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Loongson Technology Corporation Limited

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龙芯中科技术股份有限公司

Loongson Technology Corporation Limited



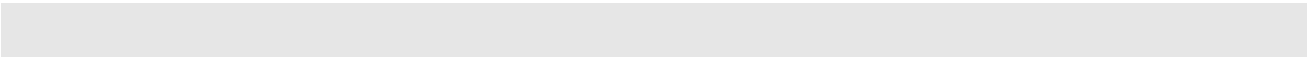
32 r



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2020/09/17



0.90 r
0.91 r
1.00 r

1) 3.2.3
convertToIntegerExact ñ roundToIntegralExact r
1.01 2) CSR r

1) 2.2.3 ¶ 2.2.5.1 ¶ 3.2.5
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1) 0"

1.02



	PC 2) 2.1.5 3) 2.2.1.10 MULH.WU U 4) 3.1.4.4 2Emin Emin 5) 3.2.4.6 MOVCF2FR 3.2.4.7 MOVCF2GR 0 0 6) 3.2.6.1 32 7) 4.2.3.3 4.2.3.4 TLB CSR.TLBIDX.NE 1 TLB TLB 8) 5.2.1 9) 5.4.3.4 N INVTLB r0, r0 N INVTLB 0, r0, r0 10) 5.4.4 found_ppn 11) 6.2.2 12) 7.4.1 7-2 DATF DATM N n n n n n 13) 7.6.1 RDTIME RDCNTID 14) GRLEN 32
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	6-1-0	5/
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6-5-1		SBEF	6/
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6-5-3		SHBKQ	60
7	@		62
7-0			62
7-1			64
7-1-0			65
7-1-1			65
7-1-2			65
7-1-3			65
7-1-4			66
7-1-5			66
7-1-6			66
7-1-7			66
7-1-8			66
8	A		68



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B H W BU HU WU
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ADD.W	ADD.D	BLT[U]	BLT	BLTU
ADD[I].{W/D}	ADD.W 4	ADD.D 4	ADDI.W	ADDI.D
				r
				r

1.4.2

32	Control and Status Register	CSR
CSR	r	CSR.%%%.####
%%%	####	r CSR.CRMD.PLV CRMD
PLV	r	



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2.1.2.1





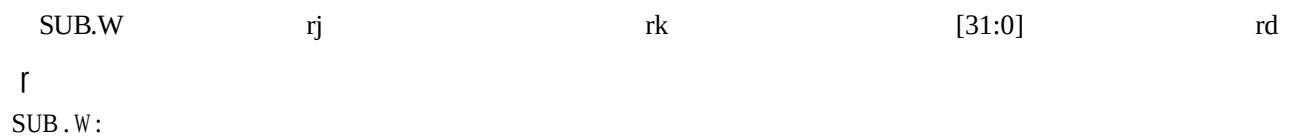
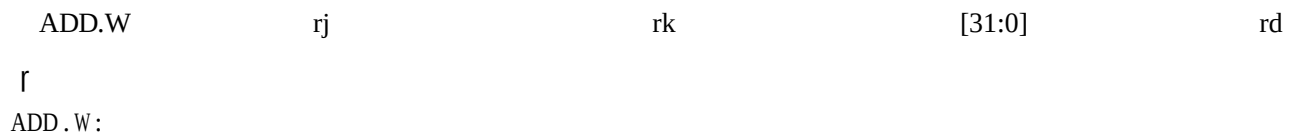


2.2

2.2.1

2.2.1.1 ADD.W, SUB.W

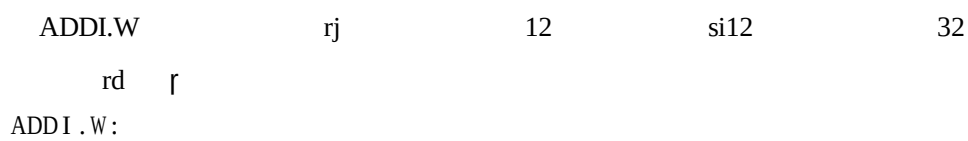
add.w rd, rj, rk
sub.w rd, rj, rk



r

2.2.1.2 ADDI.W

addi.w rd, rj, si12



r

2.2.1.3 LU12I.W

lu12i.w rd, si20



LU12I.W 20 si20 12 0 rd r
LU12I.W:

ORI 12 r

2.2.1.4 SLT[U]

slt rd, rj, rk

sltu rd, rj, rk

SLT rj rk
rd 1 0 r

SLT:

SLTU rj rk
rd 1 0 r

SLTU:

SLT SLTU r

2.2.1.5 SLT[U]I

slti rd, rj, si12

sltui rd, rj, si12

SLTI rj 12 si12
rd 1 0 r

SLTI:

SLTUI rj 12 si12
rd 1 0 r

SLTUI:



SLTI SLTUI r

SLTUI r

2.2.1.6 PCADDU12I

pcaddu12i rd, si20

PCADDU12I 20 si20 12 0 PC

rd r

PCADDU12I :

r

2.2.1.7 AND, OR, NOR, XOR

and rd, rj, rk

or rd, rj, rk

nor rd, rj, rk

xor rd, rj, rk

AND rj rk

rd r

AND :

OR rj rk rd

r

OR :

NOR rj rk

rd r

NOR :

XOR rj rk





MUL.W rj rk [31:0]
rd r
MUL.W:

MULH.W rj rk [63:32]
rd r
MULH.W:

MULH.WU rj rk
[63:32] rd r
MULH.WU:

2.2.1.11 DIV.W[U], MOD.W[U]

div.w rd, rj, rk
mod.w rd, rj, rk
div.wu rd, rj, rk
mod.wu rd, rj, rk

DIV.W DIV.WU rj rk rd
r
DIV.W:

DIV.WU:





rk [4:0]

r

2.2.2.2 SLLI.W, SRLI.W, SRAI.W

slli.w rd, rj, ui5

srli.w rd, rj, ui5

srai.w rd, rj, ui5

SLLI.W rj rd r

SLLI.W:

SRLI.W rj rd r

SRLI.W:

