PUN FORMS

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```
;;;
((main 1-input-nor)
 ((a unk))
 ((oa ~1))
 ((~1 (a))   ))

;;;
((main 2-input-nor)
 ((a unk)(b unk))
 ((oa ~1))
 ((~1 (a b))  ))

;;;
((main 4-input-nor)
 ((a unk)(b unk)(c unk)(d unk))
 ((oa ~1))
 ((~1 (a b c d))  ))

;;;
((main 2-input-and)
 ((a unk)(b unk))
 ((oa ~3))
 ((~1 (a))
  (~2 (b))
  (~3 (~1 ~2))   ))

;;;
((main 4-input-and)
 ((a unk)(b unk)(c unk)(d unk))
 ((oa ~5))
 ((~1 (a))
  (~2 (b))
  (~3 (c))
  (~4 (d))
  (~5 (~1 ~2 ~3 ~4))   ))

;;;
((main 2-input-or)
 ((a unk)(b unk))
 ((oa ~2))
 ((~1 (a b))
  (~2 (~1))  ))

;;;
((main 4-input-or)
 ((a unk)(b unk)(c unk)(d unk))
 ((oa ~2))
 ((~1 (a b c d))
  (~2 (~1))   ))
```

```
;;;
((main xor1)
 ((a unk)(b unk))
 ((oa ~5))
 ((~1 (a))
  (~2 (b))
  (~3 (a b))
  (~4 (~1 ~2))
  (~5 (~3 ~4))   ))

;;;
((main xor2)
 ((a unk)(b unk))
 ((oa ~6))
 ((~1 (a))
  (~2 (b))
  (~3 (a ~2))
  (~4 (b ~1))
  (~5 (~3 ~4))
  (~6 (~5))   ))

;;;
((main 2to1-mux)
 ((as unk)(b unk)(c unk))
 ((oa ~4))
 ((~1 (as))
  (~2 (as c))
  (~3 (b ~1))
  (~4 (~2 ~3))   ))

;;;
((main 2/3-majority)
 ((a unk)(b unk)(c unk))
 ((oa ~4))
 ((~1 (a b))
  (~2 (a c))
  (~3 (b c))
  (~4 (~1 ~2 ~3)) ))

;;;
((main half-adder)
 ((a0 unk)(a1 unk))
 ((sum ~5)(cout ~4))
 ((~1 (a))
  (~2 (b))
  (~3 (a b))
  (~4 (~1 ~2))
  (~5 (~3 ~4))   ))

;;;
((main 2bit-tally)
 ((a unk)(b unk))
 ((two ~4)(one ~5)(zero ~6))
 ((~1 (a))
  (~2 (b))
  (~3 (a b))
  (~4 (~1 ~2))
  (~5 (~3 ~4))
  (~6 (~3))   ))
```

```
;;;
((main 1to4-demux)
 ((a unk)(s0 unk)(s1 unk))
 ((oa ~3)(ob ~4)(oc ~5)(od ~6))
 ((~1 (s0))
  (~2 (s1))
  (~3 (a s0 s1))
  (~4 (a s0 ~2))
  (~5 (a s1 ~1))
  (~6 (a ~1 ~2))   ))

;;;
((main 4to1-mux)
 ((s0 unk)(s1 unk)(a unk)(b unk)(c unk)(d unk))
 ((oa ~12))
 ((~1 (s0))
  (~2 (s1))
  (~3 (a))
  (~4 (b))
  (~5 (c))
  (~6 (d))
  (~7 (s0 s1 ~6))
  (~8 (s0 ~2 ~4))
  (~9 (s1 ~1 ~5))
  (~10 (~1 ~2 ~3))
  (~11 (~7 ~8 ~9 ~10))
  (~12 (~11))   ))

;;;
((main 2to4-decoder)
 ((a unk)(b unk)(en unk))
 ((oa ~4)(ob ~5)(oc ~6)(od ~7))
 ((~1 (a))
  (~2 (b))
  (~3 (en))
  (~4 (a b ~3))
  (~5 (a ~2 ~3))
  (~6 (b ~1 ~3))
  (~7 (~1 ~2 ~3))   ))

;;;
((main decimal-to-bcd-encoder)
 ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk))
 ((oa ~5)(ob ~6)(oc ~7)(od ~8))
 ((~1 (a c e g i))
  (~2 (b c f g))
  (~3 (d e f g))
  (~4 (h i))
  (~5 (~1))
  (~6 (~2))
  (~7 (~3))
  (~8 (~4))   ))
```

```
;;;
((main bcd-to-7segment-encoder)
 ((a unk)(b unk)(c unk)(d unk))
 ((s1 ~23)(s2 ~24)(s3 ~25)(s4 ~26)(s5 ~27)(s6 ~28)(s7 ~29))
 ((~1 (a))
  (~2 (b))
  (~3 (c))
  (~4 (a b))
  (~5 (a c))
  (~6 (b ~3))
  (~7 (c ~2))
  (~8 (d ~6))
  (~9 (a ~7))
  (~10 (~1 ~2))
  (~11 (~1 ~3))
  (~12 (~11))
  (~13 (b ~12))
  (~14 (~7))
  (~15 (~8))
  (~16 (~2 ~11))
  (~17 (~9 ~15))
  (~18 (~15 ~16))
  (~19 (a d ~14))
  (~20 (b d ~5 ~11))
  (~21 (d ~3 ~4 ~10))
  (~22 (a ~6))
  (~23 (~7 ~13 ~22))
  (~24 (~17))
  (~25 (~18))
  (~26 (~19))
  (~27 (~23))
  (~28 (~20))
  (~29 (~21))   ))
```

