

**University of California at Berkeley**  
**College of Engineering**  
**Department of Electrical Engineering and Computer Science**

EECS  
 150  
 R. H. Katz  
 Fall 2000

FINAL EXAMINATION

Thursday, 14 Decemeber 2000

**INSTRUCTIONS – READ THEM NOW!** All work is to be done on these pages. Partial credit is given only if we can evaluate your approach: indicate your assumptions and write as neatly as possible. Points are assigned to problems based on our estimate of how long they should take – 1 point equals 1 minute. **PACE YOURSELF ACCORDINGLY:** it is better to get partial credit on all of the problems than to complete a handful of them. This is a closed book examination. You will need a calculator or other information appliance. You may use a *single* 8.5" by 11" piece of paper (both sides) with prepared notes. Write your name and student ID Number at the top of each examination page.

It is a sad fact of life that cheating sometimes happens. It will not be tolerated. By signing below, you assert that all of the work included herein is your own, and that you understand the harsh penalties that will be imposed should cheating be detected – a 0 on the examination, and a letter of reprimand to your file:

\_\_\_\_\_ SID: \_\_\_\_\_

(Signature)

\_\_\_\_\_  
 (Name—Please Print!)

QUESTION	POINTS ASSIGNED	POINTS OBTAINED
1	30	
2	30	
3	30	

4	30	
5	30	
TOTAL	150	

*Design Specification: READ CAREFULLY!*

Your task is to design the control state machine and datapath for a programmable video cassette recorder to the following specification:

- The VCR has the ability to store upto two programs at a time, PROGRAM[0] and PROGRAM[1].
- Each program is described by the trip <Channel, Week, StartTime, EndTime>.

StartTime is <Day of the week, Time of Day> and EndTime is <Day of the Week, Time of Day>, where:

Channel(CH):  $0 < CH \leq 99$ ;

Week (WK): 0 = the current week, 1 = the next week;

Day of the Week (DoW): Su (0), M(1), Tu (2), W (3), Th (4), F (5), Sa (6);

Time of Day (ToD): HH: MM AM/PM where  $00 < HH \leq 12$ ,  $00 < MM \leq 59$ , AM(0)/PM(1);

Note that Noon is 12:00 PM and Midnight is 12:00 AM;

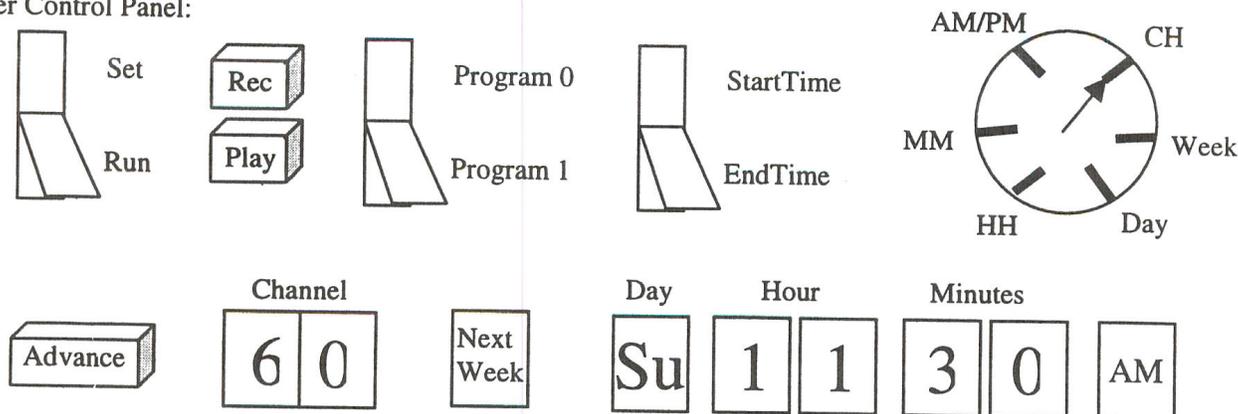
- By default, at power up, the DoW is set to 0(Sunday), and the ToD to Noon (12:00 PM). Thus the user must program the VCR with the correct current DoW and ToD.

The controller has two modes, SET(0) and RUN(1).