SRAI.W rj rd r

SRAI.W:

5 ui5 r

2.2.3

2.2.3.1 BEQ, BNE, BLT[U], BGE[U]

beq rj, rd, offs16

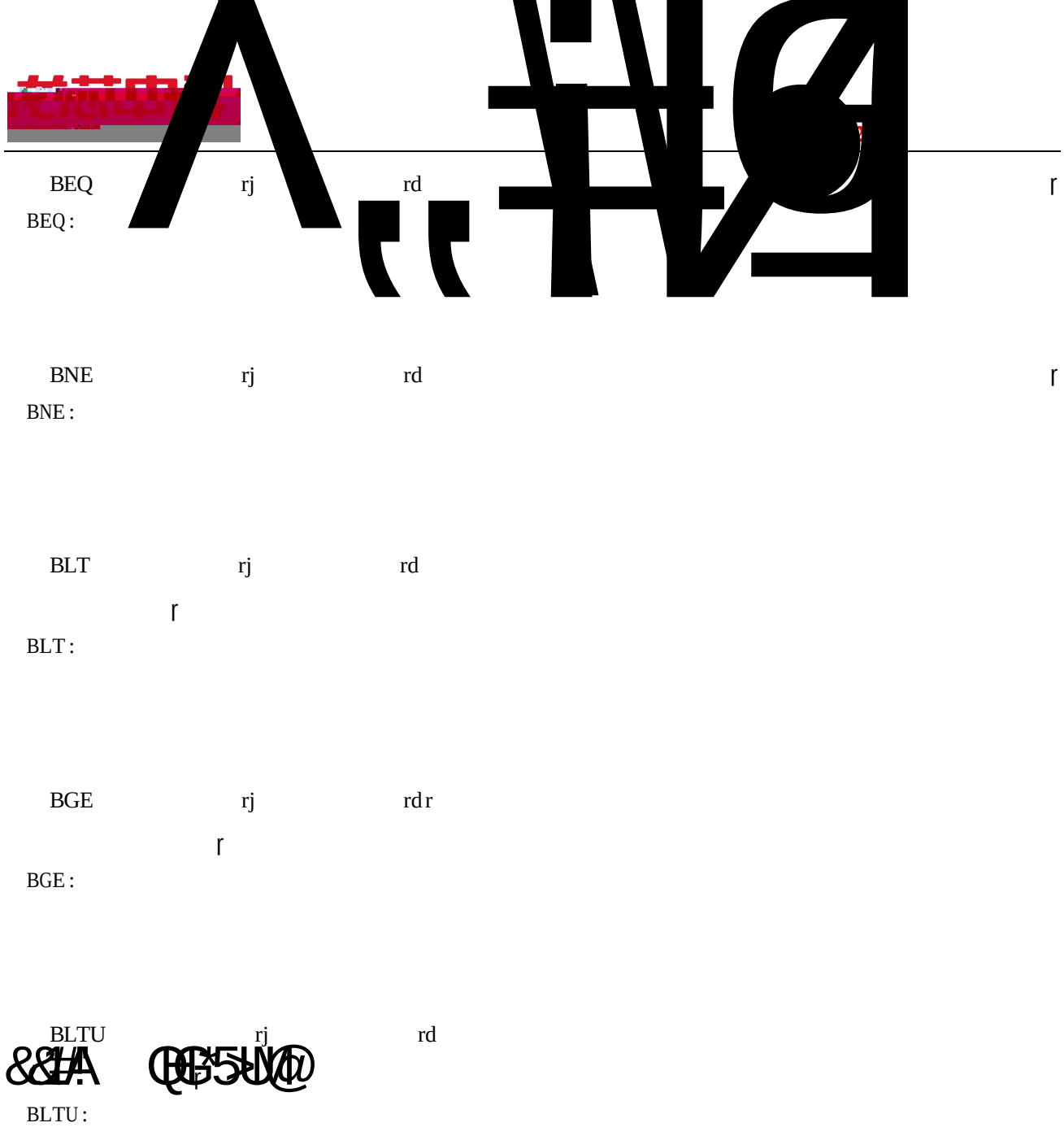
bne rj, rd, offs16

blt rj, rd, offs16

bge rj, rd, offs16

bltu rj, rd, offs16

bgeu rj, rd, offs16





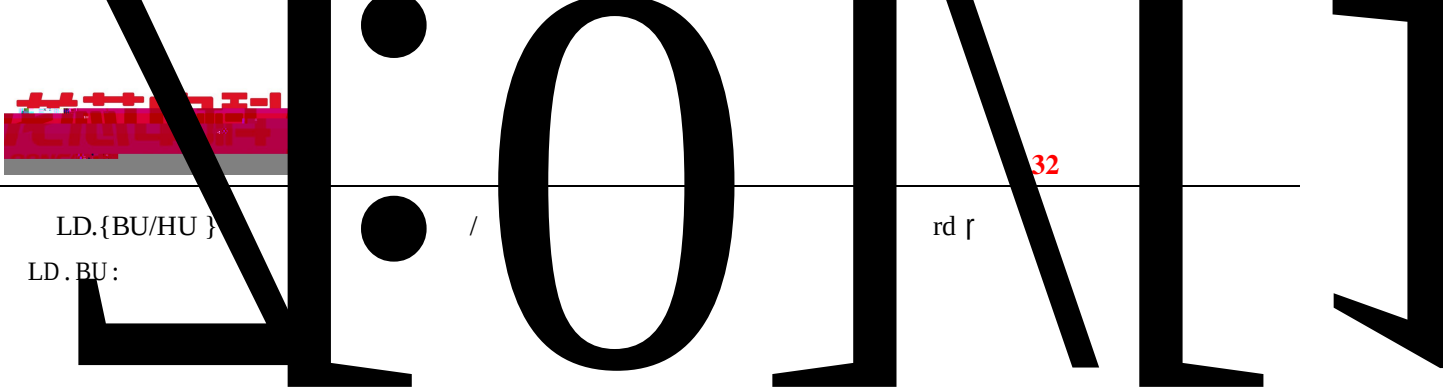


2.2.4

2.2.4.1 LD.{B[U]/H[U]/W}, ST.{B/H/W}

ld.b rtj, sml2GE

re A



LD.{BU/HU } / rd r
LD.BU:

