

ECE 662

Homework #5

Problems:

In these problems, you will implement several additional instructions with the example control unit that has been discussed in class. The instructions to be implemented are shown at the bottom of the page. The first three instructions have already been implemented. You are to implement the last five: ADD #Value, LD, ST, BEQ, and BNE.

1. Write the microinstructions for the ADD #Value, LD, ST, BEQ, and BNE instructions. Before doing so, modify the microinstructions given in class for states 8-10. The modifications are given on the next page. You will write microinstructions for states 16-22.
2. Modify the equations given in class for the encoder circuitry when hardwired control is used for the control unit. Note that you will also need to add equations for D₄ (5-bit control step counter), Write, and IMDR.

<u>Instruction</u>	<u>Opcode (IR₁₅₋₁₂)</u>	<u>Words</u>	<u>Register Transfers</u>
ADD Addr	0000	2	[Addr] + [AC] → AC; Changes N,Z,V,C
ADD (X)	0001	1	[[X]] + [AC] → AC; Changes N,Z,V,C
JMP Addr	0010	2	Addr → PC
ADD #Value	0011	2	Value + [AC] → AC; Changes N,Z,V,C
LD Addr	0100	2	[Addr] → AC; Changes N,Z,V=0,C=0
ST Addr	0101	2	[AC] → Addr; Changes N,Z,V=0,C=0
BEQ Offset	0110	2	If Z=1, then [PC _{UPD}] + Offset → PC
BNE Offset	0111	2	If Z=0, then [PC _{UPD}] + Offset → PC

Modified Microinstructions for Example Control Unit

<u>State</u>	<u>Register Transfer</u>	<u>Control Lines</u>	<u>Next State</u>
0	[PC] → MAR	OPC, IMAR	1
1	[[MAR]] → MDR	Read, Inhibit if $\overline{\text{MFC}}$	2 if MFC=1 1 if MFC=0
2	[MDR] → IR	OMDR, IIR	3
3	[PC]+1 → T2	OPC, IB, IT2, P1	4
4	[T2] → PC	OT2, IPC	14 if ADD (X) 5 otherwise
5	[PC] → MAR	OPC, IMAR	6
6	[[MAR]] → MDR	Read, Inhibit if $\overline{\text{MFC}}$	15 if MFC=1 and $\overline{\text{JMP}}$ 7 if MFC=1 and $\overline{\text{JMP}}$ 6 if MFC=0
7	[PC]+1 → T2	OPC, IB, IT2, P1	8
8	[T2] → PC	OT2, IPC	0 if Z=0 and BEQ 0 if Z=1 and BNE 16 if Z=1 and BEQ 16 if Z=0 and BNE 11 if ADD #Value 19 if ST 9 otherwise
9	[MDR] → MAR	OMDR, IMAR	10
10	[[MAR]] → MDR	Read, Inhibit if $\overline{\text{MFC}}$	22 if MFC=1 and LD 11 if MFC=1 and $\overline{\text{LD}}$ 10 if MFC=0
11	[MDR] → T1	OMDR, IT1	12
12	[T1]+[AC] → T2	IA, OAC, IB, IT2, IC, IV	13
13	[T2] → AC	OT2, IAC, IN, IZ	0
14	[X] → MAR	OX, IMAR	10
15	[MDR] → PC	OMDR, IPC	0