PUN-ENCODED CM85A CIRCUITS

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SCHEMATIC 1: Two-level Logic (PLD)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 50)
  (cm85a ((i-o 11-03) (cell 52) (lits 226) (nets 63) (path 2))
   ((inv 11) (or 38) (and 1) (nor 0) (nand 2) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 41))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~50) (gt ~51) (lt ~52))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (i)   )
   (~10    (j)   )
   (~11    (k)   )
   (~12    ((a ~2))   )
   (~13    ((b ~1))   )
   (~14    ((c ~4))   )
   (~15    ((d ~3))   )
   (~16    ((e ~6))   )
   (~17    ((f ~5))   )
   (~18    ((g ~8))   )
   (~19    ((h ~7))   )
   (~20    ((g ~8 ~10))   )
   (~21    ((h ~7 ~10))   )
   (~22    ((e g ~6 ~10))   )
   (~23    ((e ~6 ~8 ~10))   )
   (~24    ((f h ~5 ~10))   )
   (~25    ((f ~5 ~7 ~10))   )
   (~26    ((c e g ~4 ~10))   )
   (~27    ((c e ~4 ~8 ~10))   )
   (~28    ((c g ~4 ~6 ~10))   )
   (~29    ((c ~4 ~6 ~8 ~10))   )
   (~30    ((d f h ~3 ~10))   )
   (~31    ((d f ~3 ~7 ~10))   )
   (~32    ((d h ~3 ~5 ~10))   )
   (~33    ((d ~3 ~5 ~7 ~10))   )
   (~34    ((a c e g ~2 ~10))   )
   (~35    ((a c e ~2 ~8 ~10))   )
   (~36    ((a c g ~2 ~6 ~10))   )
   (~37    ((a c ~2 ~6 ~8 ~10))   )
   (~38    ((a e g ~2 ~4 ~10))   )
   (~39    ((a e ~2 ~4 ~8 ~10))   )
   (~40    ((a g ~2 ~4 ~6 ~10))   )
   (~41    ((a ~2 ~4 ~6 ~8 ~10))   )
   (~42    ((b d f h ~1 ~10))   )
   (~43    ((b d f ~1 ~7 ~10))   )
   (~44    ((b d h ~1 ~5 ~10))   )
   (~45    ((b d ~1 ~5 ~7 ~10))   )
   (~46    ((b f h ~1 ~3 ~10))   )
   (~47    ((b f ~1 ~3 ~7 ~10))   )
   (~48    ((b h ~1 ~3 ~5 ~10))   )
   (~49    ((b ~1 ~3 ~5 ~7 ~10))   )
   (~50    ((j) (~12) (~13) (~14) (~15) (~16) (~17) (~18) (~19))   )
   (~51    (((~9) (~20) (~22) (~23) (~26) (~27) (~28) (~29)
             (~34) (~35) (~36) (~37) (~38) (~39) (~40) (~41)))   )
   (~52    (((~11) (~21) (~24) (~25) (~30) (~31) (~32) (~33)
             (~42) (~43) (~44) (~45) (~46) (~47) (~48) (~49)))   )
  )) )
```

Fully expanded:

```
((cm85a parens-pun pun02 pun02 75-main 0.0 (2001 11 24 23 16 57)
  (cm85a ((i-o 11-03) (cell 3) (lits 177) (nets 157) (path 2))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     ((j)
            (a (b))
            (b (a))
            (c (d))
            (d (c))
            (e (f))
            (f (e))
            (g (h))
            (h (g)))   )
   (~2     ((i
             (g (h) (j))
             (e g (f) (j))
             (e (f) (h) (j))
             (c e g (d) (j))
             (c e (d) (h) (j))
             (c g (d) (f) (j))
             (c (d) (f) (h) (j))
             (a c e g (b) (j))
             (a c e (b) (h) (j))
             (a c g (b) (f) (j))
             (a c (b) (f) (h) (j))
             (a e g (b) (d) (j))
             (a e (b) (d) (h) (j))
             (a g (b) (d) (f) (j))
            (a (b) (d) (f) (h) (j))))   )
   (~3     ((k
             (h (g) (j))
             (f h (e) (j))
             (f (e) (g) (j))
             (d f h (c) (j))
             (d f (c) (g) (j))
             (d h (c) (e) (j))
             (d (c) (e) (g) (j))
             (b d f h (a) (j))
             (b d f (a) (g) (j))
             (b d h (a) (e) (j))
             (b d (a) (e) (g) (j))
             (b f h (a) (c) (j))
             (b f (a) (c) (g) (j))
             (b h (a) (c) (e) (j))
             (b (a) (c) (e) (g) (j))))   )
  )) )
```

SCHEMATIC 2: Multilevel Benchmark Circuit (cm85a)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 51)
  (cm85a ((i-o 11-03) (cell 76) (lits 120) (nets 87) (path 8))
   ((inv 32) (or 18) (and 26) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 44))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~61) (gt ~65) (lt ~66))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (i)   )
   (~10    (j)   )
   (~11    (k)   )
   (~12    (~37)   )
   (~13    (~38)   )
   (~14    (~41)   )
   (~15    (~42)   )
   (~16    (~43)   )
   (~17    (~44)   )
   (~18    (~45)   )
   (~19    (~46)   )
   (~20    (~62)   )
   (~21    (~63)   )
   (~22    (~68)   )
   (~23    (~67)   )
   (~24    (~64)   )
   (~25    (~69)   )
   (~26    (~70)   )
   (~27    (~71)   )
   (~28    (~72)   )
   (~29    (~76)   )
   (~30    (~75)   )
   (~31    (~74)   )
   (~32    (~73)   )
   (~33    ((c) (d))   )
   (~34    ((g) (h))   )
   (~35    ((a) (~2))    )
   (~36    ((b) (~1))    )
   (~37    ((c) (~4))    )
   (~38    ((d) (~3))    )
   (~39    ((e) (~6))    )
   (~40    ((f) (~5))    )
   (~41    ((g) (~8))    )
   (~42    ((h) (~7))    )
   (~43    ((a ~2))    )
   (~44    ((b ~1))    )
   (~45    ((e ~6))    )
   (~46    ((f ~5))    )
   (~47    ((~3) (~4))   )
   (~48    ((~7) (~8))   )
   (~49    ((~9) (~10))    )
   (~50    ((~9) (~15))    )
   (~51    ((~10) (~11))   )
   (~52    ((~11) (~14))   )
   (~53    ((~13) (~23))   )
   (~54    ((~12) (~22))   )
   (~55    ((~17) (~24))   )
   (~56    ((~16) (~24))   )
   (~57    ((~19) (~21))   )
   (~58    ((~18) (~21))   )
   (~59    ((~20) (~23))   )
   (~60    ((~20) (~22))   )
   (~61    ((~24) (~27))   )
   (~62    ((~21) (~28))   )
   (~63    ((~10 ~26))   )
   (~64    ((~20 ~25))   )
   (~65    ((~29 ~56))   )
   (~66    ((~30 ~55))   )
   (~67    ((~31 ~58))   )
   (~68    ((~32 ~57))   )
   (~69    ((~33 ~47))   )
   (~70    ((~34 ~48))   )
   (~71    ((~35 ~36))   )
   (~72    ((~39 ~40))   )
   (~73    ((~51 ~52))   )
   (~74    ((~49 ~50))   )
   (~75    ((~54 ~60))   )
   (~76    ((~53 ~59))   )
  )) )
```

SCHEMATIC 3: Suppress Inverters

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 53)
  (cm85a ((i-o 11-03) (cell 55) (lits 99) (nets 66) (path 8))
   ((inv 11) (or 2) (and 21) (nor 16) (nand 5) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 44))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~50) (gt ~53) (lt ~54))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (i)   )
   (~10    (j)   )
   (~11    (k)   )
   (~12    ((c) (d))   )
   (~13    ((g) (h))   )
   (~14    (a ~2)   )
   (~15    (b ~1)   )
   (~16    (e ~6)   )
   (~17    (f ~5)   )
   (~18    ((a) (~2))   )
   (~19    ((b) (~1))   )
   (~20    ((e) (~6))   )
   (~21    ((f) (~5))   )
   (~22    (((c) (~4)))   )
   (~23    (((d) (~3)))   )
   (~24    (((g) (~8)))   )
   (~25    (((h) (~7)))   )
   (~26    (~10 ~28)   )
   (~27    (~12 ~38)   )
   (~28    (~13 ~39)   )
   (~29    (~18 ~19)   )
   (~30    (~20 ~21)   )
   (~31    (~27 ~55)   )
   (~32    (~35 ~46)   )
   (~33    (~34 ~47)   )
   (~34    (~42 ~43)   )
   (~35    (~40 ~41)   )
   (~36    (~49 ~51)   )
   (~37    (~48 ~52)   )
   (~38    ((~3) (~4))   )
   (~39    ((~7) (~8))   )
   (~40    ((~9) (~10))   )
   (~41    ((~9) (~25))   )
   (~42    ((~10) (~11))   )
   (~43    ((~11) (~24))   )
   (~44    ((~14) (~31))   )
   (~45    ((~15) (~31))   )
   (~46    ((~16) (~26))   )
   (~47    ((~17) (~26))   )
   (~48    ((~22) (~33))   )
   (~49    ((~23) (~32))   )
   (~50    ((~29) (~31))   )
   (~51    ((~32) (~55))   )
   (~52    ((~33) (~55))   )
   (~53    ((~36 ~44))   )
   (~54    ((~37 ~45))   )
   (~55    (((~26) (~30)))   )
  )) )
```

SCHEMATIC 4: Remove Redundancy

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 54)
  (cm85a ((i-o 11-03) (cell 45) (lits 81) (nets 56) (path 7))
   ((inv 13) (or 16) (and 8) (nor 8) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 32))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~12) (gt ~40) (lt ~41))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (j)   )
   (~10    (~42)   )
   (~11    (~45)   )
   (~12    (~43)   )
   (~13    (~44)   )
   (~14    ((i j))   )
   (~15    ((j k))   )
   (~16    (a ~2)   )
   (~17    (b ~1)   )
   (~18    (c ~4)   )
   (~19    (d ~3)   )
   (~20    (e ~6)   )
   (~21    (f ~5)   )
   (~22    (g ~8)   )
   (~23    (h ~7)   )
   (~24    ((i ~22))   )
   (~25    ((k ~23))   )
   (~26    ((~10) (~20))   )
   (~27    ((~10) (~21))   )
   (~28    ((~13) (~16))   )
   (~29    ((~13) (~17))   )
   (~30    ((~14) (~24))   )
   (~31    ((~15) (~25))   )
   (~32    ((~35) (~37))   )
   (~33    ((~34) (~36))   )
   (~34    ((~11 ~38))   )
   (~35    ((~11 ~39))   )
   (~36    ((~18 ~38))   )
   (~37    ((~19 ~39))   )
   (~38    ((~26 ~30))   )
   (~39    ((~27 ~31))   )
   (~40    ((~28 ~33))   )
   (~41    ((~29 ~32))   )
   (~42    ((~9 ~22 ~23))   )
   (~43    ((~16 ~17 ~44))   )
   (~44    ((~18 ~19 ~45))   )
   (~45    ((~20 ~21 ~42))   )
  )) )
```

SCHEMATIC 5: Reduce Reconvergence

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 55)
  (cm85a ((i-o 11-03) (cell 37) (lits 69) (nets 48) (path 6))
   ((inv 13) (or 8) (and 8) (nor 8) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 24))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~12) (gt ~37) (lt ~36))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (j)   )
   (~10    (~32)   )
   (~11    (~35)   )
   (~12    (~33)   )
   (~13    (~34)   )
   (~14    (a ~2)   )
   (~15    (b ~1)   )
   (~16    (c ~4)   )
   (~17    (d ~3)   )
   (~18    (e ~6)   )
   (~19    (f ~5)   )
   (~20    (g ~8)   )
   (~21    (h ~7)   )
   (~22    ((j) (~20))   )
   (~23    ((j) (~21))   )
   (~24    ((~11) (~16))   )
   (~25    ((~11) (~17))   )
   (~26    ((~10) (~18))   )
   (~27    ((~10) (~19))   )
   (~28    ((~13) (~14))   )
   (~29    ((~13) (~15))   )
   (~30    ((i ~22 ~26))   )
   (~31    ((k ~23 ~27))   )
   (~32    ((~9 ~20 ~21))   )
   (~33    ((~14 ~15 ~34))   )
   (~34    ((~16 ~17 ~35))   )
   (~35    ((~18 ~19 ~32))   )
   (~36    ((~25 ~29 ~31))   )
   (~37    ((~24 ~28 ~30))   )
  )) )
```

SCHEMATIC 6a: Increase Fanin (poor choice)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 57)
  (cm85a ((i-o 11-03) (cell 35) (lits 67) (nets 46) (path 6))
   ((inv 11) (or 3) (and 6) (nor 15) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 24))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~35) (gt ~33) (lt ~34))

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

SCHEMATIC 6b: Increase Fanin (good choice)