LD.HU:

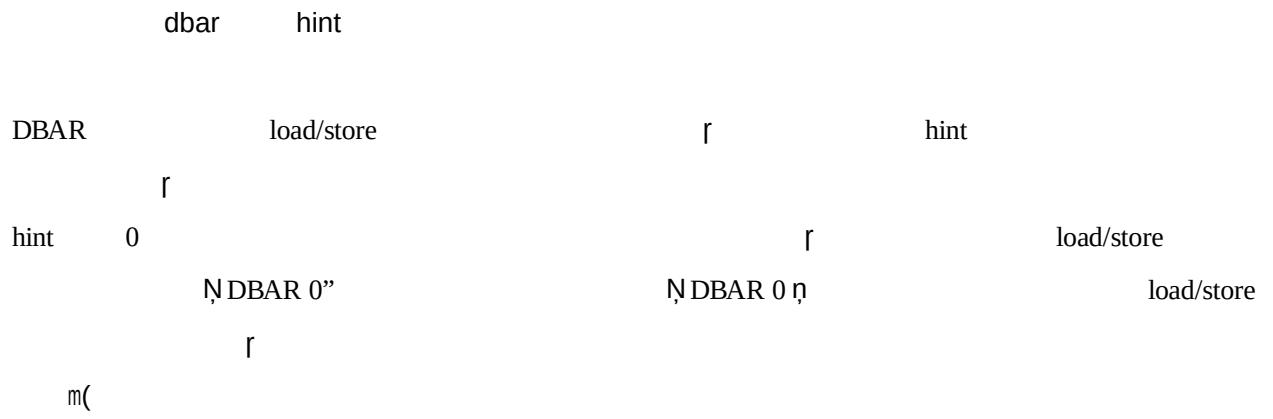
ST.{B/H/W} rd
ST.B:

ST.H:



2.2.6

2.2.6.1 DBAR





2.2.7.3 RDCNTV{L/H}.W, RDCNTID

rdcntvl.w	rd
rdcntvh.w	rd
rdcntid	rj

Counter	0	1	64	1 4÷	r
Stable Counter	0	1	64	1 4÷	r



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IEEE 754-2008

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3-1

	E@CC-R+ ERTA-R+ ELTK-R+ ECHU-R+ EL@CC-R+ ELRTA-R+ EML@CC-R+ EMLRTA-R+ EL@W-R+ ELHM-R+ EL@W@-R+ ELHM@-R+ E@AR-R+ EMDF-R+ ERPQS-R+ EQDBHO-R+ EQRPQS-R+ EBNOXRHFM-R+ EBK@RR-R
	EBLO-bnmc-R
	EEHMS-R-V+ ESHMS-V-R+ ESHMSQL-V-R+ ESHMSQO-V-R+ ESHMSQY-V-R+ ESHMSQMD-V-R+
	ELNU-R+ ERDK+ LNUFQ1EQ-V+ LNUEQ1FQ-R+ LNUFQ1EBRQ+ LNUEBRQ1FQ+ LNUEQ1BE+ LNUBE1EQ+ LNUFQ1BE+ LNUBE1FQ
	ABDPY+ ABMDY
	EKC-R+ ERS-R R

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Logson Technology Corporation Limited



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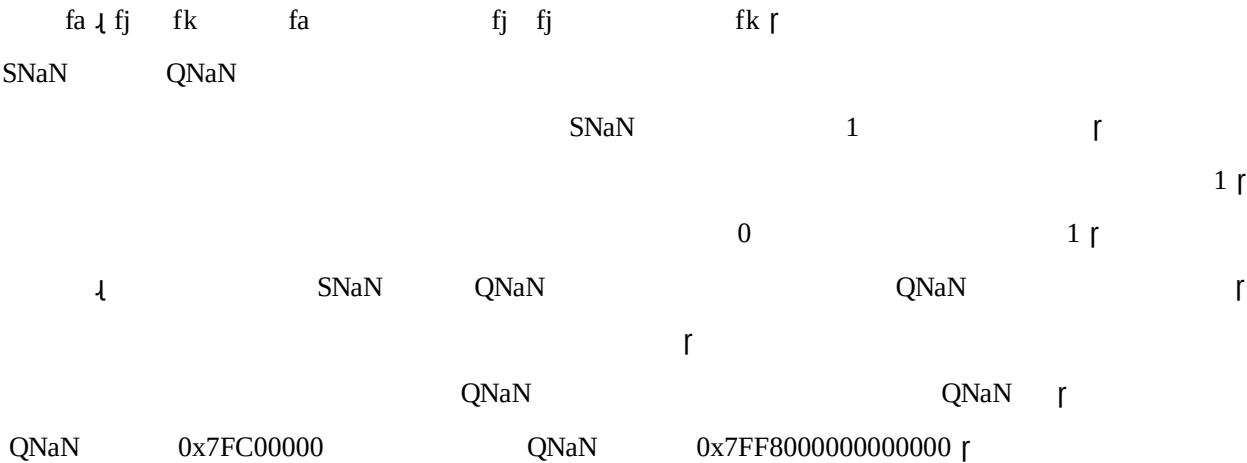
64

S	Exponent	Fraction
1	1	1
2	2	1
3	3	1
4	4	1
5	5	1
6	6	1
7	7	1
8	8	1
9	9	1
10	10	1
11	11	1
12	12	1
13	13	1
14	14	1
15	15	1
16	16	1
17	17	1
18	18	1
19	19	1
20	20	1
21	21	1
22	22	1
23	23	1
24	24	1
25	25	1
26	26	1
27	27	1
28	28	1
29	29	1
30	30	1
31	31	1
32	32	1
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90	90	1
91	91	1
92	92	1
93	93	1
94	94	1
95	95	1
96	96	1
97	97	1
98	98	1
99	99	1
100	100	1