```
;;;
((main bcd-to-7segment-encoder-diagonalized)
 ((a unk)(b unk)(c unk)(d unk))
 ((s1 ~23)(s2 ~25)(s3 ~27)(s4 ~22)(s5 ~24)(s6 ~23)(s7 ~26))
 ((~1 (b))
  (~2 (c ~1))
  (~3 (a ~2))
  (~4 (c))
  (~5 (b ~4))
  (~6 (a ~5))
  (~7 (a))
  (~8 (b ~4 ~7))
  (~9 (a c d ~1))
  (~10 (a c))
  (~11 (a b))
  (~12 (~4 ~7))
  (~13 (b d ~10 ~12))
  (~14 (d))
  (~15 (~1 ~7))
  (~16 (~1 ~12))
  (~17 (~2 ~6 ~8))
  (~18 (~14))
  (~19 (~3 ~5 ~18))
  (~20 (~4 ~11 ~15 ~18))
  (~21 (~5 ~15 ~16))
  (~22 (~9))
  (~23 (~13))
  (~24 (~17))
  (~25 (~19))
  (~26 (~20))
  (~27 (~21))   ))

;;;
((main 2bit-comparator)
 ((a0 unk)(a1 unk)(b0 unk)(b1 unk))
 ((eq ~17)(lt ~18)(gt ~19))
 ((~1 (a0))
  (~2 (a1))
  (~3 (b0))
  (~4 (b1))
  (~5 (a0 b0))
  (~6 (a1 b1))
  (~7 (a1 4))
  (~8 (b1 2))
  (~9 (1 3))
  (~10 (2 4))
  (~11 (5 9))
  (~12 (6 10))
  (~13 (a0 3 12))
  (~14 (b0 1 12))
  (~15 (7 13))
  (~16 (8 14))
  (~17 (11 12))
  (~18 (15))
  (~19 (16))   ))
```

```
;;;
((main 1bit-fulladder)
 ((a unk)(b unk)(cin unk))
 ((sum ~11)(cout ~12))
 ((~1 (a))
  (~2 (b))
  (~3 (cin))
  (~4 (a b))
  (~5 (~1 ~2))
  (~6 (~4 ~5))
  (~7 (~6))
  (~8 (~3 ~7))
  (~9 (cin ~6))
  (~10 (~5 ~8))
  (~11 (~8 ~9))
  (~12 (~10))   ))

;;;
((main 1bit-subtractor)
 ((a unk)(b unk)(bin unk))
 ((diff ~10)(bout ~11))
 ((~1 (a))
  (~2 (b))
  (~3 (bin))
  (~4 (a b))
  (~5 (b bin))
  (~6 (a ~5))
  (~7 (~1 ~2))
  (~8 (~2 ~3))
  (~9 (~6 ~8))
  (~10 (~9))
  (~11 (~4 ~7))   ))
```

```
;;;
((main 4bit-adder)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk)(a2 unk)(b2 unk)(a3 unk)(b3 unk)(cin unk))
 ((s0 ~26)(s1 ~27)(s2 ~28)(s3 ~29)(cout ~30))
 ((~1 (a0))
  (~2 (b0))
  (~3 (a1))
  (~4 (b1))
  (~5 (a2))
  (~6 (b2))
  (~7 (a3))
  (~8 (b3))
  (~9 (cin))
  (~10 (a0 b0))
  (~11 (a1 b1))
  (~12 (a2 b2))
  (~13 (a3 b3))
  (~14 (~1 ~2))
  (~15 (~3 ~4))
  (~16 (~5 ~6))
  (~17 (~7 ~8))
  (~18 (~9 ~10))
  (~19 (~14 ~18))
  (~20 (~11 ~19))
  (~21 (~15 ~20))
  (~22 (~12 ~21))
  (~23 (~16 ~22))
  (~24 (~13 ~23))
  (~25 (~17 ~24))
  (~26 (~10 ~14))
  (~27 (~11 ~15))
  (~28 (~12 ~16))
  (~29 (~13 ~17))
  (~30 (~25))   ))
```

```
;;;
((main 9bit-parity-generator)
 ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk))
 ((even ~35)(odd ~36))
 ((~1 (a))
  (~2 (b))
  (~3 (c))
  (~4 (d))
  (~5 (e))
  (~6 (f))
  (~7 (g))
  (~8 (h))
  (~9 (i))
  (~10 (a b))
  (~11 (~1 ~2))
  (~12 (~10 ~11))
  (~13 (c ~12))
  (~14 (~3 ~10 ~11))
  (~15 (~13 ~14))
  (~16 (d e))
  (~17 (~4 ~5))
  (~18 (~16 ~17))
  (~19 (f ~18))
  (~20 (~6 ~16 ~17))
  (~21 (~19 ~20))
  (~22 (g h))
  (~23 (~7 ~8))
  (~24 (~22 ~23))
  (~25 (i ~24))
  (~26 (~9 ~22 ~23))
  (~27 (~25 ~26))
  (~28 (~15 ~21))
  (~29 (~13 ~14 ~19 ~20))
  (~30 (~28 ~29))
  (~31 (~25 ~26 ~30))
  (~32 (~27 ~28 ~29))
  (~33 (~27 ~30))
  (~34 (~25 ~26 ~28 ~29))
  (~35 (~31 ~32))
  (~36 (~33 ~34))   ))

