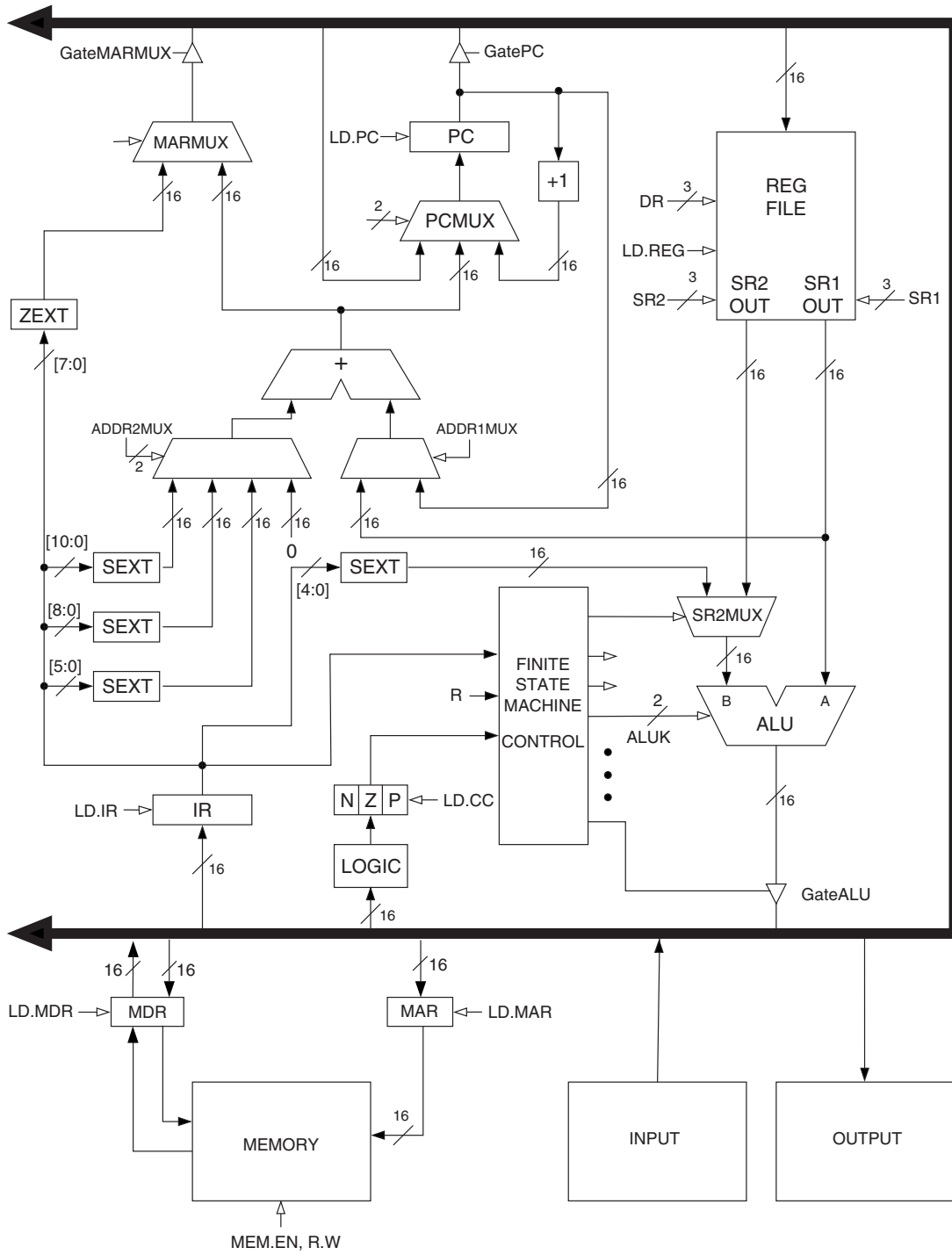


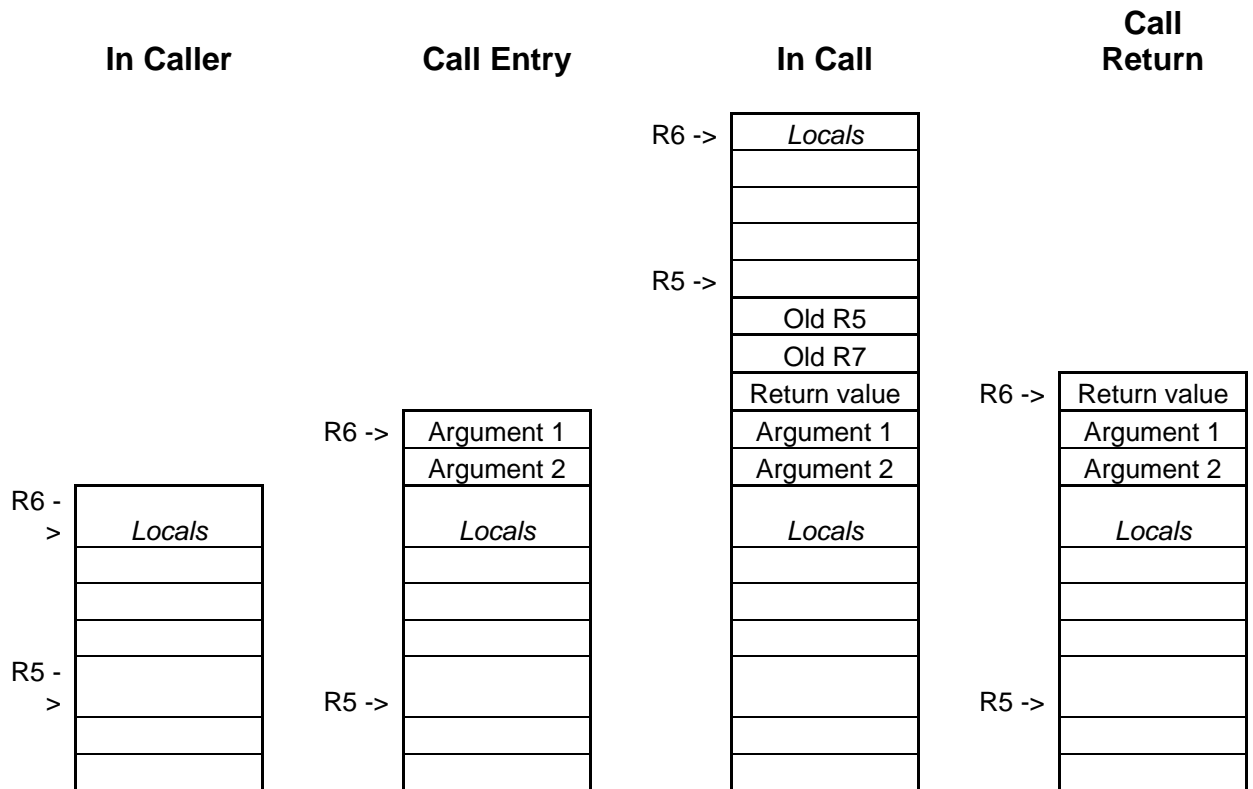
# LC/3 Data Path



## LC/3 instructions

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
<b>ADD<sup>+</sup></b>	0001			DR			SR1			0	00		SR2			
<b>ADD<sup>+</sup></b>	0001			DR			SR1			1	imm5					
<b>AND<sup>+</sup></b>	0101			DR			SR1			0	00		SR2			
<b>AND<sup>+</sup></b>	0101			DR			SR1			1	imm5					
<b>BR</b>	0000			n	z	p	PCoffset9									
<b>JMP</b>	1100			000			BaseR			000000						
<b>JSR</b>	0100			1	PCoffset11											
<b>JSRR</b>	0100			0	00		BaseR			000000						
<b>LD<sup>+</sup></b>	0010			DR			PCoffset9									
<b>LDI<sup>+</sup></b>	1010			DR			PCoffset9									
<b>LDR<sup>+</sup></b>	0110			DR			BaseR			offset6						
<b>LEA<sup>+</sup></b>	1110			DR			PCoffset9									
<b>NOT<sup>+</sup></b>	1001			DR			SR			111111						
<b>RET</b>	1100			000			111			000000						
<b>RTI</b>	1000			000000000000												
<b>ST</b>	0011			SR			PCoffset9									
<b>STI</b>	1011			SR			PCoffset9									
<b>STR</b>	0111			SR			BaseR			offset6						
<b>TRAP</b>	1111			0000			trapvect8									
<b>reserved</b>	1101															

# LC/3 Stack Example



## LC/3 Device Registers

KBSR Keyboard Status Register	xFE00	KBSR[15] is one when keyboard has a new character
KBDR Keyboard Data Register	xFE02	KBDR[7:0] is last character typed on keyboard
DSR Display Status Register	xFE04	DSR[15] is one when display can accept a new character
DDR Display Data Register	xFE06	DSR[7:0] is the character to be displayed on screen

## “Other” LC/3 Registers

*neither data nor device*

PC Program Counter	The address of the <i>next</i> instruction to be executed. Pushed to supervisor stack on interrupt. Popped from supervisor stack on RTI instruction.
PSR Processor Status Register	PSR[15] is one if in user mode, PSR[10:8] is the priority level, PSR[2:0] is NZP bits. Pushed to supervisor stack on interrupt. Popped from supervisor stack on RTI instruction.
Saved.USP Saved User Stack Pointer	On interrupt, R6 is stored here. On RTI, R6 is set from Saved.USP when <i>new</i> PSR[15] is 1.
Saved.SSP Saved Supervisor Stack Pointer	On interrupt, R6 is set from Saved.SSP.

