

5. LED

5.1 ARM

IMX6UL Cortex-A7 Cortex-A7

:

- DEN0013D_cortex_a_series_PG.pdf
- ARM® Cortex™-A Series Version: 4.0 Programmer’s Guide.pdf
- : 00_UserManual\ \Arm \ARMv7 (DEN0013D_cortex_a_series_PG).pdf
- : 3: ARM Processor Modes and Registers

5.1.1

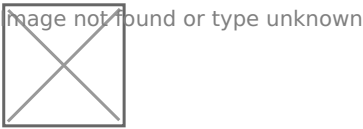
Cortex-A7 9 User Sys(System) FIQ IRQ ABT(Abort) SVC(Supervisor) UND(Undef) MON(

User	
Sys(System)	
FIQ	FIQ
IRQ	
ABT(Abort)	
SVC(Supervisor)	
UND(Undef)	
MON(Monitor)	
Hyp	

5.1.2

Cortex-A7

Cortex-A7 9



User (R0~R7)

FIQ R13(SP) SP_fiq
SVC R13(SP) SP_svc

9 34

- 1. R0~R7
- 2. R8~R14
- 3. R15
- 4.

4

5.1.2.1

R0~R7 R0~R7 R0~R7 R0~R7

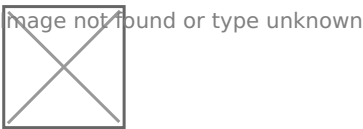
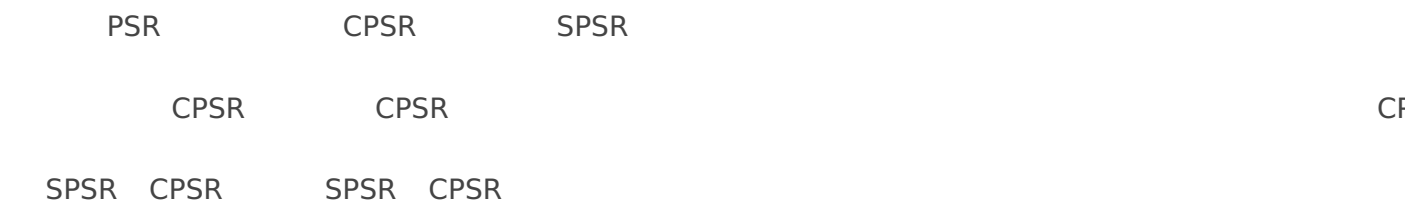
5.1.2.2

R8~R12 (FIQ) Rx_irq(x=8~12) Rx(8~12) FIQ
R13(SP) 8 User Sys 7 7
R14(LR) 7 User Sys Hyp 6 6
R14(LR) BL BLX R14(LR) R14(LR) R15(PC)

5.1.2.3

R15(PC) 8
ARM -> -> R15(PC) R15(PC)
R15(PC) = + 8

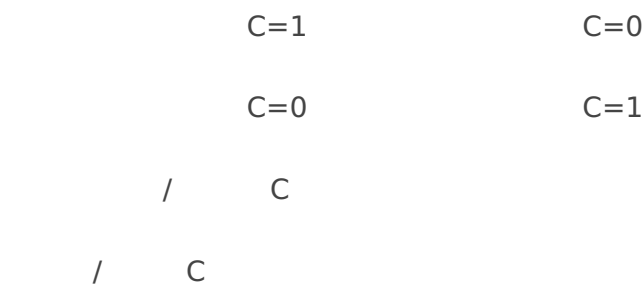
5.1.2.4



N(bit31) () N N=1/0 /

Z(bit30) CMP Z=1

C(bit29)



V(bit28) / V=1 V

Q(bit27) ARM v5TE_ J Q=1/0 /

IT1:0 IT7:2 IT[7:0] IF-THEN

J(bit24) T(bit5) ARM Thumb

J	T	
0	0	ARM
0	1	Thumb
1	1	ThumbEE
1	0	Jazelle

GE3:0 SIMD

E(bit9) E=1/0 /

A(bit8) A=1

I(bit7) I=1/0 / IRQ

F(bit6) F=1/0 / FIQ

M[4:0]

M[4:0]	
10000	User
10001	FIQ
10010	IRQ
10011	Supervisor(SVC)
10110	Monitor(MON)
10111	Abort(ABT)
11010	Hyp(HYP)
11011	Undef(UND)
11111	System(SYS)

