

微系统设计文档 (P7)

一、模块规格

1. Bridge(桥)

端口说明：

表 1 Bridge 端口说明

信号名	I/O	描述
PrAddr[31:0]	I	CPU 输出的 32 位地址
WeCPU	I	CPU 的 MEM 写使能
PrWD[31:0]	I	写入的数据
DEVO_RD[31:0]	I	Timer0 读出的数据
DEV1_RD[31:0]	I	Timer1 读出的数据
PrRD[31:0]	O	Bridge 读出的数据
DEV_WD[31:0]	O	向 timer 写入的数据
WeDEVO	O	Timer0 写使能
WeDEV1	O	Timer1 写使能
DEV_Addr[31:0]		写入的地址

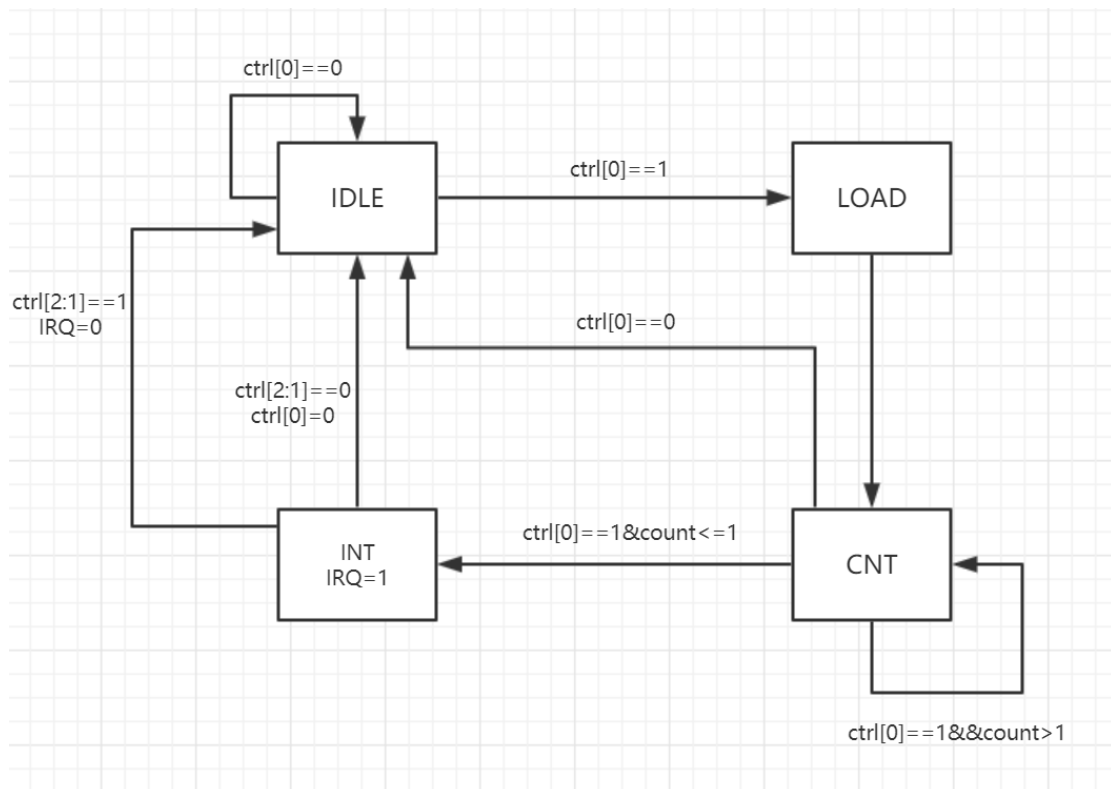
2. TC(计时器)

端口说明：

表 2 TC 端口说明

信号名	I/O	描述
Clk	I	时钟信号
reset	I	复位信号
Addr[31:2]	I	写入的地址
WE	I	计时器写使能
Din[31:0]	I	计时器写入的数据
Dout[31:0]	O	计时器读出的数据
IRQ	O	计时器中断信号

状态转移图：



计时器使用说明：

计时器内有三个寄存器，CTRL, PRESENT, COUNT

CTRL 是用来控制计时器的模式和使用，CTRL[2:1]选择模式 0 或 1，CTRL[0]是计时器使能，CTRL[3]是中断屏蔽位，控制寄存器决定该计数器启停控制，初值寄存器为 32 位计数器提供初始值，使用 store 类指令修改寄存器的优先级高于 timer 自身修改的优先级。

模式 0：

当计数器倒计时为 0 后，计数器停止计数，此时控制寄存器中的使能 CTRL[0]变为 0，当其再次被设置为 1 后，初值寄存器被再次加载到计数器，计数器重新启动倒计时。模式 0 用来产生定时中断，中断屏蔽位可以屏蔽中断。