```
((cm85a test pun02 pun02 75-main 0.0 (2001 11 24 23 16 57)
  (cm85a ((i-o 11-03) (cell 35) (lits 67) (nets 46) (path 6))
   ((inv 13) (or 6) (and 8) (nor 8) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 22))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~12) (gt ~34) (lt ~35))

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

SCHEMATIC 7a: Enhance Testability (poor choice)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 57)
  (cm85a ((i-o 11-03) (cell 40) (lits 72) (nets 51) (path 9))
   ((inv 13) (or 2) (and 0) (nor 21) (nand 0) (eq 4) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 27))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~36) (gt ~20) (lt ~21))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (j)   )
   (~10    (~37=)   )
   (~11    (~38=)   )
   (~12    (~39=)   )
   (~13    (~40=)   )
   (~14    (c ~4)   )
   (~15    (d ~3)   )
   (~16    (e ~6)   )
   (~17    (f ~5)   )
   (~18    (g ~8)   )
   (~19    (h ~7)   )
   (~20    ((i ~22))   )
   (~21    ((k ~23))   )
   (~22    (~9 ~31)   )
   (~23    (~9 ~33)   )
   (~24    (~14 ~34)   )
   (~25    (~15 ~35)   )
   (~26    (~16 ~25)   )
   (~27    (~16 ~28)   )
   (~28    (~17 ~24)   )
   (~29    (~17 ~26)   )
   (~30    (~18 ~29)   )
   (~31    (~18 ~32)   )
   (~32    (~19 ~27)   )
   (~33    (~19 ~30)   )
   (~34    (a ~2 ~15)   )
   (~35    (b ~1 ~14)   )
   (~36    (~9 ~10 ~11 ~12 ~13)   )
   (~37=   (((a b) ((a) (b))))   )
   (~38=   (((c d) ((c) (d))))   )
   (~39=   (((e f) ((e) (f))))   )
   (~40=   (((g h) ((g) (h))))   )
  )) )
```

SCHEMATIC 7b: Enhance Testability (good choice)

```
((cm85a test pun02 pun02 75-main 0.0 (2001 11 24 23 16 57)
  (cm85a ((i-o 11-03) (cell 36) (lits 68) (nets 47) (path 9))
   ((inv 11) (or 2) (and 0) (nor 23) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 25))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~36) (gt ~20) (lt ~21))

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

SCHEMATIC 8: Reduce Critical Path (6 gates)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 58)
  (cm85a ((i-o 11-03) (cell 40) (lits 80) (nets 51) (path 6))
   ((inv 15) (or 4) (and 0) (nor 21) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 25))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~40) (gt ~28) (lt ~29))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (j)   )
   (~10    (~18)   )
   (~11    (~19)   )
   (~12    (~20)   )
   (~13    (~21)   )
   (~14    (~22)   )
   (~15    (~23)   )
   (~16    (i j)   )
   (~17    (j k)   )
   (~18    (a ~2)   )
   (~19    (b ~1)   )
   (~20    (c ~4)   )
   (~21    (d ~3)   )
   (~22    (e ~6)   )
   (~23    (f ~5)   )
   (~24    (g ~8)   )
   (~25    (h ~7)   )
   (~26    (~14 ~25)   )
   (~27    (~15 ~24)   )
   (~28    (~16 ~34)   )
   (~29    (~17 ~35)   )
   (~30    ((~26 ~32))   )
   (~31    ((~27 ~33))   )
   (~32    ((~36 ~38))   )
   (~33    ((~37 ~39))   )
   (~34    (i ~24 ~30)   )
   (~35    (k ~25 ~31)   )
   (~36    (~12 ~23 ~25)   )
   (~37    (~13 ~22 ~24)   )
   (~38    (~10 ~21 ~23 ~25)   )
   (~39    (~11 ~20 ~22 ~24)   )
   (~40    (~9 ~18 ~19 ~20 ~21 ~22 ~23 ~24 ~25)   )
  )) )
```

SCHEMATIC 9: Pipeline (3 two-input gates)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 25 0 1 41)
  (cm85a ((i-o 11-03) (cell 43) (lits 75) (nets 54) (path 9))
   ((inv 11) (or 9) (and 0) (nor 23) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 32))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~37) (gt ~42) (lt ~43))

  ((1-     stage-1 (i k ~9 ~16 ~17 ~18 ~19 ~24 ~25 ~28 ~29)   )
   (2-     stage-2 (i k ~9 ~18 ~19 ~34 ~35 ~37)   )
   (3-     stage-3 (~37 ~42 ~43)   )
   ))
 ((stage-1)
  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (j)   )
   (~10    (~12)   )
   (~11    (~13)   )
   (~12    (a ~2)   )
   (~13    (b ~1)   )
   (~14    (c ~4)   )
   (~15    (d ~3)   )
   (~16    (e ~6)   )
   (~17    (f ~5)   )
   (~18    (g ~8)   )
   (~19    (h ~7)   )
   (~20    ((~12 ~13))   )
   (~21    ((~14 ~15))   )
   (~22    ((~16 ~17))   )
   (~23    ((~18 ~19))   )
   (~24    ((~20 ~21))   )
   (~25    ((~22 ~23))   )
   (~26    (~10 ~15)   )
   (~27    (~11 ~14)   )
   (~28    (~14 ~26)   )
   (~29    (~15 ~27)   )
   ))
 ((stage-2)
  ((~30    (~16 ~29)   )
   (~31    (~17 ~28)   )
   (~32    (~16 ~31)   )
   (~33    (~17 ~30)   )
   (~34    (~18 ~33)   )
   (~35    (~19 ~32)   )
   (~36    (~9 ~37)   )
   (~37    ((~24 ~25))   )
   ))
 ((stage-3)
  ((~38    (~18 ~35)   )
   (~39    (~19 ~34)   )
   (~40    (~9 ~38)   )
   (~41    (~9 ~39)   )
   (~42    ((i ~40))   )
   (~43    ((k ~41))   )
  )) )
```

SCHEMATIC 10a: Map to Specific Library (poor choice)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 15 59)
  (cm85a ((i-o 11-03) (cell 39) (lits 79) (nets 50) (path 10))
   ((inv 7) (or 10) (and 9) (nor 8) (nand 1) (eq 0) (xor 4) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 32))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~25) (gt ~21) (lt ~22))

  ((~1     (c)   )
   (~2     (d)   )
   (~3     (e)   )
   (~4     (f)   )
   (~5     (g)   )
   (~6     (h)   )
   (~7     (~36=)   )
   (~8     (a ~11)   )
   (~9     (b ~10)   )
   (~10    (c ~2)   )
   (~11    (d ~1)   )
   (~12    (e ~4)   )
   (~13    (g ~6)   )
   (~14    ((a) (~9))   )
   (~15    ((b) (~8))   )
   (~16    ((j) (~7))   )
   (~17    ((j) (~33))   )
   (~18    ((j) (~35))   )
   (~19    ((f ~3))   )
   (~20    ((h ~5))   )
   (~21    ((i ~17))   )
   (~22    ((k ~18))   )
   (~23    (~11 ~14)   )
   (~24    (~34 ~39=)   )
   (~25    ((~16) (~24))   )
   (~26    ((~19) (~30))   )
   (~27    ((~19) (~29))   )
   (~28    ((~20) (~31))   )
   (~29    ((~10 ~15))   )
   (~30    ((~12 ~23))   )
   (~31    ((~12 ~27))   )
   (~32    ((~13 ~26))   )
   (~33    ((~13 ~28))   )
   (~34    ((~37= ~38=))   )
   (~35    (((~20) (~32)))   )
   (~36=   ((a b) ((a) (b)))   )
   (~37=   ((c d) ((c) (d)))   )
   (~38=   ((e f) ((e) (f)))   )
   (~39=   ((g h) ((g) (h)))   )
  )) )
```

SCHEMATIC 10b: Map to Specific Library (good choice)

```
((cm85a test pun02 pun02 75-main 0.0 (2001 11 24 23 16 58)
  (cm85a ((i-o 11-03) (cell 32) (lits 64) (nets 43) (path 9))
   ((inv 0) (or 2) (and 4) (nor 12) (nand 10) (eq 4) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 32))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~24) (gt ~27) (lt ~28))

  ((~1     (((g) (j)))   )
   (~2     (((h) (j)))   )
   (~3     (a ~15)   )
   (~4     (b ~14)   )
   (~5     (c ~17)   )
   (~6     (d ~16)   )
   (~7     (e ~19)   )
   (~8     (f ~18)   )
   (~9     (g ~2)   )
   (~10    (h ~1)   )
   (~11    (i ~3)   )
   (~12    (k ~4)   )
   (~13    ((j) (~32=))   )
   (~14    (((a) (~23)))   )
   (~15    (((b) (~23)))   )
   (~16    (((c) (~22)))   )
   (~17    (((d) (~22)))   )
   (~18    (((e) (~13)))   )
   (~19    (((f) (~13)))   )
   (~20    (~9 ~25)   )
   (~21    (~10 ~26)   )
   (~22    ((~13) (~31=))   )
   (~23    ((~22) (~30=))   )
   (~24    ((~23) (~29=))   )
   (~25    ((~5 ~7))   )
   (~26    ((~6 ~8))   )
   (~27    (((~11) (~20)))   )
   (~28    (((~12) (~21)))   )
   (~29=   (((a b) ((a) (b))))   )
   (~30=   (((c d) ((c) (d))))   )
   (~31=   (((e f) ((e) (f))))   )
   (~32=   (((g h) ((g) (h))))   )
  )) )
```

SCHEMATIC 11: Three-level Logic

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 16 0)
  (cm85a ((i-o 11-03) (cell 23) (lits 67) (nets 34) (path 4))
   ((inv 8) (or 2) (and 9) (nor 0) (nand 0) (eq 4) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 15))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~17) (gt ~18) (lt ~19))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     ((a) (j) (~2) (~21=) (~22=) (~23=))   )
   (~10    ((b) (j) (~1) (~21=) (~22=) (~23=))   )
   (~11    ((c) (j) (~4) (~22=) (~23=))   )
   (~12    ((d) (j) (~3) (~22=) (~23=))   )
   (~13    ((e) (j) (~6) (~23=))   )
   (~14    ((f) (j) (~5) (~23=))   )
   (~15    ((g) (j) (~8))   )
   (~16    ((h) (j) (~7))   )
   (~17    ((j) (~20=) (~21=) (~22=) (~23=))   )
   (~18    ((i ~10 ~12 ~14 ~16))   )
   (~19    ((k ~9 ~11 ~13 ~15))   )
   (~20=   (((a b) ((a) (b))))   )
   (~21=   (((c d) ((c) (d))))   )
   (~22=   (((e f) ((e) (f))))   )
   (~23=   (((g h) ((g) (h))))   )
  )) )
```