- When SET is asserted, a user console allows the user to do any or all of the following three actions: (1) set the current DoW/ToD, (2) set PROGRAM[0], or (3) set PROGRAM[1]. When the user exits SET mode, she enters RUN mode automatically.
- When RUN is asserted, the VCR has two or more modes: REC(0) and PLAY (1). When REC is asserted, recording will commence when the current DoW/ToD is equal to one of the two programs' StartTime and WK indicates that it is the current week. Recording stops when the current DoW/ToD is equal to EndTime (with WK=0) of the program that caused the recording to commence.

- When in SET mode or RUN/PLAY mode, recording will be inhibited even if the current time matches a program start time. If the VCR is currently recording, and the user exits RUN mode to enter SET mode, the current recording is immediately terminated.
- Since the VCR can only record one program at a time, overlapping programs are ignored. This is not quite the same thing as Don't Care! The earlier start time has precedence, and the recording will continue through to its matched end time.

User Control Panel:



The user console works in the following way. SET/RUN, Program 0/Program 1, and StartTime/EndTime are toggle switches. With the switch's top pushed in, the top signal is indicated (e.g., Set, Program), StartTime). When the bottom is pushed in, the lower signal is indicated (e.g., Run, Program1, EndTime). Record and Play are indicated by push buttons: when first pressed, the indicated signal is asserted. When pressed a second time, the signal is unasserted.

There is also a six position rotary switch, which is used to indicated one of CH, This/Next Week, Day, HH, MM, and AM/PM. This is used to set the current time and StartTime and EndTime of the two programs.

Setting Program 1 to this tape Channel 60 on Sunday of next week, at 11:30 AM, works as follows. Place the first toggle switch in Set. Depress the Program toggle switch to indicate Program 1. Press the third toggle to StartTime. Place the rotary switch to point to CH. Keep pressing the Advance button until 60 is shown in the rotary switch to Day. Hit advance until Su appears in the day indicator. Advance the rotary to Hours. Press advance multiple times until 11 appears. Advance the rotary to MM, and press advance until 30 appears. Advance the rotary to AM/PM and tap the advance bottom until AM appears.

You would then press the EndTime side of the toggle, repeat the process with the rotary switch/advance button to set the end time (here we would skip the programming of the channel).

The program is put into effect when the first toggle is set to Run.

### Question 1. Datapath components (30 points)

- Design the DoW counter. This is a three-bit binary counter with Reset, Count, and Clock inputs. On Reset, the counter is synchronously set to 0. When the counter counts up to 6, it wraps around to 0. Draw a schematic, labeling and describing your inputs and outputs.

- ii. Design the ToD counter. This is a four-digit BCD counter, HH: MM, with an additional single bit to represent AM/PM. The MM portion of the counter is set to 12 on reset, and wraps around to 01 when counting. Note that HH portion of the counter increments only when the MM portion wraps around the from 50 to 0. The AM/PM portion of the counter increments whenever the ToD counter advances from 11:59 to 12:00. Draw a schematic, labeling and describing your inputs and outputs.
- iii. Design a DoW/ToD Comparator. This is combinational logic with two DoW/ToD inputs that outputs a 1 when if the two inputs are identical and 0 if they differ. HINT: Implement a single BCD digit comparator and show how this can be composed to form a multi-bit comparator.

**Question 2. Datapath Design (30 points)**

- i. Design the VCR datapath to the level of interconnections among high level blocks for the functional units and registers. For each such block, describe its function (e.g., the Time of Day Counter), and indicate its inputs (e.g., Reset, Clock) and outputs (e.g., HH:MM AM/PM).
- ii. Tabulate the register transfer operations supported by your datapath design. Provide a short comment with each RT operation indicate what it is used for.

**Question 3. User Console State Machine (30 Points)**

Develop the state diagram for the VCR's user console defined on page 2.

**Question 4. Control State Machine (30 Points)**

Develop a Mealy Machine state diagram for the main loop of the VCR controller that is continuously checking whether the current time of day matches the start or end time of an existing program.

**Question 5. Control Machine Implementation (30 Points)**

Develop a ROM-based design for your state machine of Question 4.

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**Posted by HKN (Electrical Engineering and Computer Science Honor Society)  
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If you have any questions about these online exams  
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