



| | | 指令流出时钟 |
|--------------------|----------------------|--------|
| 4.6 ⁽¹⁾ | FOO: L.D F2, 0(R1) | 1 |
| | (空转) | 2 |
| | MUL.D F4, F2, F0 | 3 |
| | L.D F6, 0(R2) | 4 |
| | (空转) | 5 |
| | (空转) | 6 |
| | ADD.D F6, F4, F6 | 7 |
| | (空转) | 8 |
| | (空转) | 9 |
| | S.D F6, 0[R2] | 10 |
| | DADDIU R1, R1, #8 | 11 |
| | DADDIU R2, R2, #8 | 12 |
| | DSUBIU R3, R1, #DONE | 13 |
| | BNEZ R3, FOO | 14 |

∴ 计算一个Y值要14个时钟周期，
有5个空转周期。

| | | 指令流出时钟 |
|----------|--------------------|--------|
| (2) FOO: | L.D F2, 0(R1) | 1 |
| | (空转) | 2 |
| | MUL.D F4, F2, F0 | 3 |
| | L.D F6, 0(R2) | 4 |
| | (空转) | 5 |
| | (空转) | 6 |
| | ADD.D F6, F4, F6 | 7 |
| | (空转) | 8 |
| | (空转) | 9 |
| | S.D F6, 0[R2] | 10 |
| | L.D F8, 8(R1) | 11 |
| | (空转) | 12 |
| | MUL.D F10, F8, F0 | 13 |
| | L.D F12, 8(R2) | 14 |
| | (空转) | 15 |
| | (空转) | 16 |
| | ADD.D F12, F8, F12 | 17 |
| | (空转) | 18 |
| | (空转) | 19 |
| | S.D F12, 8[R2] | 20 |
| | L.D F14, 16(R1) | 21 |
| | (空转) | 22 |
| | MUL.D F16, F14, F0 | 23 |
| | L.D F18, 16(R2) | 24 |
| | (空转) | 25 |
| | (空转) | 26 |



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| | | | |
|---------------------|----|---------------------|----|
| ADD.D F18, F16, F18 | 27 | (空转) | 35 |
| (空转) | 28 | (空转) | 36 |
| (空转) | 29 | ADD.D F24, F22, F24 | 37 |
| S.D F18, 16[R2] | 30 | (空转) | 38 |
| L.D F20, 24(R1) | 31 | (空转) | 39 |
| (空转) | 32 | S.D F24, 24[R2] | 40 |
| MUL.D F22, F20, F0 | 33 | DADDIU R1, R1, #32 | 41 |
| L.D F24, 24(R2) | 34 | DADDIU R2, R2, #32 | 42 |
| | | DSUBIU R3, R1, DONE | 43 |
| | | BNEZ R3, F00 | 44 |

∴ 平均需要 $\frac{44}{4} = 11$ 个周期

加速比为 $\frac{14}{11} = 1.27$

通过减少对 R1、R2 的整数操作, 以及比较、分支指令而来

| | | 指令流出时钟 | |
|--------------|---------------|--------|-------------------------------|
| (3) F00: L.D | F2, 0(R1) | 1 | ADD.D F18, F16, F18 15 |
| L.D | F8, 8(R1) | 2 | ADD.D F24, F22, F24 16 |
| L.D | F14, 16(R1) | 3 | S.D F6, 0[R2] 17 |
| L.D | F20, 24(R1) | 4 | S.D F12, 8[R2] 18 |
| MUL.D | F4, F2, F0 | 5 | S.D F18, 16[R2] 19 |
| MUL.D | F10, F8, F0 | 6 | S.D F24, 24[R2] 20 |
| MUL.D | F16, F14, F0 | 7 | DADDIU R1, R1, #32 21 |
| MUL.D | F22, F20, F0 | 8 | DADDIU R2, R2, #32 22 |
| L.D | F6, 0(R2) | 9 | DSUBIU R3, R1, DONE 23 |
| L.D | F12, 8(R2) | 10 | BNEZ R3, F00 24 |
| L.D | F18, 16(R2) | 11 | |
| L.D | F24, 24(R2) | 12 | ∴ 平均需要 $\frac{24}{4} = 6$ 个周期 |
| ADD.D | F6, F4, F6 | 13 | 加速比为 $\frac{14}{6} = 2.33$ |
| ADD.D | F12, F10, F12 | 14 | |