SCHEMATIC 12: Map to NAND Gates

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 16 0)
  (cm85a ((i-o 11-03) (cell 64) (lits 96) (nets 75) (path 9))
   ((inv 32) (or 0) (and 0) (nor 0) (nand 32) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 32))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~22) (gt ~54) (lt ~53))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (i)   )
   (~10    (k)   )
   (~11    (~33)   )
   (~12    (~34)   )
   (~13    (~35)   )
   (~14    (~36)   )
   (~15    (~37)   )
   (~16    (~38)   )
   (~17    (~39)   )
   (~18    (~40)   )
   (~19    (~43)   )
   (~20    (~45)   )
   (~21    (~44)   )
   (~22    (~55)   )
   (~23    (~48)   )
   (~24    (~56)   )
   (~25    (~57)   )
   (~26    (~58)   )
   (~27    (~59)   )
   (~28    (~60)   )
   (~29    (~61)   )
   (~30    (~62)   )
   (~31    (~63)   )
   (~32    (~64)   )
   (~33    (((a) (~2)))   )
   (~34    (((b) (~1)))   )
   (~35    (((c) (~4)))   )
   (~36    (((d) (~3)))   )
   (~37    (((e) (~6)))   )
   (~38    (((f) (~5)))   )
   (~39    (((g) (~8)))   )
   (~40    (((h) (~7)))   )
   (~41    (((j) (~17)))   )
   (~42    (((j) (~18)))   )
   (~43    (((j) (~30)))   )
   (~44    (((~9) (~42)))   )
   (~45    (((~10) (~41)))   )
   (~46    (((~15) (~19)))   )
   (~47    (((~16) (~19)))   )
   (~48    (((~19) (~29)))   )
   (~49    (((~11) (~24)))   )
   (~50    (((~12) (~24)))   )
   (~51    (((~13) (~23)))   )
   (~52    (((~14) (~23)))   )
   (~53    (((~20) (~25)))   )
   (~54    (((~21) (~26)))   )
   (~55    (((~24) (~27)))   )
   (~56    (((~23) (~28)))   )
   (~57    (((~31) (~51)))   )
   (~58    (((~32) (~52)))   )
   (~59    (((~33) (~34)))   )
   (~60    (((~35) (~36)))   )
   (~61    (((~37) (~38)))   )
   (~62    (((~39) (~40)))   )
   (~63    (((~46) (~49)))   )
   (~64    (((~47) (~50)))   )
  )) )
```

SCHEMATIC 13: Map to FPGA (4-LUTs)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 16 2)
  (cm85a ((i-o 11-03) (cell 11) (lits 57) (nets 77) (path 9))
   ((inv 0) (or 2) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 9) (gates 2))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~3) (gt ~1) (lt ~2))

  ((~1     ((i ~8))   )
   (~2     ((k ~9))   )
   (~3     (~10 ~11 (j))   )
   (~4     ((e (f)) (~6 (f (e))))   )
   (~5     ((f (e)) (~7 (e (f))))   )
   (~6     ((c (d)) (a (b) (d (c))))   )
   (~7     ((d (c)) (b (a) (c (d))))   )
   (~8     ((j) ((g (h)) (~4 (h (g)))))   )
   (~9     ((j) ((h (g)) (~5 (g (h)))))   )
   (~10    (((a (b)) (b (a)) (e (f)) (f (e))))   )
   (~11    (((c (d)) (d (c)) (g (h)) (h (g))))   )
  )) )
```

SCHEMATIC 14: Binary Decision Diagram

```
((cm85a parens-pun pun01 pun01 75-main 0.0 (2001 11 24 23 16 3)
  (cm85a ((i-o 11-03) (cell 3) (lits 49) (nets 75) (path 9))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1   ((j) (a (b)) (b (a)) (c (d)) (d (c)) (e (f)) (f (e)) (g (h))
          (h (g)))   )
   (~2   ((i ((j) ((g (h)) ((h (g)) ((e (f)) ((f (e)) ((c (d)) (a (b) (d (c))))))))))
)
   (~3   ((k ((j) ((h (g)) ((g (h)) ((f (e)) ((e (f)) ((d (c)) (b (a) (c (d))))))))))
)
  )) )
```

Decision tree ~1:

```
(J 1 (B
      (A
       (D (C (F (E (H (G 1 0) (G 0 1)) 1) (E 1 (H (G 1 0) (G 0 1)))) 1)
          (C 1 (F (E (H (G 1 0) (G 0 1)) 1) (E 1 (H (G 1 0) (G 0 1))))))
       1)
      (A 1
         (D (C (F (E (H (G 1 0) (G 0 1)) 1) (E 1 (H (G 1 0) (G 0 1)))) 1)
            (C 1 (F (E (H (G 1 0) (G 0 1)) 1) (E 1 (H (G 1 0) (G 0 1)))))))))
```

Decision tree ~2:

```
(I (J 1
      (H
       (G
        (F (E (D (A (C (B 0 1) 1) 1) (C 1 (A (B 0 1) 1))) 1)
           (E 1 (D (A (C (B 0 1) 1) 1) (C 1 (A (B 0 1) 1)))))
        1)
       (G 1
          (F (E (D (A (C (B 0 1) 1) 1) (C 1 (A (B 0 1) 1))) 1)
             (E 1 (D (A (C (B 0 1) 1) 1) (C 1 (A (B 0 1) 1))))))))
   1)
```

Decision tree ~3:

```
(K (J 1
      (G
       (H
        (E (F (C (B (D (A 0 1) 1) 1) (D 1 (B (A 0 1) 1))) 1)
           (F 1 (C (B (D (A 0 1) 1) 1) (D 1 (B (A 0 1) 1)))))
        1)
       (H 1
          (E (F (C (B (D (A 0 1) 1) 1) (D 1 (B (A 0 1) 1))) 1)
             (F 1 (C (B (D (A 0 1) 1) 1) (D 1 (B (A 0 1) 1))))))))
   1)
```

SCHEMATIC 15: Abstract Low-level Components

XORG, 3OR and OR-AND combined:

```
((cm85a parens-pun expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 42)
  (cm85a ((i-o 11-03) (cell 10) (lits 0) (nets 0) (path 0))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 10) (wire 0) (mix 0) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~8-2) (gt ~9-0) (lt ~10-0))

  ((1-     xorg
    ((i0 a) (i1 b))
    ((o0 ~1-0) (o1 ~1-1))   )
   (2-     xorg
    ((i0 c) (i1 d))
    ((o0 ~2-0) (o1 ~2-1))   )
   (3-     xorg
    ((i0 e) (i1 f))
    ((o0 ~3-0) (o1 ~3-1))   )
   (4-     xorg
    ((i0 g) (i1 h))
    ((o0 ~4-0) (o1 ~4-1))   )
   (5-     3nor
    ((i0 ~4-0) (i1 ~4-1) (i2 j))
    ((o0 ~5-0) (o1 ~5-1) (o2 ~5-2))   )
   (6-     3nor
    ((i0 ~3-0) (i1 ~3-1) (i2 ~5-2))
    ((o0 ~6-0) (o1 ~6-1) (o2 ~6-2))   )
   (7-     3nor
    ((i0 ~2-0) (i1 ~2-1) (i2 ~6-2))
    ((o0 ~7-0) (o1 ~7-1) (o2 ~7-2))   )
   (8-     3nor
    ((i0 ~1-0) (i1 ~1-1) (i2 ~7-2))
    ((o0 ~8-0) (o1 ~8-1) (o2 ~8-2))   )
   (9-     orand
    ((i0 i)(i1 j)(i2 ~4-0)(i3 ~2-0)(i4 ~6-2)(i5 ~3-0)(i6 ~5-2)(i7 ~1-0)(i8 ~7-2))
    ((o0 ~9-0))   )
   (10-    orand
    ((i0 k)(i1 j)(i2 ~4-1)(i3 ~2-1)(i4 ~6-2)(i5 ~3-1)(i6 ~5-2)(i7 ~1-1)(i8 ~7-2))
    ((o0 ~10-0))   )
 ))
 ((xorg)
  ((i0 unk) (i1 unk))
  ((o0 ~0) (o1 ~1))
  ((~0     (i0 (i1))   )
   (~1     (i1 (i0))   )
  ))
 ((3nor)
  ((i0 unk) (i1 unk) (i2 unk))
  ((o0 i0) (o1 i1) (o2 ~2))
  ((~2     (i0 i1 (i2))   )
  ))
 ((orand)
  ((i0 unk)(i1 unk)(i2 unk)(i3 unk)(i4 unk)(i5 unk)(i6 unk)(i7 unk)(i8 unk))
  ((o0 ~0))
  ((~0     ((i0 ((i1) (i2)) ((i3) (i4)) ((i5) (i6)) ((i7) (i8))))   )
  )) )
```

Pun expanded:

```
((cm85a test expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 43)
  (cm85a ((i-o 11-03) (cell 14) (lits 46) (nets 63) (path 6))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 14) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~8-2) (gt ~9-0) (lt ~10-0))

  ((~1-0   (a (b))   )
   (~1-1   (b (a))   )
   (~2-0   (c (d))   )
   (~2-1   (d (c))   )
   (~3-0   (e (f))   )
   (~3-1   (f (e))   )
   (~4-0   (g (h))   )
   (~4-1   (h (g))   )
   (~5-2   (~4-0 ~4-1 (j))   )
   (~6-2   (~3-0 ~3-1 (~5-2))   )
   (~7-2   (~2-0 ~2-1 (~6-2))   )
   (~8-2   (~1-0 ~1-1 (~7-2))   )
   (~9-0   ((i ((j) (~4-0)) ((~2-0) (~6-2)) ((~3-0) (~5-2)) ((~1-0) (~7-2))))   )
   (~10-0  ((k ((j) (~4-1)) ((~2-1) (~6-2)) ((~3-1) (~5-2)) ((~1-1) (~7-2))))   )
  )) )
```

SCHEMATIC 16: Abstract for Component Connectivity

AND-INV combined with XOR-3OR:

```
((cm85a test expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 44)
  (cm85a ((i-o 11-03) (cell 12) (lits 12) (nets 0) (path 0))
   ((inv 2) (or 2) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 8) (wire 0) (mix 0) (gates 2))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~10) (gt ~34) (lt ~35))

  ((21-    xor-3or
    ((i0 a) (i1 b) (i2 ~22-2))
    ((o0 ~21-0) (o1 ~21-1) (o2 ~21-2))   )
   (22-    xor-3or
    ((i0 c) (i1 d) (i2 ~23-2))
    ((o0 ~22-0) (o1 ~22-1) (o2 ~22-2))   )
   (23-    xor-3or
    ((i0 e) (i1 f) (i2 ~24-2))
    ((o0 ~23-0) (o1 ~23-1) (o2 ~23-2))   )
   (24-    xor-3or
    ((i0 g) (i1 h) (i2 ~3))
    ((o0 ~24-0) (o1 ~24-1) (o2 ~24-2))   )
   (25-    and-inv
    ((i0 ~21-1) (i1 ~21-0) (i2 ~22-2))
    ((o0 ~25-0) (o1 ~25-1))   )
   (26-    and-inv
    ((i0 ~22-0) (i1 ~22-1) (i2 ~23-2))
    ((o0 ~26-0) (o1 ~26-1))   )
   (27-    and-inv
    ((i0 ~23-0) (i1 ~23-1) (i2 ~24-2))
    ((o0 ~27-0) (o1 ~27-1))   )
   (28-    and-inv
    ((i0 ~24-0) (i1 ~24-1) (i2 ~3))
    ((o0 ~28-0) (o1 ~28-1))   )
   (~3     (j)   )
   (~10    (~21-2)   )
   (~34    ((i ~28-0 ~25-1 ~27-0 ~26-0))   )
   (~35    ((k ~28-1 ~25-0 ~27-1 ~26-1))   )
  ))
 ((xor-3or)
  ((i0 unk) (i1 unk) (i2 unk))
  ((o0 ~0) (o1 ~1) (o2 ~2))
  ((~0     (i0 (i1))   )
   (~1     (i1 (i0))   )
   (~2     ((i2 ~0 ~1))   )
  ))
 ((and-inv)
  ((i0 unk) (i1 unk) (i2 unk))
  ((o0 ~0) (o1 ~1))
  ((~0     (i2 (i0))   )
   (~1     (i2 (i1))   )
  )) )
```

Pun expanded:

```
((cm85a test expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 44)
  (cm85a ((i-o 11-03) (cell 24) (lits 56) (nets 51) (path 6))
   ((inv 2) (or 6) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 16) (gates 6))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~10) (gt ~34) (lt ~35))

  ((~21-0  (a (b))   )
   (~21-1  (b (a))   )
   (~21-2  ((~22-2 ~21-0 ~21-1))   )
   (~22-0  (c (d))   )
   (~22-1  (d (c))   )
   (~22-2  ((~23-2 ~22-0 ~22-1))   )
   (~23-0  (e (f))   )
   (~23-1  (f (e))   )
   (~23-2  ((~24-2 ~23-0 ~23-1))   )
   (~24-0  (g (h))   )
   (~24-1  (h (g))   )
   (~24-2  ((~3 ~24-0 ~24-1))   )
   (~25-0  (~22-2 (~21-1))   )
   (~25-1  (~22-2 (~21-0))   )
   (~26-0  (~23-2 (~22-0))   )
   (~26-1  (~23-2 (~22-1))   )
   (~27-0  (~24-2 (~23-0))   )
   (~27-1  (~24-2 (~23-1))   )
   (~28-0  (~3 (~24-0))   )
   (~28-1  (~3 (~24-1))   )
   (~3     (j)   )
   (~10    (~21-2)   )
   (~34    ((i ~28-0 ~25-1 ~27-0 ~26-0))   )
   (~35    ((k ~28-1 ~25-0 ~27-1 ~26-1))   )
  )) )
```