## LC/3 Trap Service Routines

x20	GETC	Read a character into R0. Do not echo the character.
x21	OUT	Write a single character stored in R0.
x22	PUTS	Write a zero-terminated string stored at address R0.
x23	IN	PUTS followed by GETC, but with echoing of the input character.
x24	PUTSP	PUTS, but with two characters stored in each word.
x25	HALT	Halt

## Powers of Two

$2^{-1}$	0.5
$2^{-2}$	0.25
$2^{-3}$	0.125
$2^{-4}$	0.0625
$2^{-5}$	0.03125

$2^0$	1
$2^1$	2
$2^2$	4
$2^3$	8
$2^4$	16
$2^5$	32
$2^6$	64

$2^7$	128
$2^8$	256
$2^9$	512
$2^{10}$	1024
$2^{11}$	2048
$2^{12}$	4096
$2^{13}$	8192

$2^{10}$	1 K
$2^{20}$	1 M
$2^{30}$	1 G

## ASCII table

Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex
<i>nul</i>	0	00	<i>space</i>	32	20	@	64	40	~	96	60
<i>soh</i>	1	01	!	33	21	A	65	41	A	97	61
<i>stx</i>	2	02	"	34	22	B	66	42	B	98	62
<i>etx</i>	3	03	#	35	23	C	67	43	C	99	63
<i>eot</i>	4	04	\$	36	24	D	68	44	D	100	64
<i>enq</i>	5	05	%	37	25	E	69	45	E	101	65
<i>ack</i>	6	06	&	38	26	F	70	46	F	102	66
<i>bel</i>	7	07	'	39	27	G	71	47	G	103	67
<i>bs</i>	8	08	(	40	28	H	72	48	H	104	68
<i>ht</i>	9	09	)	41	29	I	73	49	I	105	69
<i>lf</i>	10	0A	*	42	2A	J	74	4A	J	106	6A
<i>vt</i>	11	0B	+	43	2B	K	75	4B	K	107	6B
<i>ff</i>	12	0C	,	44	2C	L	76	4C	L	108	6C
<i>cr</i>	13	0D	-	45	2D	M	77	4D	M	109	6D
<i>so</i>	14	0E	.	46	2E	N	78	4E	N	110	6E
<i>si</i>	15	0F	/	47	2F	O	79	4F	O	111	6F
<i>dle</i>	16	10	0	48	30	P	80	50	P	112	70
<i>dc1</i>	17	11	1	49	31	Q	81	51	Q	113	71
<i>dc2</i>	18	12	2	50	32	R	82	52	R	114	72
<i>dc3</i>	19	13	3	51	33	S	83	53	S	115	73
<i>dc4</i>	20	14	4	52	34	T	84	54	T	116	74
<i>nak</i>	21	15	5	53	35	U	85	55	U	117	75
<i>syn</i>	22	16	6	54	36	V	86	56	V	118	76
<i>etb</i>	23	17	7	55	37	W	87	57	W	119	77
<i>can</i>	24	18	8	56	38	X	88	58	X	120	78
<i>em</i>	25	19	9	57	39	Y	89	59	Y	121	79
<i>sub</i>	26	1A	:	58	3A	Z	90	5A	Z	122	7A
<i>esc</i>	27	1B	;	59	3B	[	91	5B	{	123	7B
<i>fs</i>	28	1C	<	60	3C	\	92	5C		124	7C
<i>qs</i>	29	1D	=	61	3D	]	93	5D	}	125	7D
<i>rs</i>	30	1E	>	62	3E	^	94	5E	~	126	7E
<i>us</i>	31	1F	?	63	3F		95	5F	<i>Del</i>	127	7F

### Hex table

0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111

### IEEE floating point

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
s		exponent										fraction																			

$$N = (-1)^s \times 1.\text{fraction} \times 2^{\text{exponent}-127}, \text{ when } 1 \leq \text{exponent} \leq 254$$

$$N = (-1)^s \times 0.\text{fraction} \times 2^{-126}, \text{ when } \text{exponent} = 0$$

### NAND and NOR or NOR and NAND?