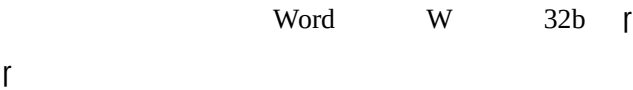
3-3

3-3

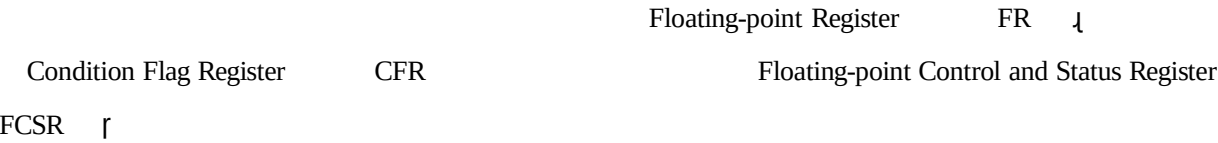
Z0+ /w6ED\



3.1.2



3.1.3



3.1.3.1



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FR r

	⋮
f0	⋮
f1	⋮
f2	⋮
f3	⋮
	⋮
f30	⋮
f31	⋮



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63 32

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3.1.3.2

CFR

1

fcc0

r CFR

1

r

1

0 r

r

3.1.3.3

FCSR

4

fcsr0~fcsr3

32

r

fcsr1~fcsr3

fcsr0

fcsr1~fcsr3

fcsr0

r

fcsr1~fcsr3

fcsr0

r fcsr0

3-4

r

3-4 FCSR0

39/	Dm`akdr	QV	UYNTH 3 U 2 Y 1 N 0 T / H r
694	/	Q/	r / r
897	QL	QV	r 3 / QMD HDDD 643,1//7 qntmcShdrSnDudm 0 QY HDDD 643,1//7 qntmcSnv`qcYdq 1 QO HDDD 643,1//7 qntmcSnv`qcrOnrshud 2 QL HDDD 643,1//7 qntmcSnv`qcrMdf`shud r
0490/	/	Q/	r / r
1/905	Ek`fr	QV	Ek`fr UYNTH 1/ U 08 Y 07 N 06 T 05 H r
12910	/	Q/	r / r
17913	B`trd	QV	UYNTH 17 U 16 Y 15 N 14 T 13 H r
20918	/	Q/	r / r

FCSR1

FCSR0

Enables

r

FCSR0

r

FCSR2

FCSR0

Cause Flags

r

FCSR0

r

FCSR3

FCSR0

RM

r

FCSR0

r

i SR2

[illegible]



Emin B 7 ~ 7



3.2

3.2.1

3.2.1.1 F{ADD/SUB/MUL/DIV}.{S/D}

	fadd.s	fd, fj, fk		fadd.d	fd, fj, fk
	fsub.s	fd, fj, fk		fsub.d	fd, fj, fk
	fmul.s	fd, fj, fk		fmul.d	fd, fj, fk
	fdiv.s	fd, fj, fk		fdiv.d	fd, fj, fk
	FADD.{S/D}	fj /		fk /	
		/		fd r	IEEE 754-2008
addition(x,y)		r			
FADD.S:					
FADD.D:					
	FSUB.{S/D}	fj /		fk /	
		/		fd r	IEEE 754-2008
subtraction(x,y)		r			
FSUB.S:					
FSUB.D:					
	FMUL.{S/D}	fj /		fk /	
		/		fd r	IEEE 754-2008
multiplication(x,y)		r			
FMUL.S:					
FMUL.D:					
	FDIV.{S/D}	fj /		fk /	
		/		fd r	IEEE 754-2008
division(x,y)		r			



FDIV.S:

FDIV.D:

3.2.1.2 F{MADD/MSUB/NMADD/NMSUB}.{S/D}

fmadd.s	fd, fj, fk, fa	fmadd.d	fd, fj, fk, fa
fmsub.s	fd, fj, fk, fa	fmsub.d	fd, fj, fk, fa
fnmadd.s	fd, fj, fk, fa	fnmadd.d	fd, fj, fk, fa
fnmsub.s	fd, fj, fk, fa	fnmsub.d	fd, fj, fk, fa

FMADD.{S/D}	fj	/	fk	/
	fa	/		/

fd r

FMADD.S:

FMADD.D:

FMSUB.{S/D}	fj	/	fk	/
	fa	/		/

fd r

FMSUB.S:

FMSUB.D:

FNMADD.{S/D}	fj	/	fk	/
	fa	/		/

fd r

FNMADD.S:

FNMADD.D:



FNMSUB.{S/D}

fj

/

fk

/



FMINA.{S/D}

fj

/

fk

/

fd

r

IEEE 754-2008

minNumMag(x,y)

r

FMINA.S:

FMINA.D:

3.2.1.5 F{ABS/NEG}.{S/D}

fabs.s

fd, fj

fabs.d

fd, fj

fneg.s

fd, fj

fneg.d

fd, fj

FABS.{S/D}

fj

/

0

fd r

IEEE 754-2008

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" or

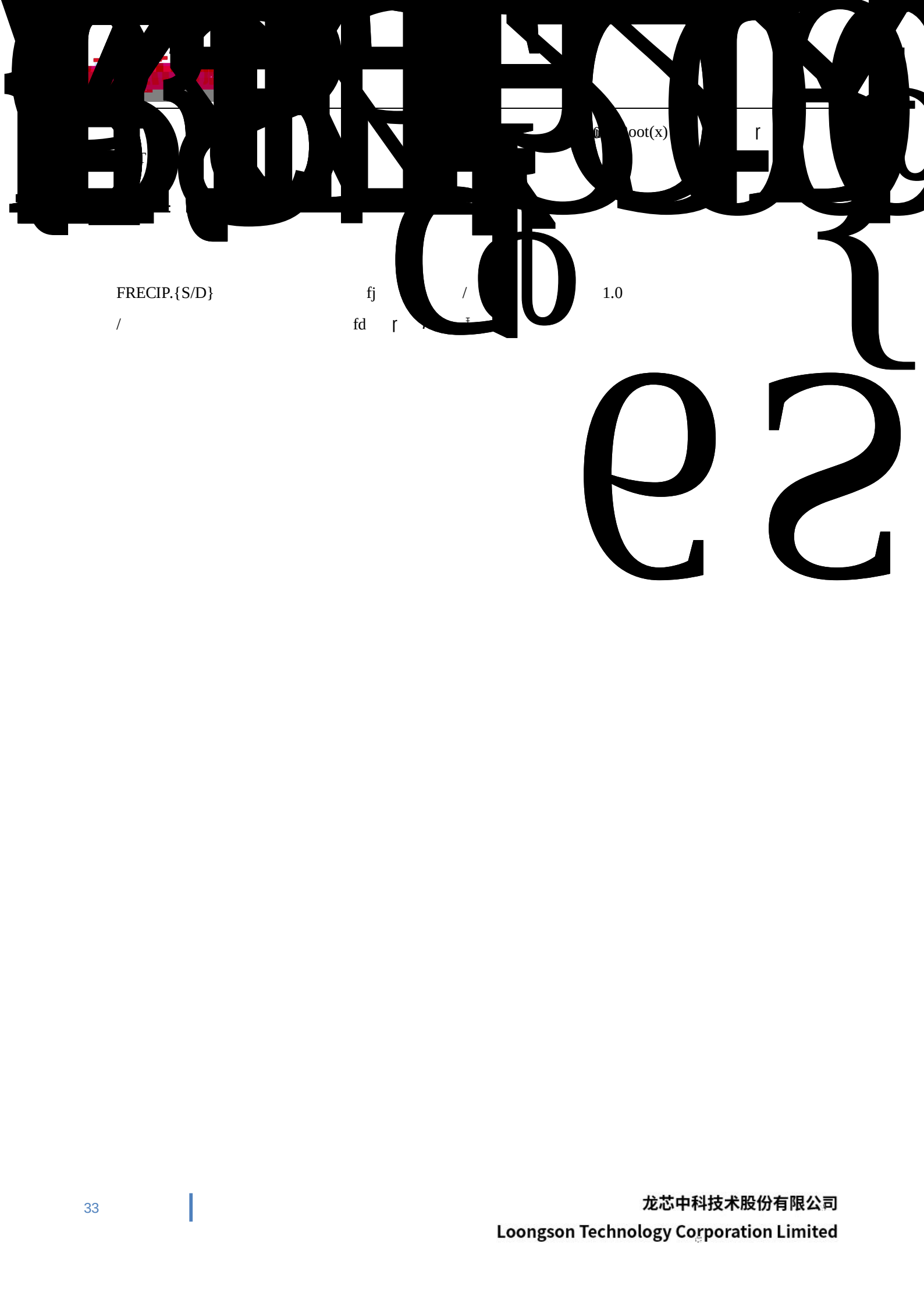
FABS.S:

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B



FRECIP.{S/D}

/

fj

/

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fd

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RM`M	PM`M	mdf`shud u`ktd				onrshud u`ktd			
		Ÿ	mnq l`k	rtamq l`k	/	Ÿ	mnq l`k	rtamq l`k	/





1 r

IEEE-754-2008 class(x) r

FCLASS.S:

FCLASS.D:

3.2.2

3.2.2.1 FCMP.cond.{S/D}

fcmp.cond.s cc, fj, fk

fcmp.cond.d cc, fj, fk

cc r cond 22

r

bnmc

Sqtd
Bnmchshnm

PM`M

HDDD 643,1//7

B@E /w/

BTM /w7

BDP /w3

BTDP /wB

TM

DP

bn l o`qdP thdsTmnqcdqdc

bn l o`qdP thdsDpt`k



3.2

3.2.3. FCVT.S.D, FCVT.D.S

fcvt.s.d

fd, fj

fcvt.d.s

fd, fj

FCVT.S.D

fj

fd r

FCVT.S.D:

7)

FCVT.D.S

fj

m" l

fd r

FCVT.D.S:

)5>l G

IEEE 754-2008

convertFormat(x)

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3.2.3.2 FFINT.{S/D}.{W/L}, FTINT.{W/L}.{S/D}

ffint.s.w

fd, fj

ftint.w.s

fd, fj

ffint.s.l

fd, fj

ftint.l.s

fd, fj

ffint.d.w

fd, fj

ftint.w.d

fd, fj

ffint.d.l

fd, fj

ftint.l.d

fd, fj

FFINT.{S/D}.{W/L}

<0?0*Å*Y fj

/

/

/

f p:e G

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/ fd , N n r
FTINTRP.W.S:

FTINTRP.W.D:

FTINTRP.L.S:

FTINTRP.L.D:

FTINTRZ.{W/L}.{S/D} fj / /
/ fd N n r
FTINTRZ.W.S:

FTINTRZ.W.D:

FTINTRZ.L.S:

FTINTRZ.L.D:

FTINTRNE.{W/L}.{S/D} fj / /
/ fd N n r
FTINTRNE.W.S:

FTINTRNE.W.D:

FTINTRNE.L.S:

FTINTRNE.L.D:

IEEE 754-2008

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	HDDD 643,1//7
ESHMSQMD-zV.K -zR.C	bnmudqsSnHmsdfdqDw`bsShdrSnDudm'w(
ESHMSQY-zV.K -zR.C	bnmudqsSnHmsdfdqDw`bsSnv`qcYdq'n'w(
ESHMSQO-zV.K -zR.C	bnmudqsSnHmsdfdqDw`bsSnv`qcOnrishiud'w(
ESHMSQL-zV.K -zR.C	bnmudqsSnHmsdfdqDw`bsSnv`qcMdf`shud'w(



3.2.4

3.2.4.1 FMOV.{S/D}

fmov.s		fd, fj		fmov.d		fd, fj													
FMOV.{S/D}		fj		/		fd		fj											
/				r															
FMOV.S																			
FMOV.d																			
IEEE 754																			
Cause										Flags									
r																			

