EENG-5560 Final Project Report

SUBMITTED BY

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# Specifications

|  |  |
| --- | --- |
| Requirement | Design Follows Requirement |
| Input data width: 4 bits | Yes |
| Homogeneous Computational Units (CUs) | Yes |
| Heterogeneous Interconnects | Yes |
| Interconnects with mirroring | Yes |
| Pass and No Op operation support | Yes |
| Support for all of the DFGs on the Super-architecture | Yes |

# Design

## Block diagram

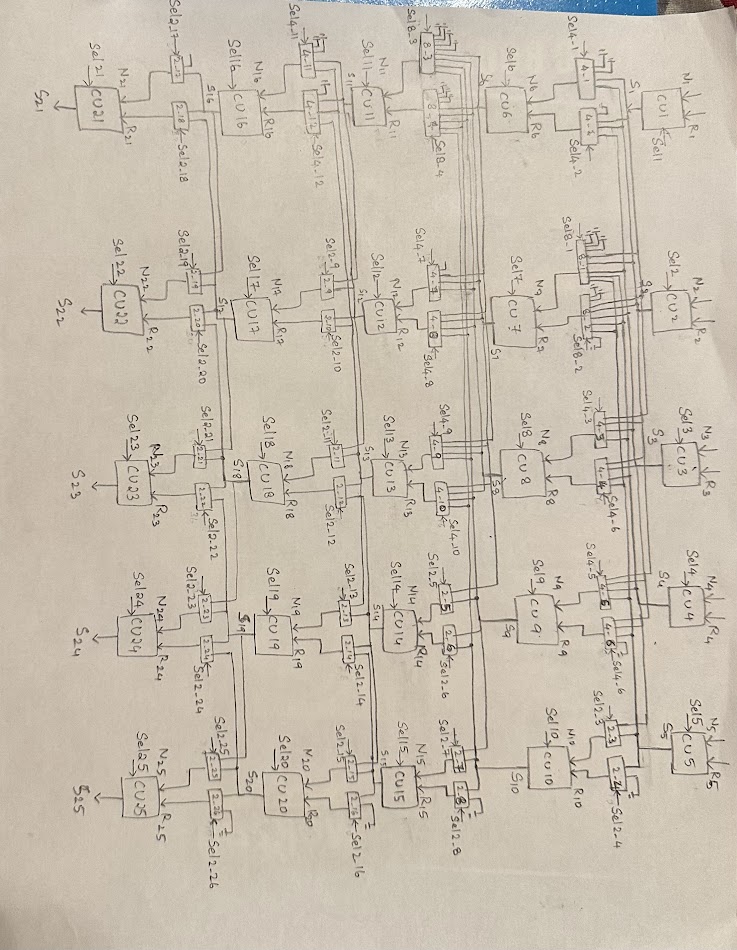


Figure -Block diagram of 5 X 5 Fabric

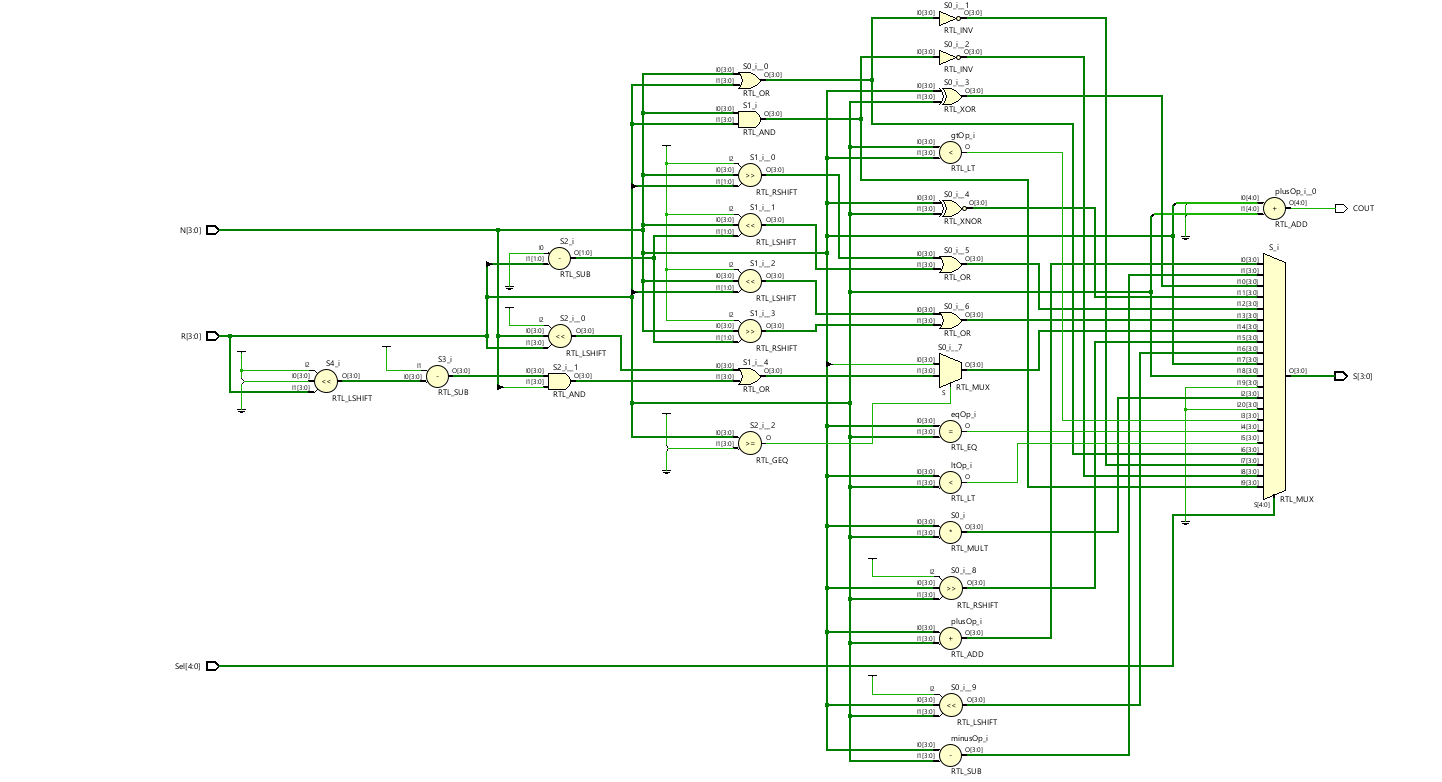
* The block diagram shows the 5 x 5 reconfigurable architecture fabric.(5 rows & 5 columns)
* The fabric consists a total of 25 CU’s (Computational Unit’s), 4 no’s of 8:1 mux’s,