模式 1：

当计数器计数为 0 后，初值寄存器被自动加载到计数器，计数器继续倒计时，模式 1 用来产生周期性脉冲，模式 1 下计数器每次计数循环只产生一周期的中断信号。

3. CP0(协处理器)

端口说明：

表 3 CP0 端口说明

信号名	I/O	描述
Instr_M[31:0]	I	M 级指令
Instr_W[31:0]	I	W 级指令
A1[4:0]	I	读 CP0 寄存器编号
A2[4:0]	I	写 CP0 寄存器编号
Din[31:0]	I	CP0 寄存器的写入数据
PC_M[31:0]	I	M 级的 PC 值
ExcCodein[6:2]	I	中断异常类型
HWInt[5:0]	I	外部设备中断源
We	I	CP0 写使能
EXLSet	I	EXL 置位信号
EXLClr	I	EXL 清除信号
Clk	I	时钟信号
Reset	I	复位信号
IntExc	O	中断异常信号
EPCout[31:0]	O	EPC 寄存器输出值
Dout[31:0]	O	CP0 寄存器输出值

二、测试程序

异常中断测试：

```
1.  
.ktext 0x4180  
mfc0 $28,$14  
addi $28,$28,12  
mtc0 $28,$14
```

```

eret
sw $28,0($0)
.text
ori $1,0x2ffc
jr $1
nop
j label
sw $1,1($0)
label:
ori $1,1
nop
nop
ori $4,4

```

期望输出:

```

@00003000: $ 1 <= 00002ffc
@00004180: $29 <= 00000010
@00004184: $28 <= 00002ffc
@00004188: $28 <= 00003008
@00004180: $29 <= 80000014
@00004184: $28 <= 0000300c
@00004188: $28 <= 00003018
@00003020: $ 4 <= 00000004

```

2.

```

.ktext 0x4180
ori $4,$0,0
ori $6,$0,0
ori $7,$0,0
ori $8,$0,0
ori $9,$0,0
ori $10,$0,0

```

```
ori $11,$0,0
ori $12,$0,0
mfc0 $28,$14
mtc0 $29,$14
mtc0 $28,$14
eret
.text
ori $1,1
ori $2,2
lui $3,0x7fff
lui $4,0x7fff
add $6,$3,$4
ori $5,5
ori $6,0x3008
sw $1,0($6)
ori $7,0x7f1c
sw $1,0($7)
ori $8,1
sw $1,0($8)
ori $9,1
sh $1,0($9)
ori $10,$0,0
ori $10,0x7f00
sb $1,0($10)
ori $11,$0,0
ori $11,0x7f00
sh $1,0($11)
ori $12,$0,0
ori $12,0x7f00
sw $1,8($12)
```

38@00003000: \$ 1 <= 00000001
42@00003004: \$ 2 <= 00000002
46@00003008: \$ 3 <= 7fff0000
50@0000300c: \$ 4 <= 7fff0000
70@00004180: \$ 4 <= 00000000
74@00004184: \$ 6 <= 00000000
78@00004188: \$ 7 <= 00000000
82@0000418c: \$ 8 <= 00000000
86@00004190: \$ 9 <= 00000000
90@00004194: \$10 <= 00000000
94@00004198: \$11 <= 00000000
98@0000419c: \$12 <= 00000000
102@000041a0: \$28 <= 00003010
130@00003010: \$ 6 <= 7fff0000
134@00003014: \$ 5 <= 00000005
138@00003018: \$ 6 <= 7fff3008
158@00004180: \$ 4 <= 00000000
162@00004184: \$ 6 <= 00000000
166@00004188: \$ 7 <= 00000000
170@0000418c: \$ 8 <= 00000000
174@00004190: \$ 9 <= 00000000
178@00004194: \$10 <= 00000000
182@00004198: \$11 <= 00000000
186@0000419c: \$12 <= 00000000
190@000041a0: \$28 <= 0000301c
214@0000301c: *00000000 <= 00000001
222@00003020: \$ 7 <= 00007f1c
242@00004180: \$ 4 <= 00000000
246@00004184: \$ 6 <= 00000000

250@00004188: \$ 7 <= 00000000
254@0000418c: \$ 8 <= 00000000
258@00004190: \$ 9 <= 00000000
262@00004194: \$10 <= 00000000
266@00004198: \$11 <= 00000000
270@0000419c: \$12 <= 00000000
274@000041a0: \$28 <= 00003024
298@00003024: *00000000 <= 00000001
306@00003028: \$ 8 <= 00000001
326@00004180: \$ 4 <= 00000000
330@00004184: \$ 6 <= 00000000
334@00004188: \$ 7 <= 00000000
338@0000418c: \$ 8 <= 00000000
342@00004190: \$ 9 <= 00000000
346@00004194: \$10 <= 00000000
350@00004198: \$11 <= 00000000
354@0000419c: \$12 <= 00000000
358@000041a0: \$28 <= 0000302c
382@0000302c: *00000000 <= 00000001
390@00003030: \$ 9 <= 00000001
410@00004180: \$ 4 <= 00000000
414@00004184: \$ 6 <= 00000000
418@00004188: \$ 7 <= 00000000
422@0000418c: \$ 8 <= 00000000
426@00004190: \$ 9 <= 00000000
430@00004194: \$10 <= 00000000
434@00004198: \$11 <= 00000000
438@0000419c: \$12 <= 00000000
442@000041a0: \$28 <= 00003034