SCHEMATIC 17: Abstract for Sequential Structure

XOR-3NOR combined with OR-AND:

```
((cm85a parens-pun expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 43)
  (cm85a ((i-o 11-03) (cell 6) (lits 0) (nets 0) (path 0))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 6) (wire 0) (mix 0) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~14-2) (gt ~9-0) (lt ~10-0))

  ((11-    xor-3nor
    ((i0 g) (i1 h) (i2 j))
    ((o0 ~11-0) (o1 ~11-1) (o2 ~11-2))   )
   (12-    xor-3nor
    ((i0 e) (i1 f) (i2 ~11-2))
    ((o0 ~12-0) (o1 ~12-1) (o2 ~12-2))   )
   (13-    xor-3nor
    ((i0 c) (i1 d) (i2 ~12-2))
    ((o0 ~13-0) (o1 ~13-1) (o2 ~13-2))   )
   (14-    xor-3nor
    ((i0 a) (i1 b) (i2 ~13-2))
    ((o0 ~14-0) (o1 ~14-1) (o2 ~14-2))   )
   (9-     orand
    ((i0 i)(i1 j)(i2 ~11-0)(i3 ~13-0)(i4 ~12-2)(i5 ~12-0)(i6 ~11-2)(i7 ~14-0)(i8 ~13-
2))
    ((o0 ~9-0))   )
   (10-    orand
    ((i0 k)(i1 j)(i2 ~11-1)(i3 ~13-1)(i4 ~12-2)(i5 ~12-1)(i6 ~11-2)(i7 ~14-1)(i8 ~13-
2))
    ((o0 ~10-0))   )
  ))
 ((xor-3nor)
  ((i0 unk) (i1 unk) (i2 unk))
  ((o0 ~0) (o1 ~1) (o2 ~2))
  ((~0     (i0 (i1))   )
   (~1     (i1 (i0))   )
   (~2     (~0 ~1 (i2))   )
  ))
 ((orand)
  ((i0 unk)(i1 unk)(i2 unk)(i3 unk)(i4 unk)(i5 unk)(i6 unk)(i7 unk)(i8 unk))
  ((o0 ~0))
  ((~0     ((i0 ((i1) (i2)) ((i3) (i4)) ((i5) (i6)) ((i7) (i8))))   )
  )) )
```

Pun expanded:

```
((cm85a test expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 43)
  (cm85a ((i-o 11-03) (cell 14) (lits 46) (nets 63) (path 6))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 14) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~14-2) (gt ~9-0) (lt ~10-0))

  ((~11-0  (g (h))   )
   (~11-1  (h (g))   )
   (~11-2  (~11-0 ~11-1 (j))   )
   (~12-0  (e (f))   )
   (~12-1  (f (e))   )
   (~12-2  (~12-0 ~12-1 (~11-2))   )
   (~13-0  (c (d))   )
   (~13-1  (d (c))   )
   (~13-2  (~13-0 ~13-1 (~12-2))   )
   (~14-0  (a (b))   )
   (~14-1  (b (a))   )
   (~14-2  (~14-0 ~14-1 (~13-2))   )
   (~9-0   ((i ((j) (~11-0)) ((~13-0) (~12-2)) ((~12-0) (~11-2)) ((~14-0) (~13-2))))
)
```

```
   (~10-0  ((k ((j) (~11-1)) ((~13-1) (~12-2)) ((~12-1) (~11-2)) ((~14-1) (~13-2))))
)
  )) )
```

SCHEMATIC 18: Abstract for Parallel Structure

3OR-ORAND combined with XOR-group:

```
((cm85a test expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 44)
  (cm85a ((i-o 11-03) (cell 7) (lits 9) (nets 0) (path 0))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 6) (wire 0) (mix 1) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~8-2) (gt ~15-0) (lt ~16-0))

  ((1-     xorg
    ((i0 a) (i1 b))
    ((o0 ~1-0) (o1 ~1-1))   )
   (2-     xorg
    ((i0 c) (i1 d))
    ((o0 ~2-0) (o1 ~2-1))   )
   (3-     xorg
    ((i0 e) (i1 f))
    ((o0 ~3-0) (o1 ~3-1))   )
   (4-     xorg
    ((i0 g) (i1 h))
    ((o0 ~4-0) (o1 ~4-1))   )
   (15-    3or-orand
    ((i0 i)(i1 j)(i2 ~4-0)(i3 ~2-0)(i4 ~3-1)(i5 ~3-0)(i6 ~4-1)(i7 ~1-0)(i8 ~2-1))
    ((o0 ~15-0))   )
   (16-    3or-orand
    ((i0 k)(i1 j)(i2 ~4-1)(i3 ~2-1)(i4 ~3-0)(i5 ~3-1)(i6 ~4-0)(i7 ~1-1)(i8 ~2-0))
    ((o0 ~16-0))   )
   (~8-2   (~1-0 ~1-1 ~2-0 ~2-1 ~3-0 ~3-1 ~4-0 ~4-1 (j))   )
  ))
 ((xorg)
  ((i0 unk) (i1 unk))
  ((o0 ~0) (o1 ~1))
  ((~0     (i0 (i1))   )
   (~1     (i1 (i0))   )
  ))
 ((3or-orand)
  ((i0 unk)(i1 unk)(i2 unk)(i3 unk)(i4 unk)(i5 unk)(i6 unk)(i7 unk)(i8 unk))
  ((o0 ~0))
  ((~0     ((i0 ((i1) (i2 (i6 (i5 (i4 (i3 (i8 (i7))))))))))   )
  )) )
```

Pun expanded:

```
((cm85a test expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 45)
  (cm85a ((i-o 11-03) (cell 11) (lits 43) (nets 51) (path 9))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 11) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~8-2) (gt ~15-0) (lt ~16-0))

  ((~1-0   (a (b))   )
   (~1-1   (b (a))   )
   (~2-0   (c (d))   )
   (~2-1   (d (c))   )
   (~3-0   (e (f))   )
   (~3-1   (f (e))   )
   (~4-0   (g (h))   )
   (~4-1   (h (g))   )
   (~8-2   (~1-0 ~1-1 ~2-0 ~2-1 ~3-0 ~3-1 ~4-0 ~4-1 (j))   )
   (~15-0  ((i ((j) (~4-0 (~4-1 (~3-0 (~3-1 (~2-0 (~2-1 (~1-0))))))))))   )
   (~16-0  ((k ((j) (~4-1 (~4-0 (~3-1 (~3-0 (~2-1 (~2-0 (~1-1))))))))))   )
  )) )
```

SCHEMATIC 19: Abstract for Output Structure

XORG-3OR-ORAND group:

```
((cm85a parens-pun expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 45)
  (cm85a ((i-o 11-03) (cell 3) (lits 17) (nets 0) (path 0))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 2) (wire 0) (mix 1) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~8-2) (gt ~17-0) (lt ~18-0))

  ((17-    xorg-3or-orand
    ((i0 i) (i1 j) (i2 g) (i3 c) (i4 f) (i5 e) (i6 h) (i7 a) (i8 d) (i9 b))
    ((o0 ~15-0))   )
   (18-    xorg-3or-orand
    ((i0 k) (i1 j) (i2 h) (i3 d) (i4 e) (i5 f) (i6 g) (i7 b) (i8 c) (i9 a))
    ((o0 ~16-0))   )
   (~8-2   ((a (b)) (b (a)) (c (d)) (d (c)) (e (f)) (f (e)) (g (h)) (h (g)) (j))   )
  ))
 ((xorg-3or-orand)
  ((i0 unk)(i1 unk)(i2 unk)(i3 unk)(i4 unk)(i5 unk)(i6 unk)(i7 unk)(i8 unk)(i9 unk))
  ((o0 ~0))
  ((~0     ((i0
             ((i1)
              ((i2 (i6))
               ((i6 (i2))
                ((i5 (i4))
                 ((i4 (i5))
                  ((i3 (i8))
                   (i7 (i9) (i8 (i3)))))))))))   )
  )) )
```

Pun expanded:

```
((cm85a parens-pun expand-lib01 expand11 75-main 0.0 (2001 11 24 23 19 45)
  (cm85a ((i-o 11-03) (cell 3) (lits 49) (nets 75) (path 9))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~8-2) (gt ~17-0) (lt ~18-0))

  ((~8-2   ((a (b)) (b (a)) (c (d)) (d (c)) (e (f)) (f (e)) (g (h)) (h (g)) (j))   )
   (~17-0  ((i
             ((j)
              ((g (h))
               ((h (g))
                ((e (f))
                 ((f (e))
                  ((c (d))
                   (a (b) (d (c)))))))))))   )
   (~18-0  ((k
             ((j)
              ((h (g))
               ((g (h))
                ((f (e))
                 ((e (f))
                  ((d (c))
                   (b (a) (c (d)))))))))))   )
  )) )
```

SCHEMATIC 20a: Abstract Bit-width (recursive)

Base-case:

```
((1bit-magcomp parens-pun pun01 pun01 75-main 0.0 (2001 11 25 0 3 7)
  (1bit-magcomp ((i-o 02-03) (cell 3) (lits 8) (nets 14) (path 2))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a0 unk) (b0 unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     (((a0 (b0)) (b0 (a0))))   )
   (~2     ((a0 (b0)))   )
   (~3     ((b0 (a0)))   )
  )) )
```

Iterated:

```
((nbit-magcomp-iterated parens-pun pun02 pun02 75-main 0.0 (2001 11 25 0 48 59)
  (nbit-magcomp-iterated ((i-o 06-03) (cell 3) (lits 32) (nets 50) (path 4))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a0 unk) (b0 unk) (a1 unk) (b1 unk) ... (an unk) (bn unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     (((a0 (b0)) (b0 (a0)) (a1 (b1)) (b1 (a1)) ... (an (bn)) (bn (an))))   )
   (~2     ((an (bn))
            ((bn (an))
             ...
              ((a1 (b1))
               ((b1 (a1))
                ((a0 (b0)))))))   )
   (~3     ((bn (an))
            ((an (bn))
             ...
              ((b1 (a1))
               ((a1 (b1))
                ((b0 (a0)))))))   )
  )) )
```

Recursive:

```
((nbit-magcomp-recursive parens-pun pun03 pun03 75-main 0.0 (2001 11 25 0 5 57)
  (nbit-magcomp-recursive ((i-o 02-03) (cell 3) (lits 15) (nets 20) (path 3))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((an unk) (bn unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     (((an (bn)) (bn (an)) EQn-1))   )
   (~2     ((an (bn)) ((bn (an)) GTn-1))   )
   (~3     ((bn (an)) ((an (bn)) LTn-1))   )
  )) )
```

SCHEMATIC 20b: Abstract Bit-width (enables)

Base-case for enables:

```
((0bit-magcomp-enable parens-pun pun04 pun04 75-main 0.0 (2001 11 25 0 6 29)
  (0bit-magcomp-enable ((i-o 03-03) (cell 3) (lits 4) (nets 6) (path 1))
   ((inv 0) (or 2) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 1) (mix 0) (gates 2))))
 ((main)
  ((i unk) (j unk) (k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     ((j))   )
   (~2     ((i j))   )
   (~3     ((k j))   )
  )) )
```

Base-case:

```
((1bit-magcomp-enable parens-pun pun05 pun05 75-main 0.0 (2001 11 25 0 6 45)
  (1bit-magcomp-enable ((i-o 05-03) (cell 3) (lits 13) (nets 25) (path 2))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a0 unk) (b0 unk) (i unk) (j unk) (k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     ((j) (a0 (b0)) (b0 (a0)))   )
   (~2     ((i ((j) ((a0 (b0))))))   )
   (~3     ((k ((j) ((b0 (a0))))))   )
  )) )
```

First iteration:

```
((2bit-magcomp-enable parens-pun pun06 pun06 75-main 0.0 (2001 11 25 0 7 48)
  (2bit-magcomp-enable ((i-o 07-03) (cell 3) (lits 25) (nets 43) (path 4))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a0 unk) (b0 unk) (a1 unk) (b1 unk) (i unk) (j unk) (k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     ((j) (a0 (b0)) (b0 (a0)) (a1 (b1)) (b1 (a1)))   )
   (~2     ((i ((j) ((a1 (b1)) ((b1 (a1)) ((a0 (b0))))))))   )
   (~3     ((k ((j) ((b1 (a1)) ((a1 (b1)) ((b0 (a0))))))))   )
  )) )
```