;;;
((main fulladder-simpler-tidy)
 ((a unk)(b unk)(cin unk))
 ((sum ~10)(cout ~11))
 ((~1 (a))
  (~2 (b))
  (~3 (cin))
  (~4 (a b))
  (~5 (~1 ~2))
  (~6 (~4 ~5))
  (~7 (~3 ~4 ~5))
  (~8 (cin ~6))
  (~9 (~5 ~7))
  (~10 (~7 ~8))
  (~11 (~9))   ))
```

```
;;;
((main fulladder-two-level)
 ((a unk)(b unk)(cin unk))
 ((sum ~13)(cout ~14))
 ((~1 (a))
  (~2 (b))
  (~3 (cin))
  (~4 (a b ~3))
  (~5 (a ~2 cin))
  (~6 (~1 b cin))
  (~7 (~1 ~2 ~3))
  (~8 (~2 ~3))
  (~9 (~1 ~3))
  (~10 (~1 ~2))
  (~11 (~4 ~5 ~6 ~7))
  (~12 (~8 ~9 ~10))
  (~13 (~11))
  (~14 (~12))   ))

;;;
((main fulladder-composed)
 ((a unk)(b unk)(cin unk))
 ((sum ~2-0)(cout ~4))
 ((1- half-adder ((a0   a)(a1   b)) ((sum ~1-5) (cout ~1-4)) )
  (2- half-adder ((a0 ~1-5)(a1 cin)) ((sum ~2-5) (cout ~2-4)) )
  (~3 (~1-4 ~2-4))
  (~4 (~3))   ))
((lib half-adder)
 ((a0 unk)(a1 unk))
 ((sum ~5)(cout ~4))
 ((~1 (a0))
  (~2 (a1))
  (~3 (a0 a1))
  (~4 (~1 ~2))
  (~5 (~3 ~4))   ))

;;;
((main fulladder-composed-expanded)
 ((a unk)(b unk)(cin unk))
 ((sum ~2-5)(cout ~2))
 ((~1-1 (a))
  (~1-2 (b))
  (~1-3 (a b))
  (~1-4 (~1-1 ~1-2))
  (~1-5 (~1-3 ~1-4))
  (~2-1 (~1-5))
  (~2-2 (cin))
  (~2-3 (cin ~1-5))
  (~2-4 (~2-1 ~2-2))
  (~2-5 (~2-3 ~2-4))
  (~1 (~1-4 ~2-4))
  (~2 (~1))   ))
```

```
;;;
((main 2bit-adder-composed)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk))
 ((s0 ~1-5)(s1 ~2-10)(cout ~2-11))
 ((1- half-adder ((a0 a0)(a1 b0)) ((sum ~1-5) (cout ~1-4)) )
  (2- fulladder-simpler-tidy ((a a1)(b b1)) ((sum ~2-10)(cout ~2-11))))   ))
((lib half-adder)
 ((a0 unk)(a1 unk))
 ((sum ~5)(cout ~4))
 ((~1 (a0))
  (~2 (a1))
  (~3 (a0 a1))
  (~4 (~1 ~2))
  (~5 (~3 ~4))   ))
((lib fulladder-simpler-tidy)
 ((a unk)(b unk)(cin unk))
 ((sum ~10)(cout ~11))
 ((~1 (a))
  (~2 (b))
  (~3 (cin))
  (~4 (a b))
  (~5 (~1 ~2))
  (~6 (~4 ~5))
  (~7 (~3 ~4 ~5))
  (~8 (cin ~6))
  (~9 (~5 ~7))
  (~10 (~7 ~8))
  (~11 (~9))   ))
```

```
;;;
((main decimal-to-7segment-encoder-composed)
 ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk))
 ((s1 ~2-23)(s2 ~2-24)(s3 ~2-25)(s4 ~2-26)(s5 ~2-27)(s6 ~2-28)(s7 ~2-29))
 ((1- decimal-to-bcd
     ((a a)(b b)(c c)(d d)(e e)(f f)(g g)(h h)(i i))
     ((oa ~1-5) (ob ~1-6)(oc ~1-7)(od ~1-8)))
  (2- bcd-to-7segment
     ((a ~1-5)(b ~1-6)(c ~1-7)(d ~1-8))
     ((s1 ~2-23)(s2 ~2-24)(s3 ~2-25)(s4 ~2-26)(s5 ~2-27)(s6 ~2-28)(s7 ~2-29)))))
((lib decimal-to-bcd-encoder)
 ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk))
 ((oa ~5)(ob ~6)(oc ~7)(od ~8))
 ((~1 (a c e g i))
  (~2 (b c f g))
  (~3 (d e f g))
  (~4 (h i))
  (~5 (~1))
  (~6 (~2))
  (~7 (~3))
  (~8 (~4))   ))
((lib bcd-to-7segment-encoder)
 ((a unk)(b unk)(c unk)(d unk))
 ((s1 ~23)(s2 ~24)(s3 ~25)(s4 ~26)(s5 ~27)(s6 ~28)(s7 ~29))
 ((~1 (a))
  (~2 (b))
  (~3 (c))
  (~4 (a b))
  (~5 (a c))
  (~6 (b ~3))
  (~7 (c ~2))
  (~8 (d ~6))
  (~9 (a ~7))
  (~10 (~1 ~2))
  (~11 (~1 ~3))
  (~12 (~11))
  (~13 (b ~12))
  (~14 (~7))
  (~15 (~8))
  (~16 (~2 ~11))
  (~17 (~9 ~15))
  (~18 (~15 ~16))
  (~19 (a d ~14))
  (~20 (b d ~5 ~11))
  (~21 (d ~3 ~4 ~10))
  (~22 (a ~6))
  (~23 (~7 ~13 ~22))
  (~24 (~17))
  (~25 (~18))
  (~26 (~19))
  (~27 (~23))
  (~28 (~20))
  (~29 (~21))   ))
```