466@00003034: *00000000 <= 00000001
474@00003038: \$10 <= 00000000
478@0000303c: \$10 <= 00007f00
498@00004180: \$ 4 <= 00000000
502@00004184: \$ 6 <= 00000000
506@00004188: \$ 7 <= 00000000
510@0000418c: \$ 8 <= 00000000
514@00004190: \$ 9 <= 00000000
518@00004194: \$10 <= 00000000
522@00004198: \$11 <= 00000000
526@0000419c: \$12 <= 00000000
530@000041a0: \$28 <= 00003040
554@00003040: *00000000 <= 00000001
562@00003044: \$11 <= 00000000
566@00003048: \$11 <= 00007f00
586@00004180: \$ 4 <= 00000000
590@00004184: \$ 6 <= 00000000
594@00004188: \$ 7 <= 00000000
598@0000418c: \$ 8 <= 00000000
602@00004190: \$ 9 <= 00000000
606@00004194: \$10 <= 00000000
610@00004198: \$11 <= 00000000
614@0000419c: \$12 <= 00000000
618@000041a0: \$28 <= 0000304c
642@0000304c: *00000000 <= 00000001
650@00003050: \$12 <= 00000000
654@00003054: \$12 <= 00007f00
674@00004180: \$ 4 <= 00000000
678@00004184: \$ 6 <= 00000000

682@00004188: \$ 7 <= 00000000
686@0000418c: \$ 8 <= 00000000
690@00004190: \$ 9 <= 00000000
694@00004194: \$10 <= 00000000
698@00004198: \$11 <= 00000000
702@0000419c: \$12 <= 00000000
706@000041a0: \$28 <= 00003058
730@00003058: *00000008 <= 00000001

3.

.ktext 0x4180

ori \$1,\$0,0
ori \$2,\$0,0
ori \$3,\$0,0
ori \$4,\$0,0
ori \$5,\$0,0
ori \$6,\$0,0
ori \$7,\$0,0
ori \$8,\$0,0
ori \$9,\$0,0
ori \$10,\$0,0
ori \$11,\$0,0
ori \$12,\$0,0
ori \$13,\$0,0
ori \$14,\$0,0
ori \$15,\$0,0
ori \$16,\$0,0
ori \$17,\$0,0
ori \$21,\$0,0
ori \$22,\$0,0
mfc0 \$28,\$13

```
mfc0 $29,$14
addi $29,$29,4
mtc0 $29,$14
eret
ori $30,0x666
.text
ori $1,1
lw $1,0($1)
ori $2,1
lh $1,0($2)
ori $3,1
lhu $1,0($3)
ori $4,0x7f00
lh $1,0($4)
ori $5,0x7f02
lhu $1,0($5)
ori $6,0x7f01
lb $1,0($6)
ori $7,0x7f03
lbu $1,0($7)
ori $8,0x3004
lw $1,0($8)
ori $9,0x3008
lh $1,0($9)
ori $10,0x3010
lhu $1,0($10)
ori $11,0x7f0d
lb $1,0($11)
ori $12,0x7f1c
lbu $1,0($12)
```

```
lui $13,0x7fff
ori $13,0xffff
lw $1,1($13)
lui $14,0x7fff
ori $14,0xffff
lh $1,3($14)
lui $15,0x7fff
ori $15,0xffff
lhu $1,3($15)
lui $16,0x7fff
ori $16,0xffff
lhu $1,4($16)
lui $17,0x7fff
ori $17,0xffff
lhu $1,6($17)
ori $19,0x30a9
jr $19
lui $21,0x7ff
ori $21,0xffff
lui $22,0x7ff
ori $22,0xffff
add $1,$21,$22
lui $21,0x7ff
ori $21,0xffff
lui $22,0x7ff
ori $22,0xffff
add $1,$21,$22
lui $21,0xf000
lui $22,0x7ff
ori $22,0xffff
```

```
sub $1,$22,$21
lui $21,0x7ff
ori $21,0xffff
addi $1,$21,0xffff
```

期望输出:

```
38@00003000: $ 1 <= 00000001
58@00004180: $ 1 <= 00000000
62@00004184: $ 2 <= 00000000
66@00004188: $ 3 <= 00000000
70@0000418c: $ 4 <= 00000000
74@00004190: $ 5 <= 00000000
78@00004194: $ 6 <= 00000000
82@00004198: $ 7 <= 00000000
86@0000419c: $ 8 <= 00000000
90@000041a0: $ 9 <= 00000000
94@000041a4: $10 <= 00000000
98@000041a8: $11 <= 00000000
102@000041ac: $12 <= 00000000
106@000041b0: $13 <= 00000000
110@000041b4: $14 <= 00000000
114@000041b8: $15 <= 00000000
118@000041bc: $16 <= 00000000
122@000041c0: $17 <= 00000000
126@000041c4: $21 <= 00000000
130@000041c8: $22 <= 00000000
134@000041cc: $28 <= 00000010
138@000041d0: $29 <= 00003004
146@000041d4: $29 <= 00003008
170@00003008: $ 2 <= 00000001
190@00004180: $ 1 <= 00000000
```