Nth iteration:

```
((nbit-magcomp-enable parens-pun pun07 pun07 75-main 0.0 (2001 11 25 0 8 23)
  (nbit-magcomp-enable ((i-o 05-03) (cell 3) (lits 8) (nets 15) (path 3))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((an unk) (bn unk) (i unk) (j unk) (k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     ((j) EQn)   )
   (~2     ((i ((j) GTn)))   )
   (~3     ((k ((j) LTn)))   )
  )) )
```

SCHEMATIC 20c: Abstract Bit-width (enables, recursive)

Iterated with enables:

```
((nbit-magcomp-enable-iterated parens-pun pun08 pun08 75-main 0.0 (2001 11 25 0 10 3)
  (nbit-magcomp-enable-iterated ((i-o 09-03) (cell 3) (lits 37) (nets 61) (path 6))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a0 unk)(b0 unk)(a1 unk)(b1 unk)...(an unk)(bn unk)(i unk)(j unk)(k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     ((j) (a0 (b0)) (b0 (a0)) (a1 (b1)) (b1 (a1)) ... (an (bn)) (bn (an)))   )
   (~2     ((i
             ((j)
              ((an (bn))
               ((bn (an))
                ...
                 ((a1 (b1))
                  ((b1 (a1))
                   ((a0 (b0)))))))))   )
   (~3     ((k
             ((j)
              ((bn (an))
               ((an (bn))
                ...
                 ((b1 (a1))
                  ((a1 (b1))
                   ((b0 (a0)))))))))   )
  )) )
```

Recursive with enables:

```
((nbit-magcompr-enable-recursive parens-pun pun09 pun09 75-main 0.0 (2001 11 25 0 8
43)
  (nbit-magcomp-enable-recursive ((i-o 05-03) (cell 3) (lits 20) (nets 31) (path 5))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((an unk) (bn unk) (i unk) (j unk) (k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1     ((j) (an (bn)) (bn (an)) EQn-1)   )
   (~2     ((i ((j) ((an (bn)) ((bn (an)) GTn-1)))))   )
   (~3     ((k ((j) ((bn (an)) ((an (bn)) LTn-1)))))   )
  )) )
```

SCHEMATIC 21: Distinction Network I

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 16 3)
  (cm85a ((i-o 11-03) (cell 36) (lits 76) (nets 47) (path 6))
   ((inv 14) (or 0) (and 0) (nor 22) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 22))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~34) (gt ~13) (lt ~14))

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

SCHEMATIC 22: Distinction Network II

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 16 4)
  (cm85a ((i-o 11-03) (cell 36) (lits 70) (nets 47) (path 9))
   ((inv 11) (or 0) (and 0) (nor 25) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 25))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~36) (gt ~10) (lt ~11))

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

SCHEMATIC 23a: Occlusion Array (Dnet 21)

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 16 4)
  (cm85a ((i-o 11-03) (cell 36) (lits 76) (nets 47) (path 6))
   ((inv 14) (or 0) (and 0) (nor 22) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 22))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~34) (gt ~35) (lt ~36))

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

SCHEMATIC 23b: Occlusion Array (Dnet 22)

```
((cm85a test pun02 pun02 75-main 0.0 (2001 11 24 23 16 59)
  (cm85a ((i-o 11-03) (cell 36) (lits 70) (nets 47) (path 9))
   ((inv 11) (or 0) (and 0) (nor 25) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 25))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~36) (gt ~34) (lt ~35))

  ((~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    (a ~2 ~13)   )
   (~19    (b ~1 ~12)   )
   (~20    (~12 ~18)   )
   (~21    (~13 ~19)   )
   (~22    (~14 ~21)   )
   (~23    (~15 ~20)   )
   (~24    (~14 ~23)   )
   (~25    (~15 ~22)   )
   (~26    (~16 ~25)   )
   (~27    (~17 ~24)   )
   (~28    (~17 ~26)   )
   (~29    (~9 ~28)   )
   (~30    (~16 ~27)   )
   (~31    (~9 ~30)   )
   (~32    (i ~31)   )
   (~33    (k ~29)   )
   (~34    (~32)   )
   (~35    (~33)   )
   (~36    (~9 ~10 ~11 ~12 ~13 ~14 ~15 ~16 ~17)   )
  )) )
```

SCHEMATIC 23c: Occlusion Array (two-level Dnet)

```
((cm85a test pun03 pun03 75-main 0.0 (2001 11 24 23 17 22)
  (cm85a ((i-o 11-03) (cell 52) (lits 226) (nets 63) (path 2))
   ((inv 11) (or 0) (and 0) (nor 41) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 41))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~50) (gt ~51) (lt ~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)   )
  )) )
```

SCHEMATIC 23d: Occlusion Array (raw multilevel benchmark)

```
((cm85a test pun04 pun04 75-main 0.0 (2001 11 24 23 17 27)
  (cm85a ((i-o 11-03) (cell 120) (lits 164) (nets 131) (path 8))
   ((inv 76) (or 0) (and 0) (nor 44) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 44))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~107) (gt ~64) (lt ~65))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (i)   )
   (~10    (j)   )
   (~11    (k)   )
   (~12    (~1)   )
   (~13    (~2)   )
   (~14    (~3)   )
   (~15    (~4)   )
   (~16    (~5)   )
   (~17    (~6)   )
   (~18    (~7)   )
   (~19    (~8)   )
   (~20    (~9)   )
   (~21    (~10)   )
   (~22    (~11)   )
   (~23    (~58)   )
   (~24    (~59)   )
   (~25    (~60)   )
   (~26    (~61)   )
   (~27    (~38)   )
   (~28    (~39)   )
   (~29    (~40)   )
   (~30    (~41)   )
   (~31    (~76)   )
   (~32    (~42)   )
   (~33    (~43)   )
   (~34    (~44)   )
   (~35    (~45)   )
   (~36    (~48)   )
   (~37    (~49)   )
   (~38    (~54)   )
   (~39    (~55)   )
   (~40    (~56)   )
   (~41    (~57)   )
   (~42    (~62)   )
   (~43    (~63)   )
   (~44    (~66)   )
   (~45    (~67)   )
   (~46    (~68)   )
   (~47    (~69)   )
   (~48    (~70)   )
   (~49    (~71)   )
   (~50    (~73)   )
   (~51    (~72)   )
   (~52    (~75)   )
   (~53    (~74)   )
   (~54    (~77)   )
   (~55    (~78)   )
   (~56    (~79)   )
   (~57    (~80)   )
   (~58    (~84)   )
```

```
 (~59    (~85)   )
 (~60    (~89)   )
 (~61    (~90)   )
 (~62    (~91)   )
 (~63    (~108)   )
 (~64    (~112)   )
 (~65    (~111)   )
 (~66    (~110)   )
 (~67    (~109)   )
 (~68    (~114)   )
 (~69    (~116)   )
 (~70    (~113)   )
 (~71    (~115)   )
 (~72    (~117)   )
 (~73    (~118)   )
 (~74    (~119)   )
 (~75    (~120)   )
 (~76    (~106)   )
 (~77    (a ~2)   )
 (~78    (b ~1)   )
 (~79    (e ~6)   )
 (~80    (f ~5)   )
 (~81    (~1 ~13)   )
 (~82    (~2 ~12)   )
 (~83    (~3 ~4)   )
 (~84    (~3 ~15)   )
 (~85    (~4 ~14)   )
 (~86    (~5 ~17)   )
 (~87    (~6 ~16)   )
 (~88    (~7 ~8)   )
 (~89    (~7 ~19)   )
 (~90    (~8 ~18)   )
 (~91    (~10 ~47)   )
 (~92    (~14 ~15)   )
 (~93    (~18 ~19)   )
 (~94    (~20 ~21)   )
 (~95    (~20 ~26)   )
 (~96    (~21 ~22)   )
 (~97    (~22 ~25)   )
 (~98    (~23 ~35)   )
 (~99    (~24 ~34)   )
 (~100   (~27 ~33)   )
 (~101   (~28 ~33)   )
 (~102   (~29 ~32)   )
 (~103   (~30 ~32)   )
 (~104   (~31 ~35)   )
 (~105   (~31 ~34)   )
 (~106   (~32 ~37)   )
 (~107   (~33 ~36)   )
 (~108   (~46 ~76)   )
 (~109   (~50 ~103)   )
 (~110   (~51 ~102)   )
 (~111   (~52 ~101)   )
 (~112   (~53 ~100)   )
 (~113   (~81 ~82)   )
 (~114   (~83 ~92)   )
 (~115   (~86 ~87)   )
 (~116   (~88 ~93)   )
 (~117   (~94 ~95)   )
 (~118   (~96 ~97)   )
 (~119   (~99 ~105)   )
 (~120   (~98 ~104)   )
)) )
```

SCHEMATIC 23e: Occlusion Array (clean multilevel benchmark)

```
((cm85a test pun05 pun05 75-main 0.0 (2001 11 24 23 17 34)
  (cm85a ((i-o 11-03) (cell 62) (lits 102) (nets 73) (path 8))
   ((inv 22) (or 0) (and 0) (nor 40) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 40))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~60) (gt ~61) (lt ~62))

  ((~1     (a)   )
   (~2     (b)   )
   (~3     (c)   )
   (~4     (d)   )
   (~5     (e)   )
   (~6     (f)   )
   (~7     (g)   )
   (~8     (h)   )
   (~9     (j)   )
   (~10    (c d)   )
   (~11    (g h)   )
   (~12    (i j)   )
   (~13    (j k)   )
   (~14    (a ~2)   )
   (~15    (b ~1)   )
   (~16    (c ~4)   )
   (~17    (d ~3)   )
   (~18    (e ~6)   )
   (~19    (f ~5)   )
   (~20    (g ~8)   )
   (~21    (h ~7)   )
   (~22    (i ~20)   )
   (~23    (k ~21)   )
   (~24    (~3 ~4)   )
   (~25    (~7 ~8)   )
   (~26    (~10 ~24)   )
   (~27    (~11 ~25)   )
   (~28    (~12 ~22)   )
   (~29    (~13 ~23)   )
   (~30    (~14 ~15)   )
   (~31    (~18 ~19)   )
   (~32    (~9 ~27)   )
   (~33    (~14)   )
   (~34    (~15)   )
   (~35    (~18)   )
   (~36    (~19)   )
   (~37    (~30)   )
   (~38    (~31)   )
   (~39    (~32)   )
   (~40    (~35 ~39)   )
   (~41    (~36 ~39)   )
   (~42    (~38 ~39)   )
   (~43    (~28 ~40)   )
   (~44    (~29 ~41)   )
   (~45    (~42)   )
   (~46    (~43)   )
   (~47    (~44)   )
   (~48    (~26 ~45)   )
   (~49    (~16 ~46)   )
   (~50    (~17 ~47)   )
   (~51    (~42 ~46)   )
   (~52    (~42 ~47)   )
   (~53    (~49 ~51)   )
   (~54    (~50 ~52)   )
   (~55    (~48)   )
   (~56    (~33 ~55)   )
   (~57    (~34 ~55)   )
   (~58    (~53 ~56)   )
   (~59    (~54 ~57)   )
   (~60    (~37 ~55)   )
   (~61    (~58)   )
   (~62    (~59)   )
  )) )
```

SCHEMATIC 24a: Comesh (multilevel)

```
((4bit-magnitude-comparator-with-enables test pun01 pun01 75-main 0.0
  (2001 11 24 23 16 5)
  (4bit-magnitude-comparator-with-enables
   ((i-o 11-03) (cell 36) (lits 70) (nets 47) (path 9))
   ((inv 11) (or 0) (and 0) (nor 25) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 25))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~36) (gt ~34) (lt ~35))

  ((~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    (a ~2 ~13)   )
   (~19    (b ~1 ~12)   )
   (~20    (~12 ~18)   )
   (~21    (~15 ~20)   )
   (~22    (~14 ~21)   )
   (~23    (~17 ~22)   )
   (~24    (~16 ~23)   )
   (~25    (~9 ~24)   )
   (~26    (i ~25)   )
   (~27    (~13 ~19)   )
   (~28    (~14 ~27)   )
   (~29    (~15 ~28)   )
   (~30    (~16 ~29)   )
   (~31    (~17 ~30)   )
   (~32    (~9 ~31)   )
   (~33    (k ~32)   )
   (~34    (~26)   )
   (~35    (~33)   )
   (~36    (~9 ~10 ~11 ~12 ~13 ~14 ~15 ~16 ~17)   )
  )) )
```

