

# LC-3 Instructions, Control Structure and Calling Sequence Reference

ADD+	0001	DR	SR1	0	00	SR2
ADD+	0001	DR	SR1	1	imm5	
AND+	0101	DR	SR1	0	00	SR2
AND+	0101	DR	SR1	1	imm5	
BR	0000	n	z	p	PCOffset9	
JMP	1100	000	BaseR	000000		
JSR	0100	1	PCOffset11			
JSRR	0100	0	00	BaseR	000000	
LD+	0010	DR	PCOffset9			
LDI+	1010	DR	PCOffset9			

+ Indicates instructions that modify condition codes

LDR+	0110	DR	BaseR	offset6
LEA+	1110	DR	PCoffset9	
NOT+	1001	DR	SR	111111
RET	1100	000	111	000000
RTI	1000	000000000000		
ST	0011	SR	PCoffset9	
STI	1011	SR	PCoffset9	
STR	0111	SR	BaseR	offset6
TRAP	1111	0000	trapvect8	
reserved	1101			

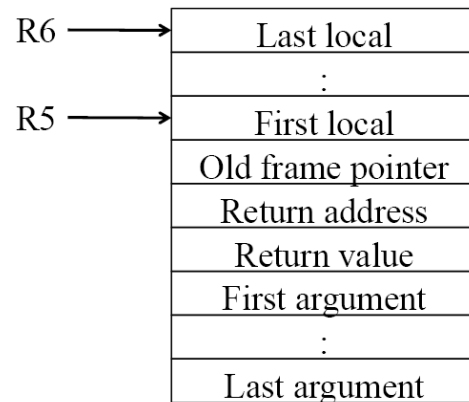
+ Indicates instructions that modify condition codes