194@00004184: \$ 2 <= 00000000
198@00004188: \$ 3 <= 00000000
202@0000418c: \$ 4 <= 00000000
206@00004190: \$ 5 <= 00000000
210@00004194: \$ 6 <= 00000000
214@00004198: \$ 7 <= 00000000
218@0000419c: \$ 8 <= 00000000
222@000041a0: \$ 9 <= 00000000
226@000041a4: \$10 <= 00000000
230@000041a8: \$11 <= 00000000
234@000041ac: \$12 <= 00000000
238@000041b0: \$13 <= 00000000
242@000041b4: \$14 <= 00000000
246@000041b8: \$15 <= 00000000
250@000041bc: \$16 <= 00000000
254@000041c0: \$17 <= 00000000
258@000041c4: \$21 <= 00000000
262@000041c8: \$22 <= 00000000
266@000041cc: \$28 <= 00000010
270@000041d0: \$29 <= 0000300c
278@000041d4: \$29 <= 00003010
302@00003010: \$ 3 <= 00000001
322@00004180: \$ 1 <= 00000000
326@00004184: \$ 2 <= 00000000
330@00004188: \$ 3 <= 00000000
334@0000418c: \$ 4 <= 00000000
338@00004190: \$ 5 <= 00000000
342@00004194: \$ 6 <= 00000000
346@00004198: \$ 7 <= 00000000
350@0000419c: \$ 8 <= 00000000

354@000041a0: \$ 9 <= 00000000
358@000041a4: \$10 <= 00000000
362@000041a8: \$11 <= 00000000
366@000041ac: \$12 <= 00000000
370@000041b0: \$13 <= 00000000
374@000041b4: \$14 <= 00000000
378@000041b8: \$15 <= 00000000
382@000041bc: \$16 <= 00000000
386@000041c0: \$17 <= 00000000
390@000041c4: \$21 <= 00000000
394@000041c8: \$22 <= 00000000
398@000041cc: \$28 <= 00000010
402@000041d0: \$29 <= 00003014
410@000041d4: \$29 <= 00003018
434@00003018: \$ 4 <= 00007f00
454@00004180: \$ 1 <= 00000000
458@00004184: \$ 2 <= 00000000
462@00004188: \$ 3 <= 00000000
466@0000418c: \$ 4 <= 00000000
470@00004190: \$ 5 <= 00000000
474@00004194: \$ 6 <= 00000000
478@00004198: \$ 7 <= 00000000
482@0000419c: \$ 8 <= 00000000
486@000041a0: \$ 9 <= 00000000
490@000041a4: \$10 <= 00000000
494@000041a8: \$11 <= 00000000
498@000041ac: \$12 <= 00000000
502@000041b0: \$13 <= 00000000
506@000041b4: \$14 <= 00000000
510@000041b8: \$15 <= 00000000

514@000041bc: \$16 <= 00000000
518@000041c0: \$17 <= 00000000
522@000041c4: \$21 <= 00000000
526@000041c8: \$22 <= 00000000
530@000041cc: \$28 <= 00000010
534@000041d0: \$29 <= 0000301c
542@000041d4: \$29 <= 00003020
566@00003020: \$ 5 <= 00007f02
586@00004180: \$ 1 <= 00000000
590@00004184: \$ 2 <= 00000000
594@00004188: \$ 3 <= 00000000
598@0000418c: \$ 4 <= 00000000
602@00004190: \$ 5 <= 00000000
606@00004194: \$ 6 <= 00000000
610@00004198: \$ 7 <= 00000000
614@0000419c: \$ 8 <= 00000000
618@000041a0: \$ 9 <= 00000000
622@000041a4: \$10 <= 00000000
626@000041a8: \$11 <= 00000000
630@000041ac: \$12 <= 00000000
634@000041b0: \$13 <= 00000000
638@000041b4: \$14 <= 00000000
642@000041b8: \$15 <= 00000000
646@000041bc: \$16 <= 00000000
650@000041c0: \$17 <= 00000000
654@000041c4: \$21 <= 00000000
658@000041c8: \$22 <= 00000000
662@000041cc: \$28 <= 00000010
666@000041d0: \$29 <= 00003024
674@000041d4: \$29 <= 00003028

698@00003028: \$ 6 <= 00007f01
718@00004180: \$ 1 <= 00000000
722@00004184: \$ 2 <= 00000000
726@00004188: \$ 3 <= 00000000
730@0000418c: \$ 4 <= 00000000
734@00004190: \$ 5 <= 00000000
738@00004194: \$ 6 <= 00000000
742@00004198: \$ 7 <= 00000000
746@0000419c: \$ 8 <= 00000000
750@000041a0: \$ 9 <= 00000000
754@000041a4: \$10 <= 00000000
758@000041a8: \$11 <= 00000000
762@000041ac: \$12 <= 00000000
766@000041b0: \$13 <= 00000000
770@000041b4: \$14 <= 00000000
774@000041b8: \$15 <= 00000000
778@000041bc: \$16 <= 00000000
782@000041c0: \$17 <= 00000000
786@000041c4: \$21 <= 00000000
790@000041c8: \$22 <= 00000000
794@000041cc: \$28 <= 00000010
798@000041d0: \$29 <= 0000302c
806@000041d4: \$29 <= 00003030
830@00003030: \$ 7 <= 00007f03
850@00004180: \$ 1 <= 00000000
854@00004184: \$ 2 <= 00000000
858@00004188: \$ 3 <= 00000000
862@0000418c: \$ 4 <= 00000000
866@00004190: \$ 5 <= 00000000
870@00004194: \$ 6 <= 00000000