3.2.4.2 FSEL

fsel		fd, fj, fk, ca	
FSEL		r FSEL	
		ca	0
fd		fk	fj
		fd	r
FSEL			

3.2.4.3 MOVGR2FR.W, MOVGR2FRH.W

movgr2fr.w		fd, rj					
movgr2frh.w		fd, rj					
MOVGR2FR.W	rj	fd	32	r	64	fd	
32	r						
MOVGR2FR.W							
MOVGR2FRH.W	rj	fd	32	fd	32	r	
MOVGR2FRH.W							



3.2.4.4 MOVFR2GR.S, MOVFRH2GR.S

movfr2gr.s rd, fj
movfrh2gr.s rd, fj

MOVFR2GR/MOVFRH2GR.S fj 32 / 32 rd r
MOVFR2GR.S
MOVFRH2GR.S

3.2.4.5 MOVGR2FCSR, MOVFCSR2GR

movgr2fcsr fcsr, rj
movfcsr2gr rd, fcsr

MOVGR2FCSR rj fcsr r
MOVGR2FCSR FCSR0 Cause Enables 1 FCSR1
Enables 1 FCSR2 Cause Cause Enables 1 MOVGR2FCSR
r
MOVGR2FCSR

MOVFCSR2GR fcsr 32 rd r
MOVFCSR2GR

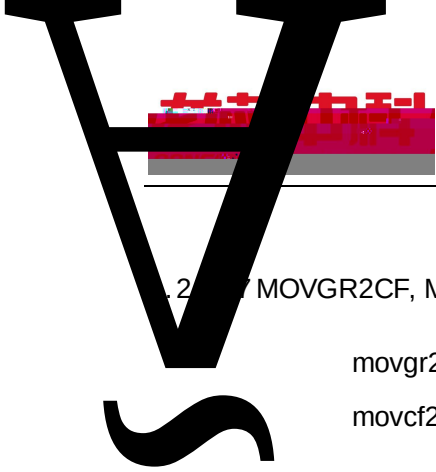
fcsr r

3.2.4.6 MOVFR2CF, MOVCF2FR

movfr2cf cd, fj
movcf2fr fd, cj

MOVFR2CF fj cd r
MOVFR2CF

MOVCF2FR cj fd fd 0 r
MOVCF2FR



3.2.5.1 MOVGR2CF, MOVCF2GR

movgr2cf cd, rj
movcf2gr rd, cj

MOVGR2CF rj cd r
MOVGR2CF

MOVCF2GR cj rd rd 0 r
MOVCF2GR

3.2.5

3.2.5.1 BCEQZ, BCNEZ

bceqz cj, ofs21
bcnez cj, ofs21

BCEQZ cj 0 r
BCNEZ cj 0 C r
21 ofs21 2
PC r

j b



3.2.6

3.2.6.1 FLD.{S/D}, FST.{S/D}

fld.s fd, rj, si12







4.2.2 Cache

4.2.2



NE 1 r
TLB



4.2.3.5 INVTLB

invtlb op, rj, rk

INVTLB TLB TLB r

op 5 r

rj [9:0] ASID N ASID"

0 r op ASID rj r0 r

rk N VA n r op

rk r0 r

op op r

no	
/w/	r
/w0	r no</ r
/w1	F<0 r
/w2	F</ r
/w3	F</ @RHC @RHC r
/w4	F</ @RHC @RHC U@ U@ r
/w5	F<0 @RHC @RHC U@ U@ r

4.2.4

4.2.4.1 ERTN

ertn

ERTN r

PPLV j PIE CSR.CRMD ERA r

PPLV j PIE CSR.PRMD ERA CSR.ERA r

ERTN CSR.LLBCTL KLO 1 LLbit 0 LLbit r

4.2.4.2 IDLE

idle level

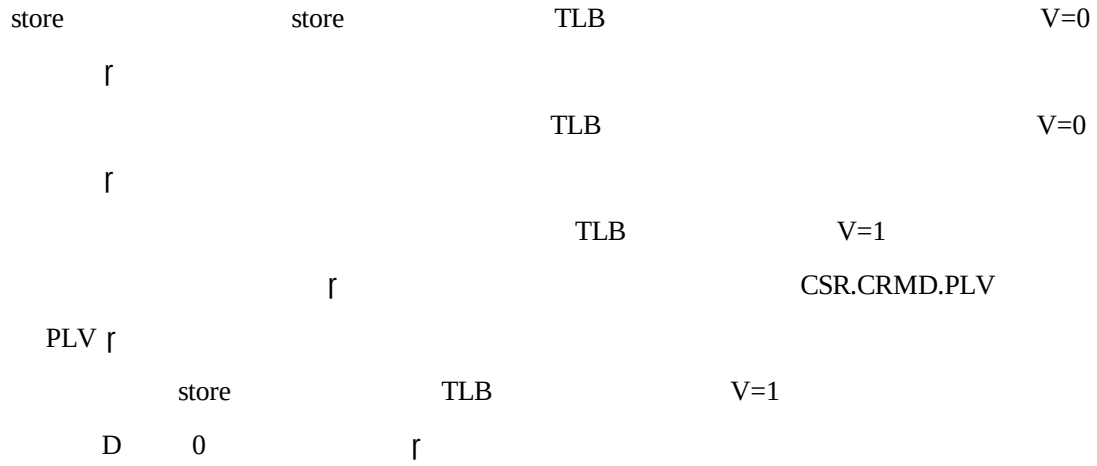
IDLE r

IDLE r

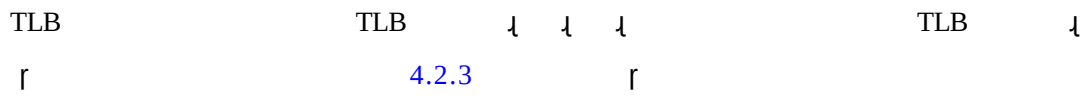
环

G)

环



5.4.3.2 TLB



5.4.3.3 TLB CSR



BADV
TLBEHI
TLBELO0
TLBELO1
TLBIDX
ASID

PGDL
PGDH
PGD

TLBRENTY



5.4.3.4 TLB





5.4.4 TLB

```

                                TLB                                r
# va:
# mem_type:          FETCH          LOAD    load          STORE    store
# plv                CSR.CRMD.PLV
# pa:
# mat:
# VALEN:
# PALEN:
# TLB[]: TLB[N]      TLB      N
# TLB_ENTRIES: TLB

#      TLB
```

#

TLB

#





6.1.1





1. 1. 1.