```
;;;
((main 4bit-multiplier-composed)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk)(a2 unk)(b2 unk)(a3 unk)(b3 unk))
 ((p0 ~9)(p1 ~1-5)(p2 ~3-10)(p3 ~6-10)(p4 ~9-5)
  (p5 ~11-10)(p6 ~12-10)(p7 ~12-11))
 ((~1 (a0))
  (~2 (b0))
  (~3 (a1))
  (~4 (b1))
  (~5 (a2))
  (~6 (b2))
  (~7 (a3))
  (~8 (b3))
  (~9 (~1 ~2))
  (~10 (~3 ~2))
  (~11 (~1 ~4))
  (~12 (~1 ~6))
  (~13 (~3 ~4))
  (~14 (~5 ~2))
  (~15 (~1 ~8))
  (~16 (~3 ~6))
  (~17 (~5 ~4))
  (~18 (~7 ~2))
  (~19 (~3 ~8))
  (~20 (~5 ~6))
  (~21 (~7 ~4))
  (~22 (~5 ~8))
  (~23 (~7 ~6))
  (~24 (~7 ~8))
  (1- half-adder ((a0 ~10)(a1 ~11)) ((sum ~1-5)(cout ~1-4)))
  (2- half-adder ((a0 ~12)(a1 ~13)) ((sum ~2-5)(cout ~2-4)))
  (3- fulladder ((a ~14)(b ~2-5)(cin ~1-4)) ((sum ~3-10)(cout ~3-11)))
  (4- half-adder ((a0 ~15)(a1 ~16)) ((sum ~4-5)(cout ~4-4)))
  (5- fulladder ((a ~17)(b ~4-5)(cin ~2-4)) ((sum ~5-10)(cout ~5-11)))
  (6- fulladder ((a ~18)(b ~5-10)(cin ~3-11)) ((sum ~6-10)(cout ~6-11)))
  (7- fulladder ((a ~19)(b ~20)(cin ~4-4)) ((sum ~7-10)(cout ~7-11)))
  (8- fulladder ((a ~21)(b ~7-10)(cin ~5-11)) ((sum ~8-10)(cout ~8-11)))
  (9- half-adder ((a0 ~8-10)(a1 ~6-11)) ((sum ~9-5)(cout ~9-4)))
  (10- fulladder ((a ~22)(b ~23)(cin ~7-11)) ((sum ~10-10)(cout ~10-11)))
  (11- fulladder ((a ~10-10)(b ~8-11)(cin ~9-4)) ((sum ~11-10)(cout ~11-11)))
  (12- fulladder ((a ~24)(b ~10-11)(cin ~11-11)) ((sum ~12-10)(cout ~12-11)))))
((lib half-adder)
 ((a0 unk)(a1 unk))
 ((sum ~5)(cout ~4))
 ((~1 (a0))
  (~2 (a1))
  (~3 (a0 a1))
  (~4 (~1 ~2))
  (~5 (~3 ~4))   ))
((lib fulladder)
 ((a unk)(b unk)(cin unk))
 ((sum ~10)(cout ~11))
 ((~1 (a))
  (~2 (b))
  (~3 (cin))
  (~4 (a b))
  (~5 (~1 ~2))
  (~6 (~4 ~5))
  (~7 (~3 ~4 ~5))
  (~8 (cin ~6))
  (~9 (~5 ~7))
  (~10 (~7 ~8))
  (~11 (~9))   ))
```

```
;;;
((main 1bit-comparator-iterative)
 ((a unk)(b unk)(prior unk))
 ((equal ~6))
 ((~1 (prior))
  (~2 (a))
  (~3 (b))
  (~4 (a b))
  (~5 (~2 ~3))
  (~6 (~1 ~4 ~5))   ))