874@00004198: \$ 7 <= 00000000
878@0000419c: \$ 8 <= 00000000
882@000041a0: \$ 9 <= 00000000
886@000041a4: \$10 <= 00000000
890@000041a8: \$11 <= 00000000
894@000041ac: \$12 <= 00000000
898@000041b0: \$13 <= 00000000
902@000041b4: \$14 <= 00000000
906@000041b8: \$15 <= 00000000
910@000041bc: \$16 <= 00000000
914@000041c0: \$17 <= 00000000
918@000041c4: \$21 <= 00000000
922@000041c8: \$22 <= 00000000
926@000041cc: \$28 <= 00000010
930@000041d0: \$29 <= 00003034
938@000041d4: \$29 <= 00003038
962@00003038: \$ 8 <= 00003004
982@00004180: \$ 1 <= 00000000
986@00004184: \$ 2 <= 00000000
990@00004188: \$ 3 <= 00000000
994@0000418c: \$ 4 <= 00000000
998@00004190: \$ 5 <= 00000000
1002@00004194: \$ 6 <= 00000000
1006@00004198: \$ 7 <= 00000000
1010@0000419c: \$ 8 <= 00000000
1014@000041a0: \$ 9 <= 00000000
1018@000041a4: \$10 <= 00000000
1022@000041a8: \$11 <= 00000000
1026@000041ac: \$12 <= 00000000
1030@000041b0: \$13 <= 00000000

1034@000041b4: \$14 <= 00000000
1038@000041b8: \$15 <= 00000000
1042@000041bc: \$16 <= 00000000
1046@000041c0: \$17 <= 00000000
1050@000041c4: \$21 <= 00000000
1054@000041c8: \$22 <= 00000000
1058@000041cc: \$28 <= 00000010
1062@000041d0: \$29 <= 0000303c
1070@000041d4: \$29 <= 00003040
1094@00003040: \$ 9 <= 00003008
1114@00004180: \$ 1 <= 00000000
1118@00004184: \$ 2 <= 00000000
1122@00004188: \$ 3 <= 00000000
1126@0000418c: \$ 4 <= 00000000
1130@00004190: \$ 5 <= 00000000
1134@00004194: \$ 6 <= 00000000
1138@00004198: \$ 7 <= 00000000
1142@0000419c: \$ 8 <= 00000000
1146@000041a0: \$ 9 <= 00000000
1150@000041a4: \$10 <= 00000000
1154@000041a8: \$11 <= 00000000
1158@000041ac: \$12 <= 00000000
1162@000041b0: \$13 <= 00000000
1166@000041b4: \$14 <= 00000000
1170@000041b8: \$15 <= 00000000
1174@000041bc: \$16 <= 00000000
1178@000041c0: \$17 <= 00000000
1182@000041c4: \$21 <= 00000000
1186@000041c8: \$22 <= 00000000
1190@000041cc: \$28 <= 00000010

1194@000041d0: \$29 <= 00003044
1202@000041d4: \$29 <= 00003048
1226@00003048: \$10 <= 00003010
1246@00004180: \$ 1 <= 00000000
1250@00004184: \$ 2 <= 00000000
1254@00004188: \$ 3 <= 00000000
1258@0000418c: \$ 4 <= 00000000
1262@00004190: \$ 5 <= 00000000
1266@00004194: \$ 6 <= 00000000
1270@00004198: \$ 7 <= 00000000
1274@0000419c: \$ 8 <= 00000000
1278@000041a0: \$ 9 <= 00000000
1282@000041a4: \$10 <= 00000000
1286@000041a8: \$11 <= 00000000
1290@000041ac: \$12 <= 00000000
1294@000041b0: \$13 <= 00000000
1298@000041b4: \$14 <= 00000000
1302@000041b8: \$15 <= 00000000
1306@000041bc: \$16 <= 00000000
1310@000041c0: \$17 <= 00000000
1314@000041c4: \$21 <= 00000000
1318@000041c8: \$22 <= 00000000
1322@000041cc: \$28 <= 00000010
1326@000041d0: \$29 <= 0000304c
1334@000041d4: \$29 <= 00003050
1358@00003050: \$11 <= 00007f0d
1378@00004180: \$ 1 <= 00000000
1382@00004184: \$ 2 <= 00000000
1386@00004188: \$ 3 <= 00000000
1390@0000418c: \$ 4 <= 00000000