5.2

- :
- DDI0406C_d_armv7ar_arm.pdf
 - ARM® Architecture Reference Manual ARMv7-A and ARMv7-R edition
 - : 00_UserManual\ \Arm \ armv7 ar CPU DDI0406C_d_armv
 - : A5: ARM Instruction Set Encoding

CPU 2

1. CISC
Complex Instruction Set Computer x86
2. RISC
Reduced Instruction Set Computing ARM RISC-V

a = a + b 4 a b a+b a

1. CISC(x86) 4 CPU
2. RISC “ ” CPU a b a

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ARM (RISC Reduced Instruction Set Computing)

- 1.
- 2. CPU
- 3. RISC CPU

5.2.1

a

- 1. CPU

```
mov r0, #addr_a // a CPU r0
ldr r1, [r0] // r0 CPU r1
```

- 2.
- CPU r1
- 3. CPU

```
add r1, r1, r2 // CPU r1=r1+r2
```

- 4. CPU

```
str r1, [r0] // r1 r0
```

mov add ldr str “ ”— mov

ARM

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cond	op1	op	
not 1111	00x	-	MOV
not 1111	010	-	/ LDR/STR

cond	op1	op	
not 1111	011	0	/ LDR/STR
not 1111	011	1	(Media instructions)
not 1111	10x	-	B BL; LDM/STM POP/PUSH
not 1111	11x	-	
1111	-	-	BL

: ARM® and Thumb®-2 Instruction Set Quick Reference Card.pdf (ARM)

: 00_UserManual\ \Arm \ ARM® and Thumb®-2 Instruction Set Quick Reference

5.2.2

```

label
[instruction @ comment

```

label label /

instruction

@ comment @ comment

```

add:
[mov r0, #0 @ R0 0

```

addmov r0, #0@ R0 0

mov bl/b add/sub ldm/stm push/pop

5.2.2.1 mov

```

mov r1, #10 @ 10 r1 r1=10

```

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1. addrA e3a0100a mov r1, #10
2. MOV
3. CPU R1 10
 e3a0100a MOV

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[31:28] 0xe [15 12] R1 0x1 [12:0] 10 0x00a

5.2.2.2 bl

```
1 bl test_tag
2 mov r1, #10
3
4 test_tag:
5   mov r3, #0
6   mov pc, lr
```

- 1 test_tag mov r3, #0 mov r1, #10 LR
- 6 mov r1, #10 mov r1, #10

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1. CPU addrA eb000000 bl test_tag PC test_tag addrA+8 tes
2. CPU addrA+8 e3a03000 mov r3, #0 CPU R3 0
3. CPU addrA+12 e1a0f00e mov pc, lr PC addrA+4
4. CPU addrA+4 e3a0100a mov r1, #10 CPU R1 10
 eb000000 BL

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imm[23:0] PC 4 0 ARM ARM addrA bl test_

5.2.2.3 b

```
1 b test_tag
2 mov r1, #10
3
4 test_tag:
5 [ ]mov r3, #0
```

1 test_tag mov r3, #0 mov r1, #10
B BL BL B/BL LR BL B

5.2.2.4 add/sub

```
1 mov r1, #10
2 add r2, r1, #4
3 sub r2, r1, #4
```

1 r1 4 r2
2 r1 4 r2

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CPU addrA+4 e2812004 add r2, r1, #4 CPU R2 14
CPU addrA+8 e2412004 sub r2, r1, #4 CPU R2 6

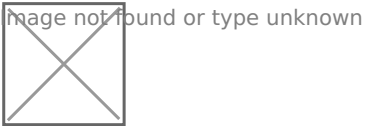
e2812004 ADD

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[19: 16] R1 1 [15: 12] R2 2 [11: 0] 4 0x004

e2412004 SUB



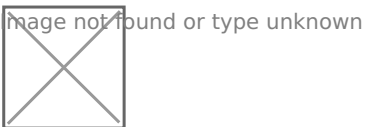
[19: 16] R1 1 [15: 12] R2 2 [11: 0] 4 0x004

5.2.2.5 ldr/str

```
1 mov r0, #400H @ 0x400
2 mov r1, #aH    @ 0xa
3 str r1, [r0]
4 ldr r2, [r0]
```

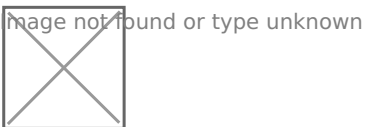
3 R1 0xa R0 0x400

4 R0 0x400 R2



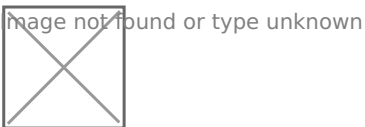
1. CPU addrA e3a00b01 mov r0, #400H
2. CPU addrA+4 e3a0100a mov r1, #aH
3. CPU addrA+8 e5801000 str r1, [r0]
4. CPU addrA+12 e5902000 ldr r2, [r0]
e5801000 STR