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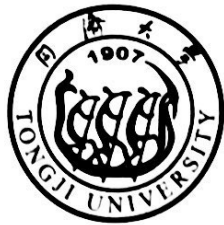
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(4)

| 指令 | 流出 | 指令执行时钟 执行 | 写结果 | 确认 |
|----------------------|----|--------------|-----|----|
| L.D F2, 0(R1) | 1 | 2 | 3 | 4 |
| MUL.D F4, F2, F0 | 2 | 4 | 5 | 6 |
| L.D F6, 0(R2) | 3 | 4 | 6 | 7 |
| ADD.D F6, F4, F6 | 4 | 8 | 9 | 10 |
| S.D F6, 0(R2) | 5 | 11 | 12 | 13 |
| DADDIU R1, R1, #8 | 6 | 7 | 8 | |
| DADDIU R2, R2, #8 | 7 | 8 | 9 | |
| DSUBIU R3, R1, #DONE | 8 | 9 | 10 | |
| BNEZ R3, F00 | 9 | 10 | | |
| L.D F2, 0(R1) | 10 | 11 | 13 | 14 |
| MUL.D F4, F2, F0 | 11 | 13 | 14 | 15 |
| L.D F6, 0(R2) | 12 | 13 | 15 | 16 |
| ADD.D F6, F4, F6 | 13 | 17 | 18 | 19 |
| S.D F6, 0(R2) | 14 | 20 | 21 | 22 |
| DADDIU R1, R1, #8 | 15 | 16 | 17 | |
| DADDIU R2, R2, #8 | 16 | 17 | 18 | |
| DSUBIU R3, R1, #DONE | 17 | 18 | 19 | |
| BNEZ R3, F00 | 18 | | | |

保留站

| 名称 | Busy | Op | Vj | Vk | Qj | Qk | Dest | A |
|-------|------|----|----|----|----|----|------|---|
| Add1 | no | | | | | | | |
| Add2 | no | | | | | | | |
| Add3 | no | | | | | | | |
| Mult1 | no | | | | | | | |
| Mult2 | no | | | | | | | |



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| 項号 | Busy | 指令 | 状态 | 目的 | Value |
|----|------|------------------|-----|-------------------|---------------------|
| 1 | yes | ADD.D F6, F4, F6 | 写结果 | F6 | Regs[F4] + Regs[F6] |
| 2 | yes | S.D F6, 0(R2) | 流出 | Mem[0 + Regs[R2]] | #2 |

浮点寄存器状态

| 字段 | F0 | F2 | F4 | F6 | F8 | F10 | F12 | F14 | ... | F30 |
|--------|----|----|----|-----|----|-----|-----|-----|-----|-----|
| ROB项编号 | | | | 1 | | | | | | |
| Busy | | | | yes | | | | | | |

| (5) 整数指令 | 浮点指令 | 周期数 |
|---------------------|---------------------|-----|
| L.D. F2, 0(R1) | | 1 |
| L.D. F8, 8(R1) | | 2 |
| L.D. F14, 16(R1) | MUL.D F4, F2, F0 | 3 |
| L.D. F20, 24(R1) | MUL.D F10, F8, F0 | 4 |
| L.D. F6, 0(R1) | MUL.D F16, F14, F0 | 5 |
| L.D. F10, 8(R1) | MUL.D F22, F20, F0 | 6 |
| L.D. F16, 16(R1) | ADD.D F6, F4, F6 | 7 |
| L.D. F22, 24(R1) | ADD.D F12, F10, F12 | 8 |
| DADDIU R1, R1, #32 | ADD.D F18, F16, F18 | 9 |
| S.D. F6, 0(R2) | ADD.D F24, F22, F24 | 10 |
| S.D. F12, 8(R2) | | 11 |
| S.D. F18, 16(R2) | | 12 |
| S.D. F24, 24(R2) | | 13 |
| DADDIU R2, R2, #32 | | 14 |
| DSUBU R3, R1, #DONE | | 15 |
| BNEZ R3, F00 | | 16 |

∴ 平均需 $\frac{16}{4} = 4$ 个周期, 加速比 $\frac{14}{4} = 3.5$



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| (6) | 访存1 | 访存2 | 浮点1 | 浮点2 | 整数/转移 | 时钟周期 |
|-----|------------------|------------------|---------------------|---------------------|-----------------------|------|
| | L.D. F2, 0(R1) | L.D. F8, 8(R1) | | | | 1 |
| | L.D. F14, 16(R1) | L.D. F20, 24(R1) | | | | 2 |
| | L.D. F6, 0(R2) | L.D. F12, 8(R2) | MULD F4, F2, F0 | MULD F10, F8, F0 | | 3 |
| | L.D. F18, 16(R2) | L.D. F24, 24(R2) | MULD F16, F14, F0 | MULD F22, F20, F0 | | 4 |
| | | | | | | 5 |
| | | | | | DADDIU, R1, R1, #32 | 6 |
| | | | ADD.D F6, F4, F6 | ADD.D F12, F10, F12 | DADDIU, R2, R2, #32 | 7 |
| | | | ADD.D F18, F16, F18 | ADD.D F24, F22, F24 | DSUBIU, R3, R1, #DONE | 8 |
| | | | | | BNEZ R3, F00 | 9 |
| | S.D F6, -32(R2) | S.D F12, -24(R2) | | | | 10 |
| | S.D F18, -16(R2) | S.D F24, -8(R2) | | | | 11 |

∴ 平均需 $\frac{11}{4} = 2.75$ 个周期, 加速比: $\frac{14}{2.75} = 5.09$