1394@00004190: \$ 5 <= 00000000
1398@00004194: \$ 6 <= 00000000
1402@00004198: \$ 7 <= 00000000
1406@0000419c: \$ 8 <= 00000000
1410@000041a0: \$ 9 <= 00000000
1414@000041a4: \$10 <= 00000000
1418@000041a8: \$11 <= 00000000
1422@000041ac: \$12 <= 00000000
1426@000041b0: \$13 <= 00000000
1430@000041b4: \$14 <= 00000000
1434@000041b8: \$15 <= 00000000
1438@000041bc: \$16 <= 00000000
1442@000041c0: \$17 <= 00000000
1446@000041c4: \$21 <= 00000000
1450@000041c8: \$22 <= 00000000
1454@000041cc: \$28 <= 00000010
1458@000041d0: \$29 <= 00003054
1466@000041d4: \$29 <= 00003058
1490@00003058: \$12 <= 00007f1c
1510@00004180: \$ 1 <= 00000000
1514@00004184: \$ 2 <= 00000000
1518@00004188: \$ 3 <= 00000000
1522@0000418c: \$ 4 <= 00000000
1526@00004190: \$ 5 <= 00000000
1530@00004194: \$ 6 <= 00000000
1534@00004198: \$ 7 <= 00000000
1538@0000419c: \$ 8 <= 00000000
1542@000041a0: \$ 9 <= 00000000
1546@000041a4: \$10 <= 00000000
1550@000041a8: \$11 <= 00000000

1554@000041ac: \$12 <= 00000000
1558@000041b0: \$13 <= 00000000
1562@000041b4: \$14 <= 00000000
1566@000041b8: \$15 <= 00000000
1570@000041bc: \$16 <= 00000000
1574@000041c0: \$17 <= 00000000
1578@000041c4: \$21 <= 00000000
1582@000041c8: \$22 <= 00000000
1586@000041cc: \$28 <= 00000010
1590@000041d0: \$29 <= 0000305c
1598@000041d4: \$29 <= 00003060
1622@00003060: \$13 <= 7fff0000
1626@00003064: \$13 <= 7fffffff
1646@00004180: \$ 1 <= 00000000
1650@00004184: \$ 2 <= 00000000
1654@00004188: \$ 3 <= 00000000
1658@0000418c: \$ 4 <= 00000000
1662@00004190: \$ 5 <= 00000000
1666@00004194: \$ 6 <= 00000000
1670@00004198: \$ 7 <= 00000000
1674@0000419c: \$ 8 <= 00000000
1678@000041a0: \$ 9 <= 00000000
1682@000041a4: \$10 <= 00000000
1686@000041a8: \$11 <= 00000000
1690@000041ac: \$12 <= 00000000
1694@000041b0: \$13 <= 00000000
1698@000041b4: \$14 <= 00000000
1702@000041b8: \$15 <= 00000000
1706@000041bc: \$16 <= 00000000
1710@000041c0: \$17 <= 00000000

1714@000041c4: \$21 <= 00000000
1718@000041c8: \$22 <= 00000000
1722@000041cc: \$28 <= 00000010
1726@000041d0: \$29 <= 00003068
1734@000041d4: \$29 <= 0000306c
1758@0000306c: \$14 <= 7fff0000
1762@00003070: \$14 <= 7fffffff
1782@00004180: \$ 1 <= 00000000
1786@00004184: \$ 2 <= 00000000
1790@00004188: \$ 3 <= 00000000
1794@0000418c: \$ 4 <= 00000000
1798@00004190: \$ 5 <= 00000000
1802@00004194: \$ 6 <= 00000000
1806@00004198: \$ 7 <= 00000000
1810@0000419c: \$ 8 <= 00000000
1814@000041a0: \$ 9 <= 00000000
1818@000041a4: \$10 <= 00000000
1822@000041a8: \$11 <= 00000000
1826@000041ac: \$12 <= 00000000
1830@000041b0: \$13 <= 00000000
1834@000041b4: \$14 <= 00000000
1838@000041b8: \$15 <= 00000000
1842@000041bc: \$16 <= 00000000
1846@000041c0: \$17 <= 00000000
1850@000041c4: \$21 <= 00000000
1854@000041c8: \$22 <= 00000000
1858@000041cc: \$28 <= 00000010
1862@000041d0: \$29 <= 00003074
1870@000041d4: \$29 <= 00003078
1894@00003078: \$15 <= 7fff0000

1898@0000307c: \$15 <= 7fffffff
1918@00004180: \$ 1 <= 00000000
1922@00004184: \$ 2 <= 00000000
1926@00004188: \$ 3 <= 00000000
1930@0000418c: \$ 4 <= 00000000
1934@00004190: \$ 5 <= 00000000
1938@00004194: \$ 6 <= 00000000
1942@00004198: \$ 7 <= 00000000
1946@0000419c: \$ 8 <= 00000000
1950@000041a0: \$ 9 <= 00000000
1954@000041a4: \$10 <= 00000000
1958@000041a8: \$11 <= 00000000
1962@000041ac: \$12 <= 00000000
1966@000041b0: \$13 <= 00000000
1970@000041b4: \$14 <= 00000000
1974@000041b8: \$15 <= 00000000
1978@000041bc: \$16 <= 00000000
1982@000041c0: \$17 <= 00000000
1986@000041c4: \$21 <= 00000000
1990@000041c8: \$22 <= 00000000
1994@000041cc: \$28 <= 00000010
1998@000041d0: \$29 <= 00003080
2006@000041d4: \$29 <= 00003084
2030@00003084: \$16 <= 7fff0000
2034@00003088: \$16 <= 7fffffff
2054@00004180: \$ 1 <= 00000000
2058@00004184: \$ 2 <= 00000000
2062@00004188: \$ 3 <= 00000000
2066@0000418c: \$ 4 <= 00000000
2070@00004190: \$ 5 <= 00000000