6.2.3 1.

6.2

6.2.1

TLB CSR.TLBREENTRY 1 CSR.EENTRY 1 CSR.ESTA
Ecode 1 IS 1

6.2.2

1
TLB 1
1
(ALE) > TLB ¹ 1

6.2.3

1
CSR.CRMD PLV 1 IE CSR.PRMD PPLV 1 PIE CSR.CRMD PLV
0 IE 0
PC CSR.ERA
1
ERTN
CSR.PRMD PPLV 1 PIE CSR.CRMD PLV 1 IE
CSR.ERA 1
CSR.PRMD PPLV 1
PIE CSR.PRMD 1

¹ TLB

TLB 1



6.3

PC 0x1C000000 r MMU r



7

7.1

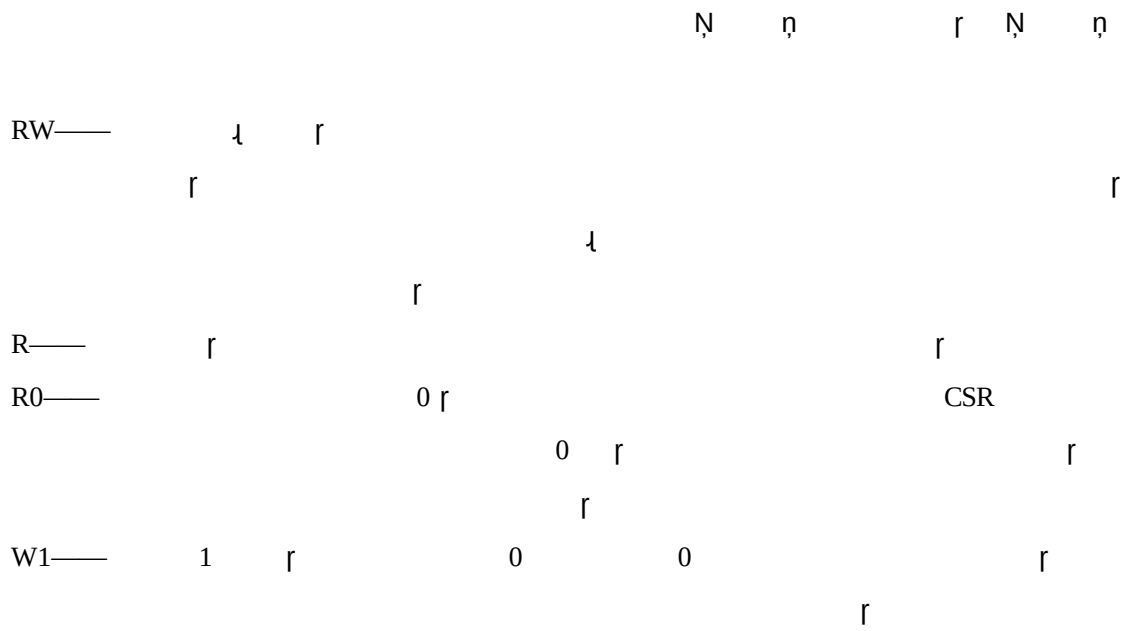
7-1

/w/		BQLC
/w0		OQLC
/w1		DTDM
/w3		DBEF
/w4		DRS@S
/w5		DQ@
/w6		A@CU
/wb		DDMSQX
/w0/	SKA	SKAHCW
/w00	SKA	SKADGH
/w01	SKA	/ SKADKN/
/w02	SKA	0 SKADKN0
/w07		@RHC
/w08		OFCK
/w0@		OF CG
/w0A		OFC
/w1/		BOTH C
/w2/ } /w22		R@UD/ } R@UD2
/w3/		SH C
/w30		SBEF
/w31		SU@K
/w33		SHBKQ
/w5/	KKALts	KKABSK
/w77	SKA	SKAQDMSQX
/w87		BS@F
/w07/ } /w070		CL V / } CL V0



7.2

7.2.1



7.2.2



7.3

7.4

7.4.1

CRMD







7.4.2 PRMD

r
7-3

09/	OOKU	QV	BRQ-BQLC OKU DQSM r BRQ-BQLC OKU
1	OHd	QV	BRQ-BQLC HD DQSM r BRQ-BQLC HD
2002	/	Q/	r / r

7.4.3 EUEN

r
r

r
r

7-4

/	EOD	(#B± 7PQW3 €	r / 2-1 EOC r
2000	/	Q/	r / r

7.4.4 ECFG

r
7-5

89/ KHDZ89/\ QV r BRQ-DRS@S HRZ89/\ 0/
=G î £ D Ψ

Opnd	Drtn	Opnd	
/wB		AQJ	
/wC	/	HMD	
/wD	/	HOD	
/wE	/	EOC	
/w01	/	EOD	
/w0@ , /w2D			
/w2E	/	SKAQ	SKA

7.4.6 ERA

PC
7-8 r

209 /	OB	QV	OB r

7.4.7 BADV

r

TLB

ADEF PC

ALE

load PIL

store PIS

PIF

PME

1 L



7.4.8

EENTRY

TLB



1	JKN	QV	DQSM KKAhs r 0 DQSM KKAhs / / r JKN 0 DQSM r
20%2	/	Q/	r / r

7.5

7.5.1 TLB TLBIDX

TLB TLB r 7-14 Inde





019/	/	Q	/ r
2002	UOOM	QV	SKAQC SKA UOOM r SKARQBG SKA UOOM SKAVQ SKAEHKK SKA UOOM r SKA ¼kn`c ¼rsnqd ¼ ¼ Z2002\
			r

7.5.3 TLB TLBELO0, TLBELO1

TLBELO0 TLBELO1 TLB TLB r

32 TLB TLB

TLBELO0 TLBELO1 rTLBELO0 TLBELO1

7-16 r

TLBWR TLBFILL TLB G ¼PPN0 ¼V0 ¼PLV0 ¼MAT0 ¼D0 ¼PPN1 ¼V1 ¼PLV1 ¼

MAT1 ¼D1 TLBELO0 TLBELO1 r

TLBRD TLB TLBELO0 TLBELO1

r

7-16 TLB

/	U	QV	U r
0	C	QV	C r
201	OKU	QV	OKU r
403	L@S	QV	L@S r
5	F	QV	F r SKAEHKK SKAVQ SKADKN/ SKADKN0 F 0 SKA F 0 r SKAQC SKA F 0 SKADKN/ SKADKN0 F 0 r
6	/	Q	/ r
0@KDM, 407	OOM	QV	OOM r
2000@KDM, 3	/	Q	/ r 0@KDM<25 r