SCHEMATIC 24b: Comesh (two-level)

```
((cm85a test pun02 pun02 75-main 0.0 (2001 11 24 23 17 0)
  (cm85a ((i-o 11-03) (cell 52) (lits 226) (nets 63) (path 2))
   ((inv 11) (or 0) (and 0) (nor 41) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 41))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((gt ~51) (eq ~50) (lt ~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)   )
  )) )
```

SCHEMATIC 25: Bit-stream Simulator

```
((cm85a parens-pun pun01 pun01 75-main 0.0 (2001 11 24 23 16 6)
  (cm85a ((i-o 11-03) (cell 3) (lits 49) (nets 75) (path 9))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1   ((j) (a (b)) (b (a)) (c (d)) (d (c)) (e (f)) (f (e)) (g (h)) (h (g)))   )
   (~2   ((i ((j) ((g (h)) ((h (g)) ((e (f)) ((f (e)) ((c (d)) (a (b) (d (c))))))))))
)
   (~3   ((k ((j) ((h (g)) ((g (h)) ((f (e)) ((e (f)) ((d (c)) (b (a) (c (d))))))))))
)
  )) )
```

Selected Input Vector:

```
((cm85a parens-pun pun26 pun99 47-builders
  (stats cm85a lits 49 conn 32 dnode 64 gate 3) 0.118 (2001 8 15 21 23 11))
 ((main fanin 999 fanout 999)
  ((a 0) (b 0) (c 1) (d 1) (e 1) (f 0) (g 1) (h 0) (i 0) (j 1) (k 0))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1 ((()))(())(()))(()(()))(()(()))(()(()))(()(()))(()(()))(()(()))   )
   (~2 ((((()))(((()))(((()))(((()))(((()))(((()))(((()))(((()))(((()))  )
   (~3 ((((()))(((()))(((()))(((()))(((()))(((()))(((()))(((()))(((()))  )
  )) )
```

Binary encoding:

```
  ((~1  1110011001100110110001101100011010011100011010011100000 )
   (~2  1111100111010011110001110100111100011101100011011011000000000000 )
   (~3  1111100111100011101001111000111010011101100011011011000000000000 ))
```

SCHEMATIC 26: Semantic Optimization, Remove EqualTo

4-bit Magnitude Comparator Circuit

```
  ((eq 38) (gt 20) (lt 21))

   ((1     (a)   )
    (2     (b)   )
    (3     (c)   )
    (4     (d)   )
    (5     (e)   )
    (6     (f)   )
    (7     (g)   )
    (8     (h)   )
    (10    (12)   )
    (11    (13)   )
    (12    (a 2)   )
    (13    (b 1)   )
    (14    (c 4)   )
    (15    (d 3)   )
    (16    (e 6)   )
    (17    (f 5)   )
    (18    (g 8)   )
    (19    (h 7)   )
    (20    ((i 22))   )
    (21    ((k 23))   )
    (24    (10 15)   )
    (25    (11 14)   )
    (26    (14 24)   )
    (27    (15 25)   )
    (28    (16 31)   )
    (29    (16 27)   )
    (30    (17 29)   )
    (31    (17 26)   )
    (32    ((18 35))   )
    (33    (18 30)   )
    (34    ((19 33))   )
    (35    (19 28)   )
    (37    (20 21)   )
    (38    ((37 j))   )   )
```

SCHEMATIC 27: Semantic Optimization, Remove LessThan

4-bit Magnitude Comparator Circuit

```
  ((eq 36) (gt 20) (lt 38))

  ( (1     (a)   )
    (2     (b)   )
    (3     (c)   )
    (4     (d)   )
    (5     (e)   )
    (6     (f)   )
    (7     (g)   )
    (8     (h)   )
    (9     (j)   )
    (10    (12)   )
    (12    (a 2)   )
    (13    (b 1)   )
    (14    (c 4)   )
    (15    (d 3)   )
    (16    (e 6)   )
    (17    (f 5)   )
    (18    (g 8)   )
    (19    (h 7)   )
    (20    ((i 22))   )
    (22    (9 32)   )
    (24    (10 15)   )
    (26    (14 24)   )
    (28    (16 31)   )
    (31    (17 26)   )
    (32    (18 35)   )
    (35    (19 28)   )
    (36    (9 12 13 14 15 16 17 18 19)   )
    (37    (20 36)   )
    (38    ((k 37))   )  )
```

SCHEMATIC 28: High Fan-in NOR Gates

same as Distinction Network I

```
((cm85a test pun01 pun01 75-main 0.0 (2001 11 24 23 16 3)
  (cm85a ((i-o 11-03) (cell 36) (lits 76) (nets 47) (path 6))
   ((inv 14) (or 0) (and 0) (nor 22) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 0) (gates 22))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~34) (gt ~13) (lt ~14))

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

SCHEMATIC 29: Fan-in and Fan-out Constraints on NOR Gates

4-bit Magnitude Comparator Circuit

```
  ((eq 36) (gt 10) (lt 11))

  ((1     (a)   )
   (2     (b)   )
   (3     (c)   )
   (4     (d)   )
   (5     (e)   )
   (6     (f)   )
   (7     (g)   )
   (8     (h)   )
   (9     (j)   )
   (10    (20)   )
   (11    (21)   )
   (12    (a 2)   )
   (13    (b 1)   )
   (14    (c 4)   )
   (15    (d 3)   )
   (16    (e 6)   )
   (17    (f 5)   )
   (18    (g 8)   )
   (19    (h 7)   )
   (20    (i 22)   )
   (21    (k 23)   )
   (22    (9 30)   )
   (23    (9 32)   )
   (24    (14 38)   )
   (25    (15 40)   )
   (26    (16 29)   )
   (27    (16 25)   )
   (28    (17 27)   )
   (29    (17 24)   )
   (30    (18 33)   )
   (31    (18 28)   )
   (32    (19 31)   )
   (33    (19 26)   )
   (34    (a 37)   )
   (37    (38)   )
   (38    (2 15)   )
   (35    (b 39)   )
   (39    (40)   )
   (40    (1 14)   )
   (36    (9 53)   )
   (41    (42)   )
   (42    (12 13)   )
   (43    (44)   )
   (44    (14 15)   )
   (45    (46)   )
   (46    (16 17)   )
   (47    (48)   )
   (48    (18 19)   )
   (49    (50)   )
   (50    (41 43)   )
   (51    (52)   )
   (52    (45 47)   )
   (53    (54)   )
   (54    (49 51)   )  )
```

SCHEMATIC 30: Fan-out of Three Constraint on NOR Gates

4-bit Magnitude Comparator Circuit

```
  ((eq 36) (gt 10) (lt 11))

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

SCHEMATIC 31: MUX Gates

4-bit Magnitude Comparator Circuit

```
((eq >11) (gt >24) (lt >37))

((>1    (((h) g)(h 40))   )
 (>2    (((e >1)(e []))   )
 (>3    (((e [])(e >1))   )
 (>4    (((f >2)(f >3))   )
 (>5    (((c >4)(c []))   )
 (>6    (((c [])(c >4))   )
 (>7    (((d >5)(d >6))   )
 (>8    (((a >7)(a []))   )
 (>9    (((a [])(a >7))   )
 (>10   (((b >8)(b >9))   )
 (>11   (((j [])(j >10))   )
 (>12   (((a 39)(a []))   )
 (>13   (((c 39)(c []))   )
 (>14   (((c [])(c >12))   )
 (>15   (((a >13)(a []))   )
 (>16   (((d >15)(d >14))   )
 (>17   (((e >16)(e []))   )
 (>18   (((e [])(e >16))   )
 (>19   (((f >17)(f >18))   )
 (>20   (((g >19)(g []))   )
 (>21   (((g [])(g >19))   )
 (>22   (((h >20)(h >21))   )
 (>23   (((j [])(j >22))   )
 (>24   (((i >23)(i []))   )
 (>25   (((b 38)(b []))   )
 (>26   (((d 38)(d []))   )
 (>27   (((d [])(d >25))   )
 (>28   (((b >26)(b []))   )
 (>29   (((c >28)(c >27))   )
 (>30   (((f >29)(f []))   )
 (>31   (((f [])(f >29))   )
 (>32   (((e >30)(e >31))   )
 (>33   (((h >32)(h []))   )
 (>34   (((h [])(h >32))   )
 (>35   (((g >33)(g >34))   )
 (>36   (((j [])(j >35))   )
 (>37   (((k >36)(k []))   )
 (38   (a)   )
 (39   (b)   )
 (40   (g)   )
```

SCHEMATIC 32: Homogeneous Graph

no code

SCHEMATIC 33: 3D Logic Blocks

same as Binary Decision Diagram

```
((cm85a parens-pun pun01 pun01 75-main 0.0 (2001 11 24 23 16 3)
  (cm85a ((i-o 11-03) (cell 3) (lits 49) (nets 75) (path 9))
   ((inv 0) (or 0) (and 0) (nor 0) (nand 0) (eq 0) (xor 0) (ite 0) (reg 0)
    (lib 0) (wire 0) (mix 3) (gates 0))))
 ((main)
  ((a unk)(b unk)(c unk)(d unk)(e unk)(f unk)(g unk)(h unk)(i unk)(j unk)(k unk))
  ((eq ~1) (gt ~2) (lt ~3))

  ((~1   ((j) (a (b)) (b (a)) (c (d)) (d (c)) (e (f)) (f (e)) (g (h))
          (h (g)))   )
   (~2   ((i ((j) ((g (h)) ((h (g)) ((e (f)) ((f (e)) ((c (d)) (a (b) (d (c))))))))))
)
   (~3   ((k ((j) ((h (g)) ((g (h)) ((f (e)) ((e (f)) ((d (c)) (b (a) (c (d))))))))))
)
  )) )
```