2074@00004194: \$ 6 <= 00000000
2078@00004198: \$ 7 <= 00000000
2082@0000419c: \$ 8 <= 00000000
2086@000041a0: \$ 9 <= 00000000
2090@000041a4: \$10 <= 00000000
2094@000041a8: \$11 <= 00000000
2098@000041ac: \$12 <= 00000000
2102@000041b0: \$13 <= 00000000
2106@000041b4: \$14 <= 00000000
2110@000041b8: \$15 <= 00000000
2114@000041bc: \$16 <= 00000000
2118@000041c0: \$17 <= 00000000
2122@000041c4: \$21 <= 00000000
2126@000041c8: \$22 <= 00000000
2130@000041cc: \$28 <= 00000010
2134@000041d0: \$29 <= 0000308c
2142@000041d4: \$29 <= 00003090
2166@00003090: \$17 <= 7fff0000
2170@00003094: \$17 <= 7fffffff
2190@00004180: \$ 1 <= 00000000
2194@00004184: \$ 2 <= 00000000
2198@00004188: \$ 3 <= 00000000
2202@0000418c: \$ 4 <= 00000000
2206@00004190: \$ 5 <= 00000000
2210@00004194: \$ 6 <= 00000000
2214@00004198: \$ 7 <= 00000000
2218@0000419c: \$ 8 <= 00000000
2222@000041a0: \$ 9 <= 00000000
2226@000041a4: \$10 <= 00000000
2230@000041a8: \$11 <= 00000000

2234@000041ac: \$12 <= 00000000
2238@000041b0: \$13 <= 00000000
2242@000041b4: \$14 <= 00000000
2246@000041b8: \$15 <= 00000000
2250@000041bc: \$16 <= 00000000
2254@000041c0: \$17 <= 00000000
2258@000041c4: \$21 <= 00000000
2262@000041c8: \$22 <= 00000000
2266@000041cc: \$28 <= 00000010
2270@000041d0: \$29 <= 00003098
2278@000041d4: \$29 <= 0000309c
2302@0000309c: \$19 <= 000030a9
2314@000030a4: \$21 <= 07ff0000
2334@00004180: \$ 1 <= 00000000
2338@00004184: \$ 2 <= 00000000
2342@00004188: \$ 3 <= 00000000
2346@0000418c: \$ 4 <= 00000000
2350@00004190: \$ 5 <= 00000000
2354@00004194: \$ 6 <= 00000000
2358@00004198: \$ 7 <= 00000000
2362@0000419c: \$ 8 <= 00000000
2366@000041a0: \$ 9 <= 00000000
2370@000041a4: \$10 <= 00000000
2374@000041a8: \$11 <= 00000000
2378@000041ac: \$12 <= 00000000
2382@000041b0: \$13 <= 00000000
2386@000041b4: \$14 <= 00000000
2390@000041b8: \$15 <= 00000000
2394@000041bc: \$16 <= 00000000
2398@000041c0: \$17 <= 00000000

2402@000041c4: \$21 <= 00000000
2406@000041c8: \$22 <= 00000000
2410@000041cc: \$28 <= 00000010
2414@000041d0: \$29 <= 000030a8
2422@000041d4: \$29 <= 000030ac
2446@000030ac: \$22 <= 07ff0000
2450@000030b0: \$22 <= 07ffffff
2454@000030b4: \$ 1 <= 07ffffff
2458@000030b8: \$21 <= 07ff0000
2462@000030bc: \$21 <= 07ffffff
2466@000030c0: \$22 <= 07ff0000
2470@000030c4: \$22 <= 07ffffff
2474@000030c8: \$ 1 <= 0ffffffe
2478@000030cc: \$21 <= f0000000
2482@000030d0: \$22 <= 07ff0000
2486@000030d4: \$22 <= 07ffffff
2490@000030d8: \$ 1 <= 17ffffff
2494@000030dc: \$21 <= 07ff0000
2498@000030e0: \$21 <= 07ffffff
2502@000030e4: \$ 1 <= 00000000
2506@000030e8: \$ 1 <= 0000ffff
2510@000030ec: \$ 1 <= 0800fffe

三、思考题

1. 我们计组课程一本参考书目标题中有“硬件/软件接口”接口字样,那么到底什么是“硬件/软件接口”?

硬件/软件接口是计算机硬件与软件的交互手段,硬件接口指的是硬件链接另一个硬件的装置,是物理存在的,软件接口指的是一个程序为别的程序留的入口,本质就是一段代码。人类与电脑等信息机器或人类与程序之间的接口称为用户界面。电脑等信息机器硬件组件间的接口叫硬件接口。电脑等信息机器软件组件间的接口叫软件接口。硬件接口指的是两个硬件设备之间的连接方式。硬件接口既包括物理上的接口,还包括逻辑上的数据传送协议。软件不同部分之间的交互接口。通常就是所谓的 API——应用程序编程接口,其表现的形式是源代码。