;;;
((main 4bit-comparator-iterative-composed)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk)(a2 unk)(b2 unk)(a3 unk)(b3 unk))
 ((equal ~4-6))
 ((1- 1bit-comparator-iterative ((a a0)(b b0)(prior ())) ((equal ~1-6)))
 ((2- 1bit-comparator-iterative ((a a1)(b b1)(prior ~1-6)) ((equal ~2-6)))
 ((3- 1bit-comparator-iterative ((a a2)(b b2)(prior ~2-6)) ((equal ~3-6)))
 ((4- 1bit-comparator-iterative ((a a3)(b b3)(prior ~3-6)) ((equal ~4-6))) ))
(lib 1bit-comparator-iterative)
 ((a unk)(b unk)(prior unk))
 ((equal ~6))
 ((~1 (prior))
  (~2 (a))
  (~3 (b))
  (~4 (a b))
  (~5 (~2 ~3))
  (~6 (~1 ~4 ~5))   ))

;;;
((main 4bit-comparator-iterative-composed-expanded)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk)(a2 unk)(b2 unk)(a3 unk)(b3 unk))
 ((equal ~4-6))
 ((~1-2 (a0))
  (~1-3 (b0))
  (~1-4 (a0 b0))
  (~1-5 (~1-2 ~1-3))
  (~1-6 (~1-4 ~1-5))
  (~2-1 (~1-6))
  (~2-2 (a1))
  (~2-3 (b1))
  (~2-4 (a1 b1))
  (~2-5 (~2-2 ~2-3))
  (~2-6 (~2-1 ~2-4 ~2-5))
  (~3-1 (~2-6))
  (~3-2 (a2))
  (~3-3 (b2))
  (~3-4 (a2 b2))
  (~3-5 (~3-2 ~3-3))
  (~3-6 (~3-1 ~3-4 ~3-5))
  (~4-1 (~3-6))
  (~4-2 (a3))
  (~4-3 (b3))
  (~4-4 (a3 b3))
  (~4-5 (~4-2 ~4-3))
  (~4-6 (~4-1 ~4-4 ~4-5))   ))
```

```
;;;
((main 2bit-adder-iterative-composed)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk))
 ((s0 ~1-10)(s1 ~2-10)(cout ~2-11))
 ((1- fulladder ((a a0)(b b0)(cin ())) ((sum ~1-10)(cout ~1-11)))
  (2- fulladder ((a a1)(b b1)(cin ~1-11)) ((sum ~2-10)(cout ~2-11)))  ))
((lib fulladder)
 ((a unk)(b unk)(cin unk))
 ((sum ~10)(cout ~11))
 ((~1 (a))
  (~2 (b))
  (~3 (cin))
  (~4 (a b))
  (~5 (~1 ~2))
  (~6 (~4 ~5))
  (~7 (~3 ~4 ~5))
  (~8 (cin ~6))
  (~9 (~5 ~7))
  (~10 (~7 ~8))
  (~11 (~9))   ))

;;;
((main 2bit-adder-iterative-composed-expanded)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk))
 ((s0 ~1-10)(s1 ~2-10)(cout ~2-11))
 ((~1-1 (a0))
  (~1-2 (b0))
  (~1-4 (a0 b0))
  (~1-11 (~1-1 ~1-2))
  (~1-10 (~1-4 ~1-11))
  (~2-1 (a1))
  (~2-2 (b1))
  (~2-3 (~1-11))
  (~2-4 (a1 b1))
  (~2-5 (~2-1 ~2-2))
  (~2-6 (~2-4 ~2-5))
  (~2-7 (~2-3 ~2-4 ~2-5))
  (~2-8 (~1-11 ~2-6))
  (~2-9 (~2-5 ~2-7))
  (~2-10 (~2-7 ~2-8))
  (~2-11 (~2-9))   ))
```

```
;;;verify
((main 2bit-adder-carry-lookahead)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk))
 ((s0 ~9)(s1 ~16)(cout ~19))
 ((~1 (a0))
  (~2 (b0))
  (~3 (a1))
  (~4 (b1))
  (~5 (a0 b0))
  (~6 (a1 b1))
  (~7 (~1 ~2))
  (~8 (~3 ~4))
  (~9 (~5 ~7))
  (~10 (~6 ~8))
  (~11 (~10))
  (~12 (~7 ~11))
  (~13 (~7))
  (~14 (~10 ~13))
  (~15 (~12 ~14))
  (~16 (~15))
  (~17 (~11 ~13))
  (~18 (~8 ~17))
  (~19 (~18))   ))

;;;
((main 2bit-adder-carry-bypass)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk))
 ((s0 ~9)(s1 ~17)(cout ~24))
 ((~1 (a0))
  (~2 (b0))
  (~3 (a1))
  (~4 (b1))
  (~5 (a0 b0))
  (~6 (a1 b1))
  (~7 (~1 ~2))
  (~8 (~3 ~4))
  (~9 (~5 ~7))
  (~10 (~6 ~8))
  (~11 (~9))
  (~12 (~7 ~11))
  (~13 (~12))
  (~14 (~10 ~13))
  (~15 (~10))
  (~16 (~12 ~15))
  (~17 (~14 ~16))
  (~18 (~11 ~15))
  (~19 (~8 ~16))
  (~20 (~19))
  (~21 (~18 ~20))
  (~22 (~18))
  (~23 (~22))
  (~24 (~21 ~23))   ))
```