APPENDIX: EDIF Code

```
(edif netlist
  (edifVersion 2 0 0)
  (edifLevel 0)
  (keywordMap (keywordLevel 0))
  (status
    (written
      (timeStamp 1993 2 0 16 45 4)
      (author "David Rickel")
      (program "autologic") ))
  (external PRIMLIB
    (edifLevel 0)
    (technology
      (numberDefinition)
      (simulationInfo
        (logicValue H (booleanMap (true)))
        (logicValue L (booleanMap (false))) ))
    (cell OR2
      (cellType GENERIC)
      (view INTERFACE
        (viewType NETLIST)
        (interface
          (port out (direction output))
          (port in0 (direction input))
          (port in1 (direction input)) ) ))
    (cell AND2
      (cellType GENERIC)
      (view INTERFACE
        (viewType NETLIST)
        (interface
          (port out (direction output))
          (port in0 (direction input))
          (port in1 (direction input)) ) ))
    (cell INV
      (cellType GENERIC)
      (view INTERFACE
        (viewType NETLIST)
        (interface
          (port out (direction output))
          (port in (direction input)))) )  )
  (library USER_LIB
    (edifLevel 0)
    (technology
      (numberDefinition)
      (simulationInfo
        (logicValue H (booleanMap (true)))
        (logicValue L (booleanMap (false)))))
    (cell TOP
      (cellType GENERIC)
      (view NETLIST
        (viewType NETLIST)
        (interface
          (port Pn (direction output))
          (port Pm (direction output))
          (port Pl (direction output))
          (port Pk (direction input))
          (port Pj (direction input))
          (port Pi (direction input))
          (port Ph (direction input))
          (port Pg (direction input))
          (port Pf (direction input))
          (port Pe (direction input))
          (port Pd (direction input))
          (port Pc (direction input))
          (port Pb (direction input))
          (port Pa (direction input)) )
        (contents
          (instance G_G0  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G1  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G2  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G3  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G4  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G5  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G6  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G7  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G8  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G9  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G10  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G11  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G12  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G13  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G14  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G15  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G16  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G17  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G18  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G19  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G20  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
          (instance G_G21  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
```

```
(instance G_G22  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G23  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G24  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G25  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G26  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G27  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G28  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G29  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G30  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G31  (viewRef INTERFACE (cellRef INV (libraryRef PRIMLIB))))
(instance G_G32  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G33  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G34  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G35  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G36  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G37  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G38  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G39  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G40  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G41  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G42  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G43  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G44  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G45  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G46  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G47  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G48  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G49  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G50  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G51  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G52  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G53  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G54  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G55  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G56  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G57  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G58  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G59  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G60  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G61  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G62  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G63  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G64  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G65  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G66  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G67  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G68  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G69  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G70  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G71  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G72  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(instance G_G73  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G74  (viewRef INTERFACE (cellRef AND2 (libraryRef PRIMLIB))))
(instance G_G75  (viewRef INTERFACE (cellRef OR2 (libraryRef PRIMLIB))))
(net N_N0 (joined
    (portRef in0 (instanceRef G_G75))
    (portRef out (instanceRef G_G0))))
(net N_N1 (joined
    (portRef in1 (instanceRef G_G74))
    (portRef out (instanceRef G_G1))))
(net N_N2 (joined
    (portRef in1 (instanceRef G_G73))
    (portRef out (instanceRef G_G2))))
(net N_N3 (joined
    (portRef in0 (instanceRef G_G72))
    (portRef out (instanceRef G_G3))))
(net N_N4 (joined
    (portRef in1 (instanceRef G_G71))
    (portRef out (instanceRef G_G4))))
(net N_N5 (joined
    (portRef in0 (instanceRef G_G74))
    (portRef in0 (instanceRef G_G73))
    (portRef in0 (instanceRef G_G71))
    (portRef out (instanceRef G_G5))))
(net N_N6 (joined
    (portRef in1 (instanceRef G_G68))
    (portRef in1 (instanceRef G_G67))
    (portRef out (instanceRef G_G6))))
(net N_N7 (joined
    (portRef in0 (instanceRef G_G67))
    (portRef out (instanceRef G_G7))))
(net N_N8 (joined
    (portRef in1 (instanceRef G_G64))
    (portRef in1 (instanceRef G_G63))
    (portRef out (instanceRef G_G8))))
(net N_N9 (joined
    (portRef in0 (instanceRef G_G63))
    (portRef out (instanceRef G_G9))))
(net N_N10 (joined
    (portRef in0 (instanceRef G_G70))
    (portRef in1 (instanceRef G_G60))
    (portRef out (instanceRef G_G10))))
```

```
(net N_N11 (joined
    (portRef in1 (instanceRef G_G66))
    (portRf in0 (instanceRef G_G60))
    (portR ef out (instanceRef G_G11))))
(net N_N12 (joined
    (portRef in0 (instanceRef G_G57))
    (portRef in0 (instanceRef G_G68))
    (portRef in0 (instanceRef G_G64))
    (portRef out (instanceRef G_G12))))
(net N_N13 (joined
    (portRef in1 (instanceRef G_G57))
    (portRef out (instanceRef G_G13))))
(net N_N14 (joined
    (portRef in1 (instanceRef G_G58))
    (portRef in0 (instanceRef G_G55))
    (portRef out (instanceRef G_G14))))
(net N_N15 (joined
    (portRef in0 (instanceRef G_G59))
    (portRef in1 (instanceRef G_G54))
    (portRef out (instanceRef G_G15))))
(net N_N16 (joined
    (portRef in1 (instanceRef G_G53))
    (portRef out (instanceRef G_G16))))
(net N_N17 (joined
    (portRef in0 (instanceRef G_G52))
    (portRef out (instanceRef G_G17))))
(net N_N18 (joined
    (portRef in0 (instanceRef G_G51))
    (portRef out (instanceRef G_G18))))
(net N_N19 (joined
    (portRef in0 (instanceRef G_G50))
    (portRef out (instanceRef G_G19))))
(net N_N20 (joined
    (portRef in1 (instanceRef G_G49))
    (portRef out (instanceRef G_G20))))
(net N_N21 (joined
    (portRef in0 (instanceRef G_G53))
    (portRef in1 (instanceRef G_G51))
    (portRef in0 (instanceRef G_G49))
    (portRef out (instanceRef G_G21))))
(net N_N22 (joined
    (portRef in1 (instanceRef G_G46))
    (portRef in1 (instanceRef G_G45))
    (portRef out (instanceRef G_G22))))
(net N_N23 (joined
    (portRef in0 (instanceRef G_G45))
    (portRef out (instanceRef G_G23))))
(net N_N24 (joined
    (portRef in1 (instanceRef G_G42))
    (portRef in1 (instanceRef G_G41))
    (portRef out (instanceRef G_G24))))
(net N_N25 (joined
    (portRef in0 (instanceRef G_G41))
    (portRef out (instanceRef G_G25))))
(net N_N26 (joined
    (portRef in0 (instanceRef G_G48))
    (portRef in1 (instanceRef G_G38))
    (portRef out (instanceRef G_G26))))
(net N_N27 (joined
    (portRef in1 (instanceRef G_G44))
    (portRef in0 (instanceRef G_G38))
    (portRef out (instanceRef G_G27))))
(net N_N28 (joined
    (portRef in0 (instanceRef G_G35))
    (portRef in0 (instanceRef G_G46))
    (portRef in0 (instanceRef G_G42))
    (portRef out (instanceRef G_G28))))
(net N_N29 (joined
    (portRef in1 (instanceRef G_G35))
    (portRef out (instanceRef G_G29))))
(net N_N30 (joined
    (portRef in1 (instanceRef G_G36))
    (portRef in0 (instanceRef G_G33))
    (portRef out (instanceRef G_G30))))
(net N_N31 (joined
    (portRef in0 (instanceRef G_G37))
    (portRef in1 (instanceRef G_G32))
    (portRef out (instanceRef G_G31))))
(net N_N32 (joined
    (portRef in1 (instanceRef G_G34))
    (portRef out (instanceRef G_G32))))
(net N_N33 (joined
    (portRef in0 (instanceRef G_G34))
    (portRef out (instanceRef G_G33))))
(net N_N34 (joined
    (portRef in1 (instanceRef G_G40))
    (portRef out (instanceRef G_G38))))
(net N_N35 (joined
    (portRef in0 (instanceRef G_G40))
    (portRef out (instanceRef G_G39))))
(net Nq0 (joined
    (portRef in (instanceRef G_G29))
```

```
    (portRef out (instanceRef G_G40))))
(net N_N36 (joined
    (portRef in1 (instanceRef G_G43))
    (portRef out (instanceRef G_G41))))
(net N_N37 (joined
    (portRef in0 (instanceRef G_G43))
    (portRef out (instanceRef G_G42))))
(net Nm0 (joined
    (portRef in (instanceRef G_G25))
    (portRef out (instanceRef G_G44))))
(net N_N38 (joined
    (portRef in1 (instanceRef G_G47))
    (portRef out (instanceRef G_G45))))
(net N_N39 (joined
    (portRef in0 (instanceRef G_G47))
    (portRef out (instanceRef G_G46))))
(net Nk0 (joined
    (portRef in (instanceRef G_G23))
    (portRef out (instanceRef G_G48))))
(net N_N40 (joined
    (portRef in1 (instanceRef G_G50))
    (portRef out (instanceRef G_G49))))
(net Nj0 (joined
    (portRef in (instanceRef G_G24))
    (portRef out (instanceRef G_G50))))
(net N_N41 (joined
    (portRef in1 (instanceRef G_G52))
    (portRef out (instanceRef G_G51))))
(net Ni0 (joined
    (portRef in (instanceRef G_G22))
    (portRef out (instanceRef G_G52))))
(net Nh0 (joined
    (portRef in (instanceRef G_G28))
    (portRef out (instanceRef G_G53))))
(net N_N42 (joined
    (portRef in1 (instanceRef G_G56))
    (portRef out (instanceRef G_G54))))
(net N_N43 (joined
    (portRef in0 (instanceRef G_G56))
    (portRef out (instanceRef G_G55))))
(net Ng0 (joined
    (portRef in (instanceRef G_G16))
    (portRef out (instanceRef G_G56))))
(net Nf0 (joined
    (portRef in (instanceRef G_G21))
    (portRef out (instanceRef G_G57))))
(net Ne0 (joined
    (portRef in (instanceRef G_G18))
    (portRef out (instanceRef G_G58))))
(net Nd0 (joined
    (portRef in (instanceRef G_G20))
    (portRef out (instanceRef G_G59))))
(net N_N44 (joined
    (portRef in1 (instanceRef G_G62))
    (portRef out (instanceRef G_G60))))
(net N_N45 (joined
    (portRef in0 (instanceRef G_G62))
    (portRef out (instanceRef G_G61))))
(net Na0 (joined
    (portRef in (instanceRef G_G13))
    (portRef out (instanceRef G_G62))))
(net N_N46 (joined
    (portRef in1 (instanceRef G_G65))
    (portRef out (instanceRef G_G63))))
(net N_N47 (joined
    (portRef in0 (instanceRef G_G65))
    (portRef out (instanceRef G_G64))))
(net Nx (joined
    (portRef in (instanceRef G_G19))
    (portRef out (instanceRef G_G65))))
(net Nw (joined
    (portRef in (instanceRef G_G9))
    (portRef out (instanceRef G_G66))))
(net N_N48 (joined
    (portRef in1 (instanceRef G_G69))
    (portRef out (instanceRef G_G67))))
(net N_N49 (joined
    (portRef in0 (instanceRef G_G69))
    (portRef out (instanceRef G_G68))))
(net Nv (joined
    (portRef in (instanceRef G_G17))
    (portRef out (instanceRef G_G69))))
(net Nu (joined
    (portRef in (instanceRef G_G7))
    (portRef out (instanceRef G_G70))))
(net N_N50 (joined
    (portRef in1 (instanceRef G_G72))
    (portRef out (instanceRef G_G71))))
(net Nl0 (joined
    (portRef in (instanceRef G_G3))
    (portRef out (instanceRef G_G47))))
(net Nu0 (joined
```

```
    (portRef in (instanceRef G_G4))
    (portRef out (instanceRef G_G36))))
(net Nm (joined
    (portRef Pm)
    (portRef out (instanceRef G_G73))))
(net Nw0 (joined
    (portRef in (instanceRef G_G2))
    (portRef out (instanceRef G_G34))))
(net N_N51 (joined
    (portRef in1 (instanceRef G_G75))
    (portRef out (instanceRef G_G74))))
(net Nn0 (joined
    (portRef in (instanceRef G_G0))
    (portRef out (instanceRef G_G43))))
(net Nt0 (joined
    (portRef in (instanceRef G_G1))
    (portRef out (instanceRef G_G37))))
(net Nv0 (joined
    (portRef in (instanceRef G_G5))
    (portRef out (instanceRef G_G35))))
(net Nn (joined
    (portRef out (instanceRef G_G72))
    (portRef Pn)))
(net Nl (joined
    (portRef out (instanceRef G_G75))
    (portRef Pl)))
(net Nk (joined
    (portRef in0 (instanceRef G_G36))
    (portRef in (instanceRef G_G31))
    (portRef in1 (instanceRef G_G33))
    (portRef Pk)))
(net Nj (joined
    (portRef in1 (instanceRef G_G37))
    (portRef in (instanceRef G_G30))
    (portRef in0 (instanceRef G_G32))
    (portRef Pj)))
(net Ni (joined
    (portRef in (instanceRef G_G26))
    (portRef in1 (instanceRef G_G39))
    (portRef in0 (instanceRef G_G44))
    (portRef Pi)))
(net Nh (joined
    (portRef in (instanceRef G_G27))
    (portRef in0 (instanceRef G_G39))
    (portRef in1 (instanceRef G_G48))
    (portRef Ph)))
(net Ng (joined
    (portRef in0 (instanceRef G_G58))
    (portRef in (instanceRef G_G15))
    (portRef in1 (instanceRef G_G55))
    (portRef Pg)))
(net Nf (joined
    (portRef in1 (instanceRef G_G59))
    (portRef in (instanceRef G_G14))
    (portRef in0 (instanceRef G_G54))
    (portRef Pf)))
(net Ne (joined
    (portRef in (instanceRef G_G10))
    (portRef in1 (instanceRef G_G61))
    (portRef in0 (instanceRef G_G66))
    (portRef Pe))))
(net Nd (joined
    (portRef in (instanceRef G_G11))
    (portRef in0 (instanceRef G_G61))
    (portRef in1 (instanceRef G_G70))
    (portRef Pd)))
(net Nc (joined
    (portRef in (instanceRef G_G6))
    (portRef Pc)))
(net Nb (joined
    (portRef in (instanceRef G_G12))
    (portRef Pb)))
(net Na (joined
    (portRef in (instanceRef G_G8))
    (portRef Pa)))  )))))
```