CPU R0 0x400
CPU R1 0xa
R1 0xa R0 0x400 0x400
R0 0x400 CPU R2 CPU



[19: 16] R0 0 [15: 12] R1 1

e5902000 LDR



[19: 16] R0 0 [15: 12] R2 2

```
ldr sp, =0x80200000
```

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ldr sp,=0x80200000

0x80200000

addrA+4

LDR

SP

0x80200000

ldr sp, [pc, #-4]

e51fd004

LDR

imm12[11: 0]

Rn

5.2.2.6 ldm/stm

ldm

stm

ldm{cond} Rn{! }, reglist

stm{cond} Rn{! }, reglist

cond

IA :

4

STMIA R0,{R1,LR}

R1

LR

IB :

4

DA :

4

STMDA R0,{R1,LR}

LR

R1

DB :

4

FD :

FA :

ED :

EA :

Rn

Rn

reglist , {R1,R2,R6-R9}

```
1 ldr r1,=0x10000000
2
3 ldmib r1!, {r0,r4-r6}
4 stmda r1!, {r0,r4-r6}
```

1 0x10000000 r1

3 ib 4

0X10000004 R0

0X10000008 R4

0X1000000C R5

0X10000010 R6

! R1 R1=0X10000010

4 da 4

R6 0X10000010

R5 0X1000000C

R4 0X10000008

R0 0X10000004

! R1 R1=0X10000000

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```
1 ldr sp,=0x80200000
2
3 stmfd sp!, {r0-r2} @
```

```
4 ldmfd sp!, {r0-r2} @
```

1 0x80200000 sp

3

R2 0X80200000

R1 0X801FFFFC

R0 0X801FFFF8

4

0X801FFFF8 R0

0X801FFFFC R1

0X80200000 R2

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3 4

push pop

```
1 ldr sp,=0x80200000
```

```
2
```

```
3 push {r0-r2} @
```

```
4 pop {r0-r2} @
```

5.3

5.3.1

0~F

0x

H

0xA AH

0~9 D

10 10D

0~7 0 O

012 12O

0~1 0b B

0b1010 1010B

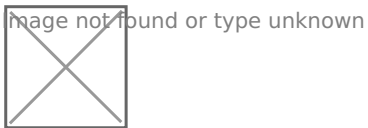
5.3.2 C

```
:int a = 0xA;    // 0x
: int a = 10;
: int a = 012;    // 0
: int a = 0b1010; // 0b
```

5.3.3

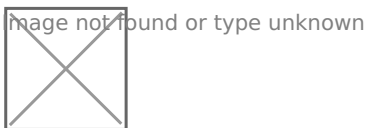
2/16 8 4 2 1 —>

0b01101110101



0x375

0xABC1



1010 1011 1100 0001

5.4 /

5.4.1 /

Big-endian

Little-endian

0x12345678 /

addr+3	0x78	0x12
addr+2	0x56	0x34
addr+1	0x34	0x56
addr	0x12	0x78

5.4.2

5.4.2.1

```
1 int a = 0x6; // 0b0110
2 int b = a<<1;
3 int c = a>>1;
```

2 a 0b0110->0b1100 b=0xC

3 a 0b0110->0b0011 b=0x3

5.4.2.2

```
1 int a = 0x6; // 0b0110
2 int b = ~a;
```

2 a 0b0110->0b1001 b=0x9

5.4.2.3

1 1

```

1 int a = 0x6; //    0b0110
2 int b = 0x7; //    0b0111
3
4 int c = a&b;

```

4 a&b 0b0110 c=0x6

5.4.2.4

1 1

```

1 int a = 0x6; //    0b0110
2 int b = 0x7; //    0b0111
3
4 int c = a|b;

```

4 a|b 0b0111 c=0x7

5.4.2.5

```

1 int a = 0x6;      //    0b0110
2
3 int a |= (1<<3);

```

3 a bit3 1 1<<3 = 0b1000 0b1000|0b0110=0b1110 a=0xe

5.4.2.6