2. 在我们设计的流水线中,DM 处于 CPU 内部,请你考虑现代计算机中它的位置应该在何处。

在主存中,CPU 通过 Cache 与主存交换数据

4. BE 部件对所有的外设都是必要的吗?

不是,只有需要字节或者半字读取或写入才需要,如果只需按字写入或读取就不需要

5. 请阅读官方提供的定时器源代码,阐述两种中断模式的异同,并分别针对每一种模式绘制状态转移图

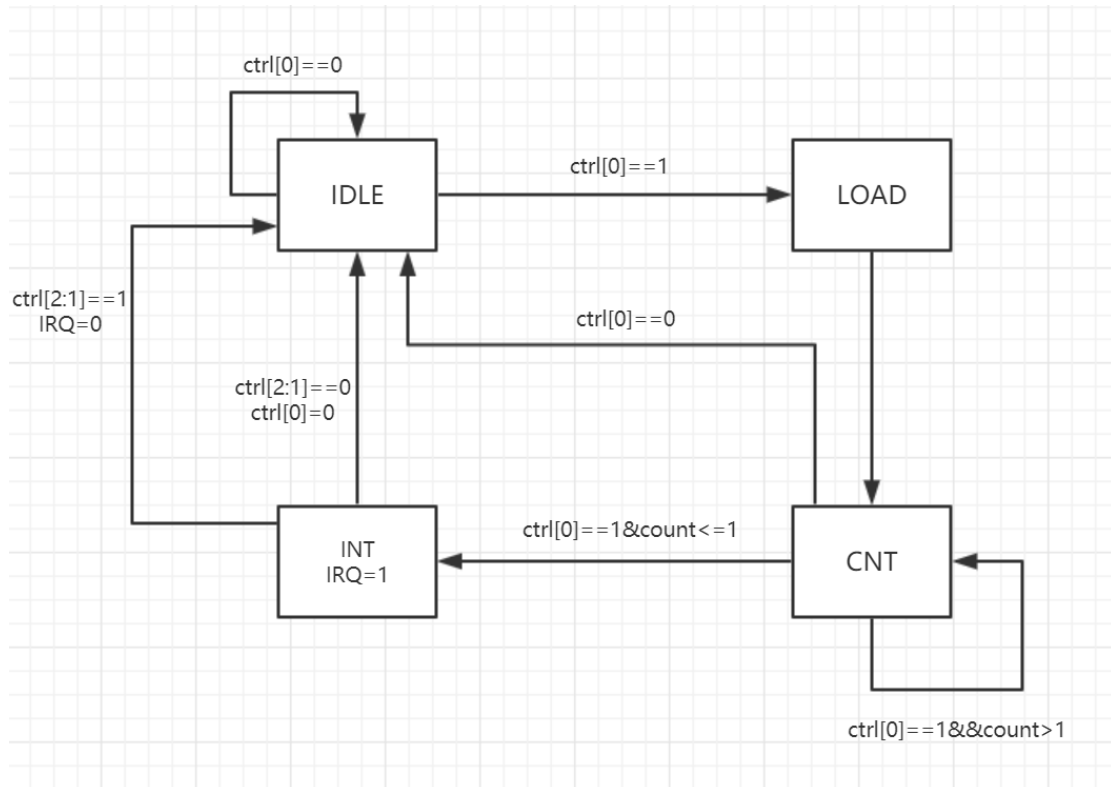
模式 0:

当计数器倒计时为 0 后,计数器停止计数,此时控制寄存器中的使能 CTRL[0]变为 0,当其再次被设置为 1 后,初值寄存器被再次加载到计数器,计数器重新启动倒计时。模式 0 用来产生定时中断,中断屏蔽位可以屏蔽中断。

模式 1:

当计数器计数为 0 后,初值寄存器被自动加载到计数器,计数器继续倒计时,模式 1 用来产生周期性脉冲,模式 1 下计数器每次计数循环只产生一周期的

中断信号。



6. 请开发一个主程序以及定时器的 **exception handler**。整个系统完成如下功能：

- i. 定时器在主程序中被初始化为模式 0；
- ii. 定时器倒计时至 0 产生中断；
- iii. handler 设置使能 Enable 为 1 从而再次启动定时器的计数器。2 及 3 被无限重复。
- iv. 主程序在初始化时将定时器初始化为模式 0，设定初值寄存器的初值为某个值，如 100 或 1000。（注意，主程序可能需要涉及对 CP0.SR 的编程，推荐阅读过后文后再进行。）

.ktext 0x4180

```
ori $24,$0,9
```

```
ori $25,$0,0x7f00
```

```
sw $24,0($25)
```

```
eret
```

```
.text
```

```
ori $4,0xfc01
```

```
mtc0 $4,$12
```

```
ori $1,0x7f00
```

```
ori $2,3
```

```
sw $2,4($1)
```

```
ori $3,9
```

```
sw $3,0($1)
```

```
lui $5,5
```

```
lui $6,6
```

```
lui $7,7
```

```
lui $8,8
```

```
lui $9,9
```

```
lui $10,10
```

```
lui $11,11
```

```
lui $12,12
```

```
lui $13,12
```

```
lui $14,14
```

```
lui $15,15
```

7. 请查阅相关资料，说明鼠标和键盘的输入信号是如何被 CPU 知晓的？

鼠标和键盘的输入信号相当于中断，当键盘、鼠标有信息时，产生一个中断然后中断例程会从端口读入数据到寄存器。CPU 接收到中断请求之后进入中断处理程序获得鼠标键盘的信息。