APPENDIX: Verilog Code

```
// exported by GateVision VerilogWriter 1.6
module INV_LOSPRESULT ( IN  ,  OUT  );
  input  IN ;
  output  OUT ;
endmodule
module NOR2_LOSPRESULT ( IN0  ,  IN1  ,  OUT  );
  input  IN0 ;  input  IN1 ;
  output  OUT ;
endmodule
module Cone1 ( A , B , C , D , E , F , G , H , I , J ,  K , OA , OB , OC );
  input  A ;  input  B ;  input  C ;  input  D ;  input  E ;  input  F ;
  input  G ;  input  H ;  input  I ;  input  J ;  input  K ;
  output  OA ;  output  OB ;  output  OC ;
  wire   N100 ;  wire   N101 ;  wire   N102 ;  wire   N103 ;  wire   N104 ;
  wire   N105 ;  wire   N106 ;  wire   N107 ;  wire   N108 ;  wire   N109 ;
  wire   N110 ;  wire   N111 ;  wire   N112 ;  wire   N113 ;  wire   N114 ;
  wire   N115 ;  wire   N116 ;  wire   N117 ;  wire   N118 ;  wire   N119 ;
  wire   N12 ;  wire   N120 ;  wire   N121 ;  wire   N122 ;  wire   N123 ;
  wire   N125 ;  wire   N126 ;  wire   N127 ;  wire   N128 ;  wire   N129 ;
  wire   N13 ;  wire   N130 ;  wire   N131 ;  wire   N14 ;  wire   N15 ;
  wire   N16 ;  wire   N17 ;  wire   N18 ;  wire   N19 ;  wire   N20 ;
  wire   N21 ;  wire   N22 ;  wire   N23 ;  wire   N24 ;  wire   N25 ;
  wire   N26 ;  wire   N27 ;  wire   N28 ;  wire   N29 ;  wire   N30 ;
  wire   N31 ;  wire   N32 ;  wire   N33 ;  wire   N34 ;  wire   N35 ;
  wire   N36 ;  wire   N37 ;  wire   N38 ;  wire   N39 ;  wire   N40 ;
  wire   N41 ;  wire   N42 ;  wire   N43 ;  wire   N44 ;  wire   N45 ;
  wire   N46 ;  wire   N47 ;  wire   N48 ;  wire   N49 ;  wire   N50 ;
  wire   N51 ;  wire   N52 ;  wire   N53 ;  wire   N54 ;  wire   N55 ;
  wire   N56 ;  wire   N57 ;  wire   N58 ;  wire   N59 ;  wire   N60 ;
  wire   N61 ;  wire   N62 ;  wire   N63 ;  wire   N64 ;  wire   N65 ;
  wire   N66 ;  wire   N67 ;  wire   N68 ;  wire   N69 ;  wire   N70 ;
  wire   N71 ;  wire   N72 ;  wire   N73 ;  wire   N74 ;  wire   N75 ;
  wire   N76 ;  wire   N77 ;  wire   N78 ;  wire   N79 ;  wire   N80 ;
  wire   N81 ;  wire   N82 ;  wire   N83 ;  wire   N84 ;  wire   N85 ;
  wire   N86 ;  wire   N87 ;  wire   N88 ;  wire   N89 ;  wire   N90 ;
  wire   N91 ;  wire   N94 ;  wire   N95 ;  wire   N96 ;  wire   N97 ;
  wire   N98 ;  wire   N99 ;
  INV_LOSPRESULT G1 ( A  ,  N12  );
  INV_LOSPRESULT G10 ( J  ,  N13  );
  NOR2_LOSPRESULT G100 ( N79  ,  N80  ,  N14  );
  NOR2_LOSPRESULT G101 ( N79  ,  N81  ,  N15  );
  NOR2_LOSPRESULT G102 ( N82  ,  N83  ,  N16  );
  NOR2_LOSPRESULT G103 ( N82  ,  N84  ,  N17  );
  NOR2_LOSPRESULT G104 ( N85  ,  N86  ,  N18  );
  NOR2_LOSPRESULT G105 ( N84  ,  N85  ,  N19  );
  NOR2_LOSPRESULT G106 ( N61  ,  N62  ,  N20  );
  NOR2_LOSPRESULT G107 ( N41  ,  N123  ,  N21  );
  NOR2_LOSPRESULT G108 ( N43  ,  N125  ,  N22  );
  NOR2_LOSPRESULT G109 ( N13  ,  N53  ,  N23  );
  INV_LOSPRESULT G11 ( K  ,  N24  );
  NOR2_LOSPRESULT G110 ( N57  ,  N14  ,  N25  );
  NOR2_LOSPRESULT G111 ( N54  ,  N15  ,  N26  );
  NOR2_LOSPRESULT G112 ( N40  ,  N48  ,  N27  );
  NOR2_LOSPRESULT G113 ( N112  ,  N113  ,  N28  );
  NOR2_LOSPRESULT G114 ( N114  ,  N20  ,  N29  );
  NOR2_LOSPRESULT G115 ( N18  ,  N19  ,  N30  );
  NOR2_LOSPRESULT G116 ( N16  ,  N17  ,  N31  );
  NOR2_LOSPRESULT G117 ( N117  ,  N118  ,  N32  );
  NOR2_LOSPRESULT G118 ( N119  ,  N130  ,  N33  );
  NOR2_LOSPRESULT G119 ( N128  ,  N129  ,  N34  );
  INV_LOSPRESULT G12 ( N98  ,  N35  );
  NOR2_LOSPRESULT G120 ( N126  ,  N127  ,  N36  );
  INV_LOSPRESULT G13 ( N97  ,  N37  );
  INV_LOSPRESULT G14 ( N87  ,  N38  );
  INV_LOSPRESULT G15 ( N89  ,  N39  );
  INV_LOSPRESULT G16 ( N100  ,  N40  );
  INV_LOSPRESULT G17 ( N101  ,  N41  );
  INV_LOSPRESULT G18 ( N115  ,  N42  );
  INV_LOSPRESULT G19 ( N102  ,  N43  );
  INV_LOSPRESULT G2 ( B  ,  N44  );
  INV_LOSPRESULT G20 ( N116  ,  N45  );
  INV_LOSPRESULT G21 ( N96  ,  N46  );
  INV_LOSPRESULT G22 ( N95  ,  N47  );
  INV_LOSPRESULT G23 ( N131  ,  N48  );
  INV_LOSPRESULT G24 ( N103  ,  N49  );
  INV_LOSPRESULT G25 ( N94  ,  N50  );
  INV_LOSPRESULT G26 ( N90  ,  N51  );
```

```
  INV_LOSPRESULT G27 ( N91  ,  N52  );
  INV_LOSPRESULT G28 ( N104  ,  N53  );
  INV_LOSPRESULT G29 ( N105  ,  N54  );
  INV_LOSPRESULT G3 ( C  ,  N55  );
  INV_LOSPRESULT G30 ( N120  ,  N56  );
  INV_LOSPRESULT G31 ( N106  ,  N57  );
  INV_LOSPRESULT G32 ( N122  ,  N58  );
  INV_LOSPRESULT G33 ( N44  ,  N59  );
  INV_LOSPRESULT G34 ( N12  ,  N60  );
  INV_LOSPRESULT G35 ( N66  ,  N61  );
  INV_LOSPRESULT G36 ( N55  ,  N62  );
  INV_LOSPRESULT G37 ( N88  ,  N63  );
  INV_LOSPRESULT G38 ( N77  ,  N64  );
  INV_LOSPRESULT G39 ( N110  ,  N65  );
  INV_LOSPRESULT G4 ( D  ,  N66  );
  INV_LOSPRESULT G40 ( N99  ,  N67  );
  INV_LOSPRESULT G41 ( N39  ,  N68  );
  INV_LOSPRESULT G42 ( N37  ,  N69  );
  INV_LOSPRESULT G43 ( N35  ,  N70  );
  INV_LOSPRESULT G44 ( N38  ,  N71  );
  INV_LOSPRESULT G45 ( N121  ,  N72  );
  INV_LOSPRESULT G46 ( N58  ,  N73  );
  INV_LOSPRESULT G47 ( N13  ,  N74  );
  INV_LOSPRESULT G48 ( N24  ,  N75  );
  INV_LOSPRESULT G49 ( N56  ,  N76  );
  INV_LOSPRESULT G5 ( E  ,  N77  );
  INV_LOSPRESULT G50 ( N49  ,  N78  );
  INV_LOSPRESULT G51 ( N50  ,  N79  );
  INV_LOSPRESULT G52 ( N51  ,  N80  );
  INV_LOSPRESULT G53 ( N52  ,  N81  );
  INV_LOSPRESULT G54 ( N47  ,  N82  );
  INV_LOSPRESULT G55 ( N45  ,  N83  );
  INV_LOSPRESULT G56 ( N48  ,  N84  );
  INV_LOSPRESULT G57 ( N46  ,  N85  );
  INV_LOSPRESULT G58 ( N42  ,  N86  );
  INV_LOSPRESULT G59 ( N107  ,  N87  );
  INV_LOSPRESULT G6 ( F  ,  N88  );
  INV_LOSPRESULT G60 ( N108  ,  N89  );
  INV_LOSPRESULT G61 ( N109  ,  N90  );
  INV_LOSPRESULT G62 ( N111  ,  N91  );
  INV_LOSPRESULT G63 ( N21  ,  OC  );
  INV_LOSPRESULT G64 ( N22  ,  OA  );
  INV_LOSPRESULT G65 ( N23  ,  N94  );
  INV_LOSPRESULT G66 ( N25  ,  N95  );
  INV_LOSPRESULT G67 ( N26  ,  N96  );
  INV_LOSPRESULT G68 ( N27  ,  N97  );
  INV_LOSPRESULT G69 ( N28  ,  N98  );
  INV_LOSPRESULT G7 ( G  ,  N99  );
  INV_LOSPRESULT G70 ( N29  ,  N100  );
  INV_LOSPRESULT G71 ( N30  ,  N101  );
  INV_LOSPRESULT G72 ( N31  ,  N102  );
  INV_LOSPRESULT G73 ( N32  ,  N103  );
  INV_LOSPRESULT G74 ( N33  ,  N104  );
  INV_LOSPRESULT G75 ( N34  ,  N105  );
  INV_LOSPRESULT G76 ( N36  ,  N106  );
  NOR2_LOSPRESULT G77 ( A  ,  N44  ,  N107  );
  NOR2_LOSPRESULT G78 ( B  ,  N12  ,  N108  );
  NOR2_LOSPRESULT G79 ( E  ,  N88  ,  N109  );
  INV_LOSPRESULT G8 ( H  ,  N110  );
  NOR2_LOSPRESULT G80 ( F  ,  N77  ,  N111  );
  NOR2_LOSPRESULT G81 ( N12  ,  N59  ,  N112  );
  NOR2_LOSPRESULT G82 ( N44  ,  N60  ,  N113  );
  NOR2_LOSPRESULT G83 ( N55  ,  N66  ,  N114  );
  NOR2_LOSPRESULT G84 ( N55  ,  N61  ,  N115  );
  NOR2_LOSPRESULT G85 ( N66  ,  N62  ,  N116  );
  NOR2_LOSPRESULT G86 ( N77  ,  N63  ,  N117  );
  NOR2_LOSPRESULT G87 ( N88  ,  N64  ,  N118  );
  NOR2_LOSPRESULT G88 ( N99  ,  N110  ,  N119  );
  NOR2_LOSPRESULT G89 ( N99  ,  N65  ,  N120  );
  INV_LOSPRESULT G9 ( I  ,  N121  );
  NOR2_LOSPRESULT G90 ( N110  ,  N67  ,  N122  );
  NOR2_LOSPRESULT G91 ( N68  ,  N69  ,  N123  );
  NOR2_LOSPRESULT G92 ( N69  ,  N70  ,  OB  );
  NOR2_LOSPRESULT G93 ( N69  ,  N71  ,  N125  );
  NOR2_LOSPRESULT G94 ( N72  ,  N73  ,  N126  );
  NOR2_LOSPRESULT G95 ( N72  ,  N74  ,  N127  );
  NOR2_LOSPRESULT G96 ( N75  ,  N76  ,  N128  );
  NOR2_LOSPRESULT G97 ( N74  ,  N75  ,  N129  );
  NOR2_LOSPRESULT G98 ( N65  ,  N67  ,  N130  );
  NOR2_LOSPRESULT G99 ( N78  ,  N79  ,  N131  );
endmodule
```