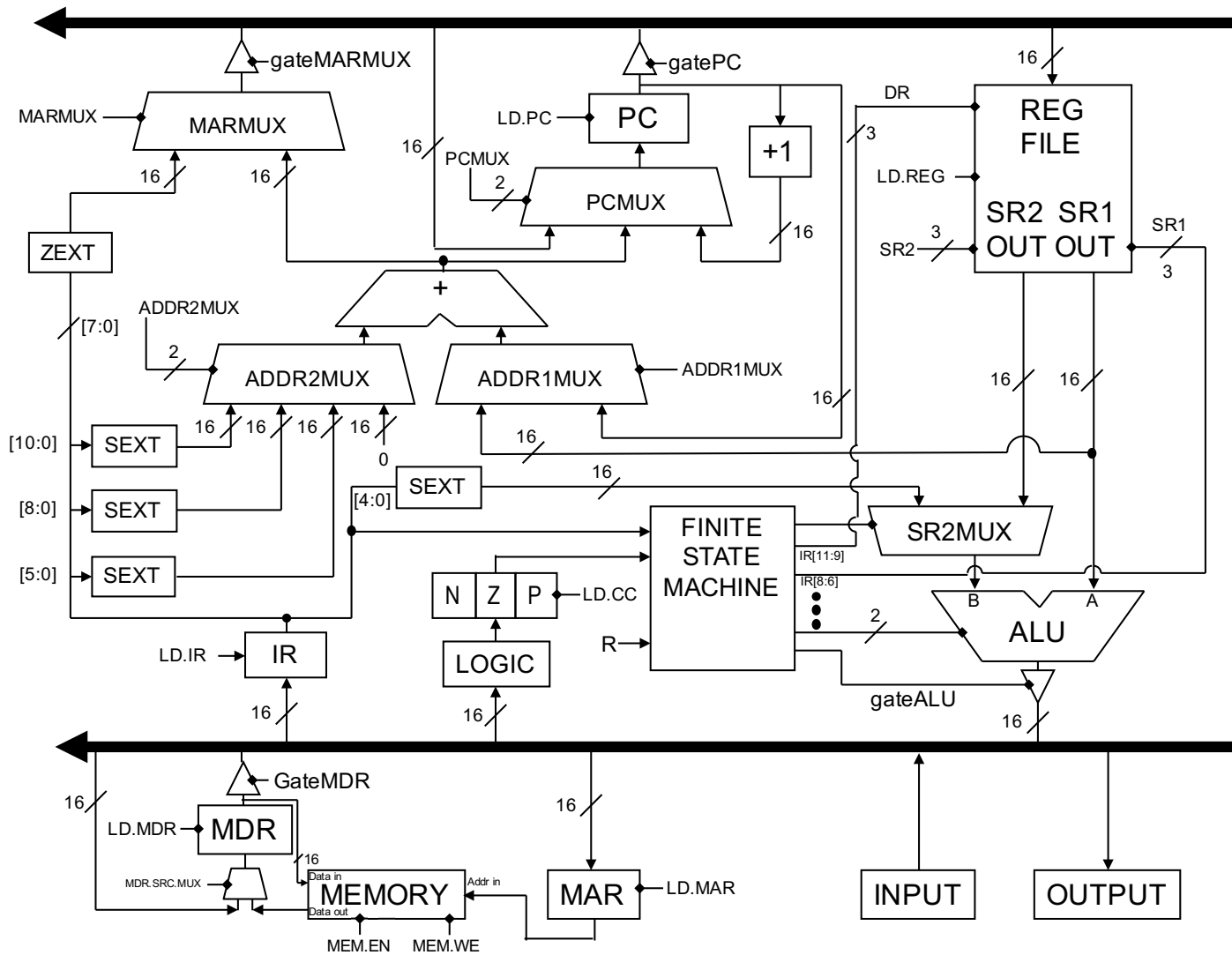
## CS2110 REFERENCE SHEET

ADD	0001	DR	SR1	0	00	SR2
ADD	0001	DR	SR1	1	imm5	
AND	0101	DR	SR1	0	00	SR2
AND	0101	DR	SR1	1	imm5	
BR	0000	n	z	p	PCoffset9	
JMP	1100	000	BaseR	000000		
JSR	0100	1	PCoffset11			
JSRR	0100	0	00	BaseR	000000	
LD	0010	DR	PCoffset9			
LDI	1010	DR	PCoffset9			
LDR	0110	DR	BaseR	offset6		
LEA	1110	DR	PCoffset9			
NOT	1001	DR	SR	111111		
ST	0011	SR	PCoffset9			
STI	1011	SR	PCoffset9			
STR	0111	SR	BaseR	offset6		
TRAP	1111	0000	trapvect8			

<i>Trap Vector</i>	<i>Assembler Name</i>
x20	GETC
x21	OUT
x22	PUTS
x23	IN
x25	HALT

<i>Device Register</i>	<i>Address</i>
Keybd Status Reg	xFE00
Keybd Data Reg	xFE02
Display Status Reg	xFE04
Display Data Reg	xFE06





Boolean Signals	
LD.MAR	GateMARMUX
LD.MDR	GateMDR
LD.REG	GatePC
LD.CC	GateALU
LD.PC	LD.IR
MEM.EN	MEM.WE

MUX Name	Possible Values
ALUK	ADD, AND, NOT, PASSA
ADDR1MUX	PC, BaseR
ADDR2MUX	ZERO, offset6, PCOffset9, PCOffset11
PCMUX	PC+1, BUS, ADDER
MARMUX	ZEXT, ADDER
MDR.SRC.MUX	BUS, MEM
SR2MUX	SR2, SEXT

if (R1>0) then .. else ..

```
ADD      R1,R1,#0 ; if (R1>0) then  
BRNZ     ELSE1
```

...[THEN part]...

```
BRNZP    ENDIF1  
ELSE1    NOP ; else
```

...[ELSE part]...

```
ENDIF1   NOP ; endif
```

for (init; R1>0; reinit)

...[init loop]... ; for (init;

FOR1      ADD      R1,R1,#0  
             BRNZ      ENDF1      ; R1>0;

...[FOR body]...

...[reinit loop]... ; reinit)

             BRNZP      FOR1  
ENDF1      NOP

while(R1>0)

```
WHILE1  ADD      R1,R1,#0 ; while(R1>0)  
        BRNZ     ENDW1
```

...[WHILE body]...

```
        BRNZP    WHILE1  
ENDW1   NOP      ; endwhile
```



do ... while(R1>0);

DO1    NOP                    ; do

...[DO WHILE body]...

ADD    R1,R1,#0

BRP    DO1    ; while(x)

# Boilerplate: Caller

before foo() returns - (3 arguments)

Caller

ADD R6, R6, -1 ; push(arg3)

AND R0, R0, 0

ADD R0, R0, 3

STR R0, R6, 0

ADD R6, R6, -1 ; push(arg2)

AND R0, R0, 0

ADD R0, R0, 1

STR R0, R6, 0

ADD R6, R6, -1 ; push(arg1)

LD R0, X

STR R0, R6, 0

JSR FOO ; foo()

...