```
;;;
((main 4bit-comparator-parallel)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk)(a2 unk)(b2 unk)(a3 unk)(b3 unk))
 ((equal ~26))
 ((~1 (a0))
  (~2 (b0))
  (~3 (a1))
  (~4 (b1))
  (~5 (a2))
  (~6 (b2))
  (~7 (a3))
  (~8 (b3))
  (~9 (a0 b0))
  (~10 (a1 b1))
  (~11 (a2 b2))
  (~12 (a3 b3))
  (~13 (~1 ~2))
  (~14 (~3 ~4))
  (~15 (~5 ~6))
  (~16 (~7 ~8))
  (~17 (~9 ~13))
  (~18 (~10 ~14))
  (~19 (~11 ~15))
  (~20 (~12 ~16))
  (~21 (~17 ~18))
  (~22 (~19 ~20))
  (~23 (~21))
  (~24 (~22))
  (~25 (~23 ~24))
  (~26 (~25))   ))
```

```
;;;
((main 4bit-magnitude-comparator-with-enables)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk)(a2 unk)(b2 unk)(a3 unk)(b3 unk)
  (engt unk)(eneq unk)(enlt unk))
 ((lt ~34)(eq ~36)(gt ~35))
 ((~1 (a0))
  (~2 (b0))
  (~3 (a1))
  (~4 (b1))
  (~5 (a2))
  (~6 (b2))
  (~7 (a3))
  (~8 (b3))
  (~9 (eneq))
  (~10 (a0 ~2))
  (~11 (b0 ~1))
  (~12 (a1 ~4))
  (~13 (b1 ~3))
  (~14 (a2 ~6))
  (~15 (b2 ~5))
  (~16 (a3 ~8))
  (~17 (b3 ~7))
  (~18 (a0 ~2 ~13))
  (~19 (b0 ~1 ~12))
  (~20 (~12 ~16))
  (~21 (~13 ~19))
  (~22 (~14 ~21))
  (~23 (~15 ~22))
  (~24 (~15 ~20))
  (~25 (~14 ~24))
  (~26 (~16 ~23))
  (~27 (~17 ~25))
  (~28 (~17 ~26))
  (~29 (~16 ~27))
  (~30 (~9 ~28))
  (~31 (~9 ~29))
  (~32 (enlt ~30))
  (~33 (engt ~31))
  (~34 (~32))
  (~35 (~33))
  (~36 (~9 ~10 ~11 ~12 ~13 ~14 ~15 ~16~ ~17))   ))
```

```
;;;
((main 4bit-magnitude-comparator-two-level)
 ((a0 unk)(b0 unk)(a1 unk)(b1 unk)(a2 unk)(b2 unk)(a3 unk)(b3 unk)
  (eneq unk)(engt unk)(enlt unk))
 ((lt ~51)(eq ~50)(gt ~52))
  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (j)   )
   (~10    (a ~2)   )
   (~11    (b ~1)   )
   (~12    (c ~4)   )
   (~13    (d ~3)   )
   (~14    (e ~6)   )
   (~15    (f ~5)   )
   (~16    (g ~8)   )
   (~17    (h ~7)   )
   (~18    (g ~8 ~9)   )
   (~19    (h ~7 ~9)   )
   (~20    (e g ~6 ~9)   )
   (~21    (e ~6 ~8 ~9)   )
   (~22    (f h ~5 ~9)   )
   (~23    (f ~5 ~7 ~9)   )
   (~24    (c e g ~4 ~9)   )
   (~25    (c e ~4 ~8 ~9)   )
   (~26    (c g ~4 ~6 ~9)   )
   (~27    (c ~4 ~6 ~8 ~9)   )
   (~28    (d f h ~3 ~9)   )
   (~29    (d f ~3 ~7 ~9)   )
   (~30    (d h ~3 ~5 ~9)   )
   (~31    (d ~3 ~5 ~7 ~9)   )
   (~32    (a c e g ~2 ~9)   )
   (~33    (a c e ~2 ~8 ~9)   )
   (~34    (a c g ~2 ~6 ~9)   )
   (~35    (a c ~2 ~6 ~8 ~9)   )
   (~36    (a e g ~2 ~4 ~9)   )
   (~37    (a e ~2 ~4 ~8 ~9)   )
   (~38    (a g ~2 ~4 ~6 ~9)   )
   (~39    (a ~2 ~4 ~6 ~8 ~9)   )
   (~40    (b d f h ~1 ~9)   )
   (~41    (b d f ~1 ~7 ~9)   )
   (~42    (b d h ~1 ~5 ~9)   )
   (~43    (b d ~1 ~5 ~7 ~9)   )
   (~44    (b f h ~1 ~3 ~9)   )
   (~45    (b f ~1 ~3 ~7 ~9)   )
   (~46    (b h ~1 ~3 ~5 ~9)   )
   (~47    (b ~1 ~3 ~5 ~7 ~9)   )
   (~48    (i ~18 ~20 ~21 ~24 ~25 ~26 ~27 ~32 ~33 ~34 ~35 ~36 ~37 ~38 ~39)   )
   (~49    (k ~19 ~22 ~23 ~28 ~29 ~30 ~31 ~40 ~41 ~42 ~43 ~44 ~45 ~46 ~47)   )
   (~50    (~9 ~10 ~11 ~12 ~13 ~14 ~15 ~16 ~17)   )
   (~51    (~48)   )
   (~52    (~49)   )  ))
```