7.5.4

ASID

TLB

ASID

r ASID

ASID

r

7-17



7.5.7 PGD

CSR

7-20

009/	/	Q	/ r
2001	A`rd	Q	BRQ-A@CU / BRQ-OFCK A`rd BRQ-OFCK A`rd r

7.5.8 TLB TLBENTRY

TLB

TLB

7-21 TLB

49/	/	Q	SKA Z49/\ r / r
205	0@	QV	SKA Z205\ r r

7.5.9 DMW0~DMW1

5.2.1

7-22

/	OKU/	QV	0 OKU/ r
10	/	Q/	r / r
2	OKU2	QV	0 OKU2 r
43	L@S	QV	r
135	/	Q/	r / r
1614	ORDF	QV	Z2018\ r
17	/	Q/	r / r
2018	URDF	QV	Z2018\ r





7.6.4

TICLR



annkd`m

ahs

hmsdfdq

ahsr' $\mathcal{M}$

Ydqndwsdmc' _____+ $\mathcal{M}$

RhfmDwsdmc' _____+ $\mathcal{M}$

hrRM`M' _____(

M

M

M

rhfm`khmf M`M 4q

š

v

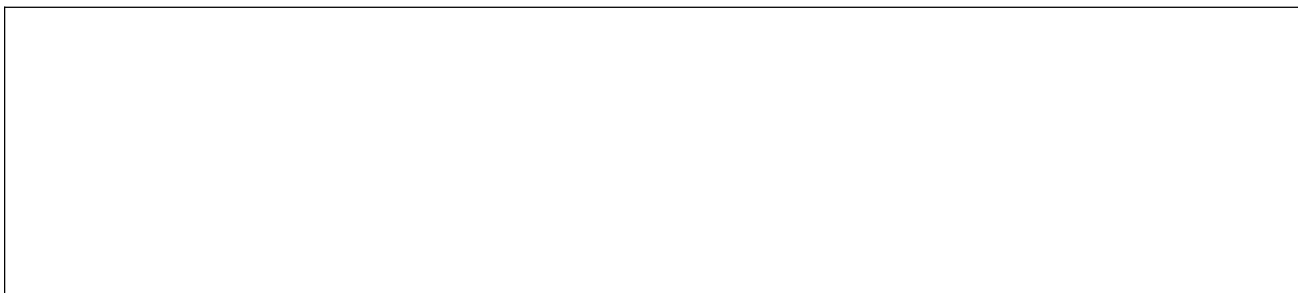
(w







8.2.1



8.2.2



8.2.3

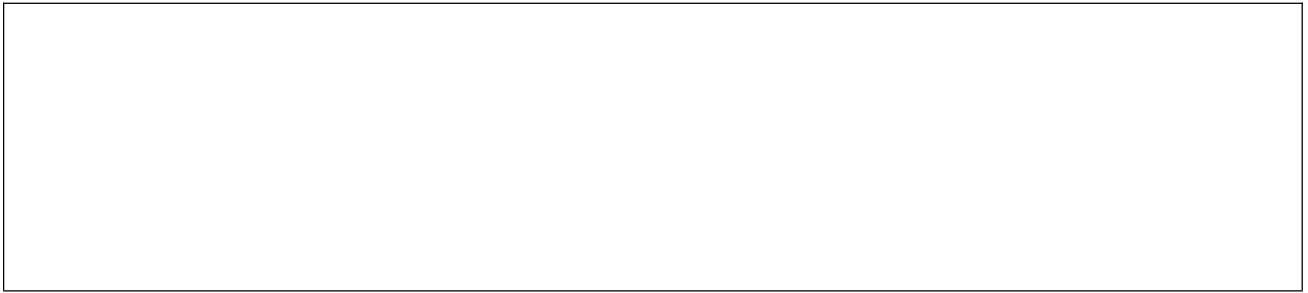


8.2.4





8.2.5



8.2.6



8.2.7

х 2

81

		2 2 2 2 2 2 1 1 1 1 1 1																				1 1 1 0 0 0 0 0 0 0 0 0																
		1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	2	1	0	9	8	7	6	5	4	3	2	1	0		
ST.W	rd, rj, si12	0	0	1	0	1	0	0	1	1	0												si12													rj		rd
LD.BU	rd, rj, si12	0	0	1	0	1	0	1	0	0	0												si12												rj		rd	
LD.HU	rd, rj, si12	0	0	1	0	1	0	1	0	0	1												si12												rj		rd	
PRELD	hint, rj, si12	0	0	1	0	1	0	1	0	1	1												si12												rj		hint	
FLD.S	fd, rj, si12	0	0	1	0	1	0	1	1	0	0												si12												rj		fd	
FST.S	rd, rj, si12	0	0	1	0	1	0	1	1	0	1												si12												rj		fd	
FLD.D	fd, rj, si12	0	0	1	0	1	0	1	1	1	0												si12												rj		fd	
FST.D	fd, rj, si12	0	0	1	0	1	0	1	1	1	1												si12												rj		fd	
DBAR	hint	0	0	1	1	1	0	0	0	0	1	1	1	0	0	1	0	0																	hint			
IBAR	hint	0	0	1	1	1	0	0	0	0	1	1	1	0	0	1	0																					