to obtain unusual chips or complicated devices. You are free to obtain any chips, electromechanical devices, or other components that you wish from available outside sources. It is a challenge to find parts for nothing but many such parts are available at very little cost from surplus outlets such as Gateway Electronics(best for electronics), Murphy's and California Electronics in El Cajon, or Industrial Liquidators(also has mechanical stuff). Other sources are Radio Shack(new), Western Radio Electronics(new), Shanks & Wright(new and surplus). If you have never been to such a store it is highly recommended that you browse through one of the surplus stores to see how many of the components and devices you can identify and to learn about the types of components that are available. Many more are in the Yellow Pages; the above are sources I happened to have used in the past.

Examples of possible projects are described below, listed approximately in order of increasing difficulty. You are encouraged to invent modifications of them or completely different ones. Note that there are no examples of analog projects; they tend to be more difficult to complete.

EXAMPLES OF POSSIBLE PROJECTS

1. Build an interval timer based on a crystal controlled or other stable oscillator. The timer should measure the interval between a start level change and a stop level change, and display the result. It should ignore start signals after the original and before the associated stop or running off scale.

2. Construct a time-of-day clock on which the hours are indicated by single LED's located in a circle as the numbers of an ordinary analog clock. Use two 7 segment LED's to display minutes. For this you could use 7447 BCD to 7 segment LED drivers, 7474 "D" flip flops, 7492 divide by 12 counters, 74196 decade scalers or 74197 4 bit counters.

3. Construct an electronic timer for control of a sprinkling system or similar application in the home. It is to work on a 7 day schedule such that it will turn on at the hour and day selected by the switches, for a time interval also determined by switch selection. Assume that a time base of 1 minute will be used, but run the device from a 1/60 sec or 1 sec time base for testing and demonstration. For this you could use 74197 4-bit counters and logic gates as required.

4. Construct a single slope analog-to digital converter with 4-bit resolution. This is one of the types of converters which are used in inexpensive commercial digital voltmeters. A ramp generator is constructed and its output is connected to one input terminal of a voltage comparator. The other input of the comparator is connected to the voltage source to be measured. A clock signal (10 or 100 kHz) is passed through a gate to a counter. The gate is opened at the beginning of the ramp and closed when the comparator switches states. The output from the counters should be used to drive LED’s in a binary display or converted to 7-segment decimal LED display. In either case, the display should hold until the next ramp is completed so that there is a continuous display. Design the device so that a convenient number of counts (say 100) corresponds to 1 Volt at the input. Components could be:

Op amp for ramp generator e.g. LF351
Comparator
Counter 74196 bcd or 74197 binary
npn transistor to convert comparator output to TTL
switch across capacitor of ramp generator, e.g. 4401
logic gates to control gate, switch, and counter reset.

5. Construct a two (or more) bit A/D converter using analog comparators and voltage dividers after the model shown in Figure 10.27 on page 447 of Fortney. Construct an appropriate truth table for the binary outputs, 1, 2, in terms of the inputs, a,b,c, and then implement it with logic gates. Include an input buffer amplifier, and consider making it a clocked or triggered system.

5a. An even better ADC than #6 above. Implement the successive approximation ADC of Figure 10.28a using the results of Problem 17 of Chapter 10.

6. Design the tail light system for a Ford Thunderbird. This consists of six or more LEDs in in two groups in a horizontal line, with the following functions:

a) A right turn signal activates the cyclic sequence (L=lighted, U=unlighted)
UUU LUU
UUU ULU
UUU UUL
and repeat with about a 1 Hz rate.
b) A left turn is the mirror image of right.
c) Applying brakes lights all lights. If brakes are on at the same time as the turn signal, the UUU set should go to LLL, but the other lights should maintain the turn sequence.
d) The emergency flasher initiates the sequence
UUU UUU
LLL LLL
and repeat with about a 1 Hz rate.
e) Brakes override the emergency flasher.

The turn signal could be an SPDT switch with center off, emergency an SPST switch, and brakes a push button. The LEDs could be driven from shift registers or counters.

7. Optical One Dimensional Ping Pong. This consists of a 12 or more LEDs in a horizontal line, and a push button at each end. The game begins when one player pushes their button; the end LED lights and is transferred toward the other end at a clock determined rate. If the receiving end button is pressed when the end LED is on, the transfer direction is reversed and the lighted LED travels in the opposite direction. If the button is pressed when the end LED is off, the lighted LED goes to the end and disappears (no lights on).

Constraints: At any time there is at most one LED on. When the lighted LED is going away from a player (server), repeated button pushes do nothing. When it is approaching a player (receiver), the circuit functions as above. If no lights are on, either button will start an LED and define the server and receiver.

Options: a) Score keeping
b) Several clock rates for different skill levels
c) Ball speed depends on button push

8. Electronic Roulette. Construct an electronic roulette wheel in the form of 16 or more single LED's in a circle. When you press a "spin" button, a single lighted LED moves around the circle, slowing down and finally stopping at one LED. The LED's should be driven with a shift register clocked by an oscillator whose frequency can be slowly reduced to zero. You should test the wheel by showing (within reasonable statistics) that all LED's are equally probable as the final lighted LED. This would imply some randomization of the initial velocity or of the rate at which the lighted LED slows down, or both.

DEVELOPMENT HINTS

1) Develop one subsystem at a time rather than trying to do the whole thing at once.
2 Make a block diagram, a circuit diagram, and a physical layout diagram showing pin connections before you touch the protoboard.
3) Use buss lines for power, ground, clock. Put bypass capacitors on the power buss(es) at the chip.Debounce all switches.
4) Drive LEDs from open collector outputs with current limiting resistors. There are LED arrays such as 7 segment LEDs for numerical display. Be aware that they typically have either the anodes or the cathodes connected together; the LED driver must match this. Common anode is preferred, driven from open collector outputs.
5) Color code wiring to differentiate power and signal wiring.
6) You may need two protoboards.
7) Be aware of possible timing problems in clocked circuits. Be sure that levels are stable when circuits are clocked; synchronize inputs with clock to avoid marginal signals.
8) The circuit should have a power on and/or reset sequence which places it in a well defined state.
9) Never drive several circuits in parallel from a marginal source. First make a standard TTL or other pulse. Then use the standard TTL pulse to drive the parallel inputs.
10) Be sure to consider what happens if inputs are missing, or unintended inputs are present.
11) There is a temptation to use a divide by 12 counter like the 7492 in counting seconds, minutes and hours. Be aware that the output is not BCD for counts of 6 or higher, so there is no 7 segment LED driver to convert the output. There are some tricks which can be used to make a 4 line divide-by-12 counter drive 12 LEDs.
12) Be sure you have no "floating" inputs. Unused inputs should be grounded or connected to an appropriate voltage level.
13) There are a wide variety of medium scale integrated (MSI) circuits to carry out complex functions, so spend some time leafing through an Intel, Texas Instruments, or other 74000 series chip manual before doing your preliminary design. Be aware that there are many different options in counter chips; some can count up/down, some divide by 10,12 or 16, some have parallel load, some incorporate the LED driver, etc. The same is true of shift registers; they can have 4, 5, 8 or more cells, can be serial or parallel load, can shift left or right or both.