```
;;;
((main 4bit-shiftregister-serialin-serialout)
 ((a unk))
 ((oa !4))
 ((!1 (@ (a)))
  (!2 (@ (!1)))
  (!3 (@ (!2)))
  (!4 (@ (!3)))   ))

;;;
((main 4bit-shiftregister-serialin-parallelout)
 ((a unk))
 ((oa !1) (ob !2)(oc !3)(od !4))
 ((!1 (@ (a)))
  (!2 (@ (!1)))
  (!3 (@ (!2)))
  (!4 (@ (!3)))   ))

;;;
((main 4bit-shiftregister-serial-parallel-load)
 ((a unk)(b unk)(c unk)(d unk)(sin unk)(load unk))
 ((oa !1)(ob !2)(oc !3)(od !4))
 ((!1 (@ (~30)))
  (!2 (@ (~26)))
  (!3 (@ (~22)))
  (!4 (@ (~18)))
  (~5 (!1))
  (~6 (!2))
  (~7 (!3))
  (~8 (!4))
  (~9 (a))
  (~10 (b))
  (~11 (c))
  (~12 (d))
  (~13 (sin))
  (~14 (load))
  (~15 (load ~13))
  (~16 (~12 ~14))
  (~17 (~15 ~16))
  (~18 (~17))
  (~19 (load ~8))
  (~20 (~11 ~14))
  (~21 (~19 ~20))
  (~22 (~21))
  (~23 (load ~7))
  (~24 (~10 ~14))
  (~25 (~23 ~24))
  (~26 (~25))
  (~27 (load ~6))
  (~28 (~9 ~14))
  (~29 (~27 ~28))
  (~30 (~29))   ))
```

```
;;;
((main 4bit-shiftregister-parallelin-serialout)
 ((a unk)(b unk)(c unk)(d unk)(sin unk)(load unk))
 ((oa !4))
 ((!1 (@ (~17)))
  (!2 (@ (~21)))
  (!3 (@ (~25)))
  (!4 (@ (~29)))
  (~5 (!1))
  (~6 (!2))
  (~7 (!3))
  (~8 (a))
  (~9 (b))
  (~10 (c))
  (~11 (d))
  (~12 (sin))
  (~13 (load))
  (~14 (load ~12))
  (~15 (~8 ~13))
  (~16 (~14 ~15))
  (~17 (~16))
  (~18 (load ~5))
  (~19 (~9 ~13))
  (~20 (~18 ~19))
  (~21 (~20))
  (~22 (load ~6))
  (~23 (~10 ~13))
  (~24 (~22 ~23))
  (~25 (~24))
  (~26 (load ~7))
  (~27 (~11 ~13))
  (~28 (~26 ~27))
  (~29 (~28))   ))

;;;
((main 4bit-shiftregister-bidirectional)
 ((rin unk)(lin unk)(dir unk))
 ((oa !1)(ob !2)(oc !3)(od !4))
 ((!1 (@ (~15)))
  (!2 (@ (~19)))
  (!3 (@ (~23)))
  (!4 (@ (~27)))
  (~5 (!1))
  (~6 (!2))
  (~7 (!3))
  (~8 (!4))
  (~9 (rin))
  (~10 (lin))
  (~11 (dir))
  (~12 (~9 ~11))
  (~13 (dir ~6))
  (~14 (~12 ~13))
  (~15 (~14))
  (~16 (~5 ~11))
  (~17 (dir ~7))
  (~18 (~16 ~17))
  (~19 (~18))
  (~20 (~6 ~11))
  (~21 (dir ~8))
  (~22 (~20 ~21))
  (~23 (~22))
  (~24 (~7 ~11))
  (~25 (dir ~10))
  (~26 (~24 ~25))
  (~27 (~26))   ))
```

```
;;;
((main 4bit-ripple-counter)
 ()
 ((oa !1)(ob !2)(oc !3)(od !4))
 ((!1 @)
  (!2 (@ (~8)))
  (!3 (@ (~9)))
  (!4 (@ (~10)))
  (~5 (!1))
  (~6 (!2))
  (~7 (!3))
  (~8 (~5))
  (~9 (~6))
  (~10 (~7))   ))

;;;
((main 4bit-synchronous-counter-serialenable)
 ((en unk))
 ((oa !1)(ob !2)(oc !3)(od !4))
 ((!1 (@ ()))
  (!2 (@ (~10)))
  (!3 (@ (~12)))
  (!4 (@ (~14)))
  (~5 (!1))
  (~6 (!2))
  (~7 (!3))
  (~8 (en))
  (~9 (~5 ~8))
  (~10 (~9))
  (~11 (~6 ~10))
  (~12 (~11))
  (~13 (~7 ~12))
  (~14 (~13))   ))

;;;
((main 4bit-synchronous-counter)
 ()
 ((oa !1)(ob !2)(oc !3)(od !4))
 ((!1 (@ ()))
  (!2 (@ (~11)))
  (!3 (@ (~14)))
  (!4 (@ (~17)))
  (~5 (!1))
  (~6 (!2))
  (~7 (!3))
  (~8 (!4))
  (~9 (!1 !2))
  (~10 (~5 ~6))
  (~11 (~9 ~10))
  (~12 (!3 ~10))
  (~13 (~5 ~6 ~7))
  (~14 (~12 ~13))
  (~15 (!4 ~13))
  (~16 (~5 ~6 ~7 ~8))
  (~17 (~15 ~16))   ))
```