12 no’s of 4:1 mux’s, and 24 no’s of 2:1 mux’s

* The data width for the CU is 4 bits wide.
* Each CU can perform 19 operations. These include Arithmetic, Shift and Comparison operations.
* Each of the mux’s used are operated based on mirroring concept.
* The CU’s in the fabric are operated based on the Data flow graphs given in the problem. And the operation of the fabric is left justified.
* There is no multi-level connectivity in the fabric.
* Pass Gates are used in the fabric to pass the output values from 1st row to 3rd /4th / 5th row CU’s. Two pass gates are used for this, namely Pass gate 1 & Pass gate 2.
* CU with Pass Gate 1 operation passes the output for Input 1.
* CU with Pass Gate 2 operation passes the output for Input 2.
* Depending on data flow graph’s given each CU does the operation specified to it.
* The rest of all CU’s are set to No Operation (NOOP), where these CU’s output is 0000 irrespective of inputs.
* We will get the final outputs from S21 and S22 depending on DFG’s.

**Overall Component**: 5 x 5 Fabric

* Overall ports:
  + Inputs:
    - N1, R1, N2, R2, N3, R3, N4, R4, N5, R5: 4 bits
    - Sel 1 - Sel 25: 5 bits (CU Sel’s)
  + Outputs:
    - S21, S22, S23, S24, S25: 4 bits
* Subcomponents:
  + **ALU**

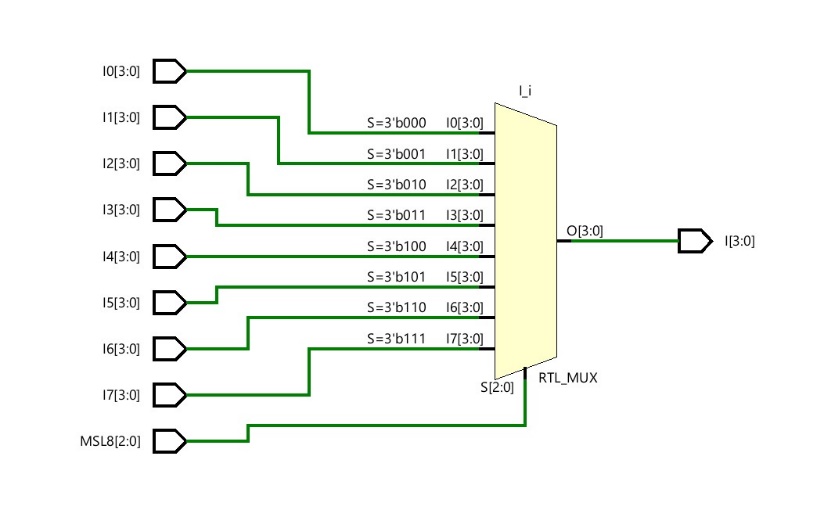
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N, R: Input’s (4 bits)

S: Output (4 bits)

Sel: Selector (5 bit’s)

* + **8:1 Mux**



I0,I1,I2,I3,I4,I5,I6,I7 : Inputs(4 bit)  
MSL8 : Selector (3 bits)  
I : Output(4 bit)

* + **4:1 Mux**

Diagram

Description automatically generated

J0,J1,J2,J3 : Inputs(4 bit)

MSL4 : Selector(2 bit)

J : Output(4bit)

* + **2:1 Mux**

Diagram

Description automatically generated

K0, K1: Inputs (4 bit)

MSL2: Selector (1 bit)

K: Output (4 bit)

* Necessary intermediate signals:
  + S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20,

S21, S22, S23, S24, S25: outputs of CU’s given as input’s to 8:1,4:1,2:1 mux’s.