```

1 int a = 0x6;      //    0b0110
2
3 int a &= ~(1<<2);

```

3 a bit2 ~(1<<2) = 0b1011 0b1011&0b0110=0b0010 a=0x2

5.5 C

C ARM ATPCS ATPCS

:

- ATPCS.pdf
- The ARM-THUMB Procedure Call Standard
- : 00_UserManual\ \Arm \ ATPCS(ATM-Thumb).pdf
- :

5.5.1 ATPCS

ATPCS ARM-THUMB procedure call standard ARM-Thumb ARM THUMB

R0~R15 ATPCS

- R0~R3 R0~R3
- R4~R11
- R12 scratch
- R13 SP R13 SP
- R14 LR R14
- R15 PC

5.5.2 C

- 4 R0~R3
- 4

5.5.3 C

- 32 R0
- 64 R0 R1 .
- f0 d0 s0
- f0-fN d0~dN
-

5.5.4 C

- /
- /

CPU R0~R3 LR

, CPU

push

pop

•

4

4

4

5.6 C

volatile

CCM_CCGR1

32

unsigned int *

```
volatile unsigned int *CCM_CCGR1 = (volatile unsigned int *) (0x20C406C);
```

```
val = *CCM_CCGR1;          //  
*CCM_CCGR1 |= (3<<30);    //      CCM_CCGR1    [ 31 30]  1
```

5.7 start.S

```
2 .text  
3 .global _start  
4 _start:
```

- 2 .text
- 3 .global _start
- 4 _start _start ENTRY C main() _start

```
@      _start  
4 _start:  
5  
6 //  
7 ldr sp,=0x80200000  
8  
9 bl clean_bss  
10
```

```

11 bl main
12
13 halt:
14 b halt

```

- 7 0x80200000 sp C /
- 9 clean_bss clean_bss bl main lr
- 11 C main() b halt lr
- 13 halt
- 14 halt b halt

```

@ clean_bss
16 clean_bss:
17 /* BSS */
18 ldr r1, =__bss_start
19 ldr r2, =__bss_end
20 mov r3, #0
21 clean: @ R1 R2
22 str r3, [r1]
23 add r1, r1, #4
24 cmp r1, r2
25 bne clean
26
27 mov pc, lr @

```

- 16 clean_bss BSS BSS 0
- 18 bss r1
- 19 bss r2
- 20 0 r3 r3=0
- 21 clean
- 22 r3 r1
- 23 r1 4 r1 r1 = r1+4
- 24 r1 r2
- 25 r1 r2 clean
- 26 r1 r2 bl main

5.8 led.dis

```

led.dis      imx6ull      led.bin      DDR

imx6ull      bootRom

```

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bootRom

- 1. bootRom EMMC TF 4K RAM
- 2. bootRom DCD DDR
- 3. bootRom IVT EMMC TF led.bin DDR 0x80100000
- 4. DDR 0x80100000

led.bin CPU 0x80100000 32 /4 led.bin led.l

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/ e59fd028 ldr sp,=0x80200000

00000000	28
00000001	d0
00000002	9f
00000003	e5

imx6ARM bin objdump led.dis :

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led.dis 1.7 start.S

1)	CPU	0x80100000	e59fd028	ldr sp, [pc, #40]	Start.S	ldr sp,=0x80200000
----	-----	------------	----------	-------------------	---------	--------------------

80100000:	e59fd028	ldr sp, [pc, #40] ; 80100030 <clean+0x14>
-----------	----------	---

2. 0x80100004 eb000001 bl 80100010 Start.S bl clean_bss

80100004:	eb000001	bl 80100010 <clean_bss>
....		
80100010	<clean_bss>	
80100010:	e59f101c	ldr r1, [pc, #28] ; 80100034 <clean+0x18>

80100014: e59f201c ldr r2, [pc, #28] ; 80100038 <clean+0x1c>

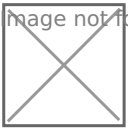
3.	0x80100010	e59f101c	ldr r1, [pc, #28]	Start.S	ldr r1, =__bss_start
4.	clean_bss	CPU	4	mov pc, lr	0x80100008 fa000057
	CPU	C	main()		
	C		main()		

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1. main() R7 LR / main() R7

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2.	led_init()	BL	bl 8010003c		
3.	led_ctl(1)	R0	movs r0, #1	BL	bl 801000f8
4.	delay(1000000)	R0	BL		
5.	led_ctl(0)	R0	BL		
6.	delay(1000000)	R0	BL		
7.	while(1)	B	b.n 80100174	0x80100174	led_
	main()		led_init() led_ctl() delay()		

Revision #1

Created 3 March 2022 02:35:35 by

Updated 3 March 2022 02:35:51 by