```
;;;
((main 4bit-johnson-counter-decode)
 ()
 ((oa ~12)(ob ~13)(oc ~14)(od ~15)(oe ~16)(of ~17)(og ~18)(oh ~19))
 ((!1 (@ (~9)))
  (!2 (@ (~10)))
  (!3 (@ (~11)))
  (!4 (@ (~5)))
  (~5 (!1))
  (~6 (!2))
  (~7 (!3))
  (~8 (!4))
  (~9 (~6))
  (~10 (~7))
  (~11 (~8))
  (~12 (~5 ~8))
  (~13 (!4 ~7))
  (~14 (!3 ~6))
  (~15 (!2 ~5))
  (~16 (!1 !4))
  (~17 (!3 ~8))
  (~18 (!2 ~7))
  (~19 (!1 ~6))   ))

;;;
((main fulladder-serial)
 ((a unk)(b unk)(cin unk)(reset unk))
 ((sum ~11)(cout !1))
 ((!1 (@ (~13)))
  (~2 (a))
  (~3 (b))
  (~4 (!1))
  (~5 (a b))
  (~6 (~2 ~3))
  (~7 (~5 ~6))
  (~8 (~4 ~5 ~6))
  (~9 (!1 ~7))
  (~10 (~6 ~8))
  (~11 (~8 ~9))
  (~12 (reset))
  (~13 (~10 ~12))
   ))

;;;
((main 2bit-comparator-serial)
 ((a unk)(b unk)(reset unk))
 ((eq ~10))
 ((!1 (@ (~11)))
  (~2 (!1))
  (~3 (reset))
  (~4 (a))
  (~5 (b))
  (~6 (a b))
  (~7 (~4 ~5))
  (~8 (~6 ~7))
  (~9 (~2 ~8))
  (~10 (~3 ~9))
  (~11 (~10))   ))
```

```
;;;
((main 15cent-vending-FSM)
 ((nick unk)(dime unk))
 ((open ~14))
 ((!1 (@ (~11)))
  (!2 (@ (~13)))
  (~3 (!1))
  (~4 (nick))
  (~5 (nick !1))
  (~6 (nick ~3))
  (~7 (!1 ~4))
  (~8 (nick !2))
  (~9 (dime !2))
  (~10 (dime !2 ~5))
  (~11 (~10))
  (~12 (~6 ~7 ~8 ~9))
  (~13 (~12))
  (~14 (!1 !2))   ))

;;;
((main lion)
 ((a unk)(b unk))
 ((oa ~17))
 ((!1 (@ (~15)))
  (!2 (@ (~16)))
  (~3 (a))
  (~4 (!1))
  (~5 (!2))
  (~6 (a b !1))
  (~7 (b !2))
  (~8 (a ~4))
  (~9 (b ~4))
  (~10 (~9))
  (~11 (~3 ~10))
  (~12 (a ~7))
  (~13 (~5 ~6))
  (~14 (!2 ~8 ~9))
  (~15 (~8 ~12))
  (~16 (~11 ~13))
  (~17 (~14))   ))
```

```
;;;
((main daio)
 ((a unk))
 ((oa ~20))
 ((!1 (@ (~5)))
  (!2 (@ (~6)))
  (!3 (@ (~19)))
  (!4 (@ (~21)))
  (~5 (a))
  (~6 (!1))
  (~7 (!2))
  (~8 (!3))
  (~9 (!4))
  (~10 (!1 !2))
  (~11 (!2 !3))
  (~12 (~5 ~6))
  (~13 (~6 ~7))
  (~14 (~8 ~9))
  (~15 (~10 ~12))
  (~16 (~11 ~13))
  (~17 (~16))
  (~18 (!4 ~17))
  (~19 (~15 ~16))
  (~20 (~8 ~19))
  (~21 (~14 ~18))   ))

;;;
((main s27)
 ((a unk)(b unk)(c unk)(d unk))
 ((oa ~32))
 ((!1 (@ (~29)))
  (!2 (@ (~30)))
  (!3 (@ (~31)))
  (~4 (a))
  (~5 (b))
  (~6 (c))
  (~7 (d))
  (~8 (!1))
  (~9 (!2))
  (~10 (!3))
  (~11 (d !1))
  (~12 (d ~4))
  (~13 (~4 ~5))
  (~14 (~4 ~9))
  (~15 (~4 ~10))
  (~16 (!1 ~5))
  (~17 (!1 ~10))
  (~18 (a ~8))
  (~19 (a c ~5))
  (~20 (~4 ~5 ~6))
  (~21 (~4 ~6 ~9))
  (~22 (~4 ~6 ~10))
  (~23 (a c !3 ~9))
  (~24 (a c !2 ~10))
  (~25 (b ~4 ~9 ~10))
  (~26 (b d !2 !3 ~4))
  (~27 (b !2 !3 ~11))
  (~28 (~2 ~11 ~12 ~13 ~15 ~16 ~17))
  (~29 (~18 ~27))
  (~30 (~12 ~13 ~14 ~15))
  (~31 (~19 ~20 ~21 ~22 ~23 ~24 ~25 ~26))
  (~32 (~28))   ))
```