**m = foo(x, 1, 3)**

**= x + 1 - 3**

		SR2
		SR1
		lv 1
		lv 0
		OldFP
		RA
		RV
SP->	x	arg 1
SP->	1	arg 2
SP->	3	arg 3
SP->		

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# Boilerplate: Caller

after foo() returns - (3 arguments)

...

```
JSR FOO      ; foo()
LDR R0, R6, 0 ; m = RV
ST R0, M
ADDR6, R6, 4 ; pop 3+1 words
```

; and the function call is done!

```
m = foo(x, 1, 3)
    = x + 1 - 3
```

	old R2	SR2	0000 ↑
	old R1	SR1	
		lv 1	
		lv 0	
	old R5	OldFP	↓ FFFF
	old R7	RA	
<del>SP-&gt;</del>	x+1-3	RV	
	x	arg 1	
	1	arg 2	
	3	arg 3	
<i>SP-&gt;</i>			

# Boilerplate: Callee

(3 arguments, 2 local variables (lv), 2 saved registers (SR))

FOO

```

ADD R6, R6, -4 ; push 4 words
                ; for RV, RA, OldFP, lv0
                ; set RV later
STR R7, R6, 2   ; store RA
STR R5, R6, 1   ; store OldFP
                ; set lv0 & 1 later
ADD R5, R6, 0   ; FP = SP
ADD R6, R6, -3 ; push 3 words
                ; 2+2-1(lv0)
STR R1, R5, -2  ; save SR1
STR R2, R5, -3  ; save SR2
... ; foo() implementation
    
```

SP->

SP->	old R2	SR2	FP-3
	old R1	SR1	FP-2
		lv 1	FP-1
FP->		lv 0	FP
	old R5	OldFP	FP+1
	old R7	RA	FP+2
		RV	FP+3
SP->	x	arg 1	FP+4
	1	arg 2	FP+5
	3	arg 3	FP+6

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int foo(int a, int b, int c)

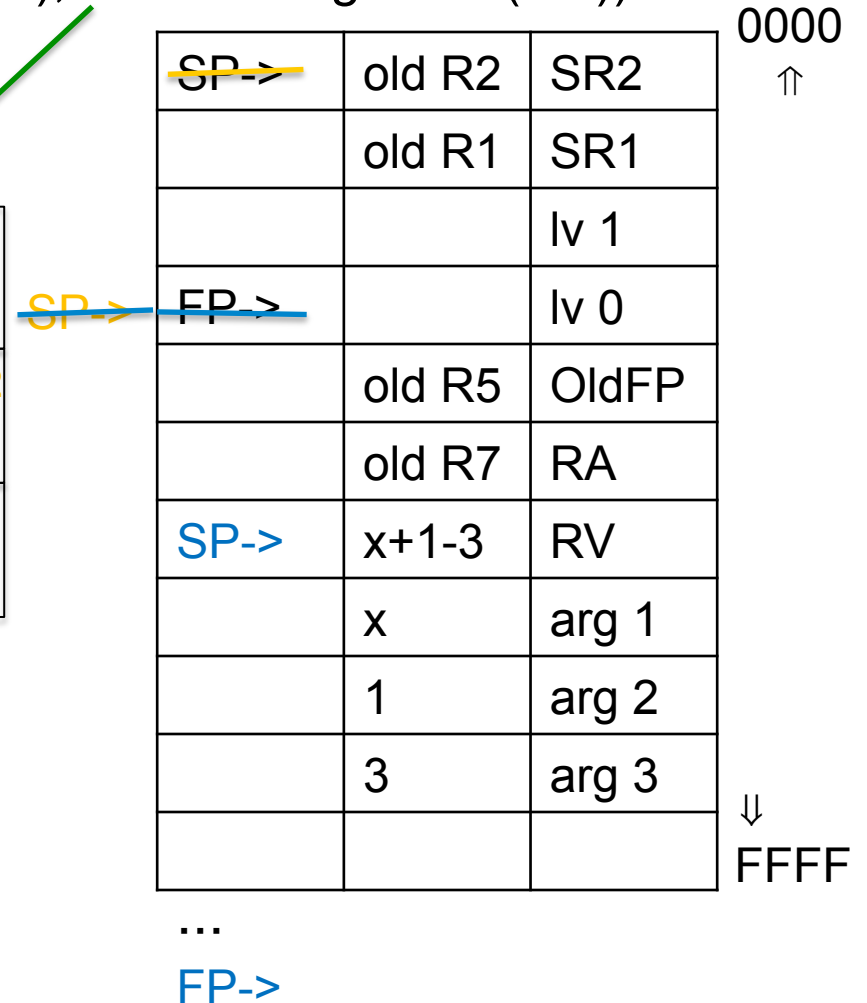
...

# Boilerplate: Callee

(3 arguments, **2** local variables (lv), **2** saved registers (SR))

```
... ;foo() implementation
; And now we're ready to return
```

<i>LDR R1, R5, -2 ; restore SR1</i>
<i>LDR R2, R5, -3 ; restore SR2</i>
<i>ADD R6, R5, 0 ; pop lv0/1 &amp; SR1/2</i>
<i>LDR R7, R5, 2 ; R7 = RA</i>
<i>LDR R5, R5, 1 ; FP = OldFP</i>
<i>ADD R6, R6, 3 ; pop 3 words</i>
<i>RET ; foo() is done!</i>



```
int foo(int a, int b, int c)...
```