* + N6,R6,N7,R7,N8,R8,N9,R9,N10,R10,N11,R11,N12,R12,N13,R13,N14,R14,N15,R15,

N16,R16,N17,R17,N18,R18,N19,R19,N20,R20,N21,R21,N22,R22,N23,R23,N24,R24,

N25,R25 : Output’s from mux’s given as input’s to next row CU’s, 4 bits

Opcode table: (FOR CU’s)

|  |  |
| --- | --- |
| **OPCODE** | **OPERATION** |
| 00000 | ADDITION (+) |
| 00001 | SUBTRACTION (-) |
| 00010 | MULTIPLICATION (\*) |
| 00011 | EQUAL TO (=) |
| 00100 | GREATER THAN (>) |
| 00101 | LESS THAN (<) |
| 00110 | OR |
| 00111 | NOR |
| 01000 | AND |
| 01001 | XOR |
| 01011 | XNOR |
| 01100 | ROR (rotate right) |
| 01101 | ROL (rotate left) |
| 01110 | ASL (arithmetic shift left) |
| 01111 | LSR (logical shift right) |
| 10000 | LSL (logical shift left) |
| 10001 | PASS GATE-1 |
| 10010 | PASS GATE-2 |
| 10011 | NO OPERATION |

## Design explanation:

* The design of the 5 x 5 fabric satisfies all the conditions that were given in the DFG’s.
* Two Input’s(4bit) are given to each and every CU presented in the fabric. Based on the DFG the operations are assigned to each CU depending on their Opcode(Sel line). And output(4 bit) is generated
* A total of 25 CU’s are included in this fabric.
* For the connectivity between the 1st row CU’s to the next row CU’s we used different mux’s(8:1/4:1/2:1) depending on the connectivity. i.e., output’s of 1st row CU’s are given as input’s to next row CU’s and so on up to 5 rows.
* For this handling we used two mux’s(which are mirrored to each other) for each CU inputs. We used mirroring concept to connect the mux’s. Basically the two mux’s combined gets us reachability. i.e., for 2:1 pair of mux’s it is -1 to +1 and for 4:1 pair of mux’s -2 to +2 and for 8:1 pair of mux’s it is -4 to +4
* We used 8:1 mux, because we have operated our CU’s in the fabric to be left justified. So in this case, if the 1st CU of 2nd row wants to get an input from 5th CU of 1st row we can easily reach with the help of mirrored 8:1 mux.
* Similarly 4:1 and 2:1 mux’s are used by considering the data flow that was specified in the DFG’s given and the type of CU connections that are specified in all DFG’s.
* **For DFG-1:** As given in the DFG the operations and connectivity for the CU’s are given accordingly. CU1 performs addition, CU2 performs multiplication, CU3-addition, CU4-subtraction, CU-5 multiplication, for the given set of inputs for each CU.
* Now the outputs from the first row CU’s i.e., S1,S2,S3,S4,S5 are given as inputs to the next row CU’s by using mux’s. The output’s from row 1 CU’s are first given as inputs to mux’s present below and the output’s from the mux’s based on the sel line of the mux(MSL) is given as input to next row CU.
* For **CU6(SUB)** inputs N6,R6 are taken from outputs of CU1 & CU3. For this Mux’s 4\_1, 4\_2 are used. For mux 4\_1, pins J0,J1 are grounded. And J2 is connected to S1& J3 is connected to S2. And in mux 4\_2 J0 pin is grounded and pins J1,J2,J3 are connected to S1,S2,S3 respectively. Mux 4\_1 gives output from pin J2 by setting MSL4\_1 as “10”. And mux 4\_2 gives output from pin J3 by setting MSL4\_2 as “11”.
* For **CU7(ADD)** inputs N7,R7 are taken from outputs of CU3 & CU5 . For this Mux’s 8\_1, 8\_2 are used. For mux 8\_1, pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S1,S2,S3,S4,S5 respectively. In mux 8\_2 pins I0,I1,I7 are grounded and I2,I3,I4,I5,I6 are connected to outputs S1,S2,S3,S4,S5 respectively. Mux 8\_1 gives output from pin I5 by setting MSL8\_1 as “101” and for mux 8\_2 from pin I6 by setting MSL8\_2 as “110”.
* For **CU8(SUB)** inputs N8,R8 are taken from outputs of CU2 & CU4 . For this Mux’s 4\_3, 4\_4 are used. For mux 4\_3, pins J0,J1,J2,J3 are connected to outputs S1,S2,S3,S4 respectively. In mux 4\_4 pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. Mux 4\_3 gives output from pin J1 by setting MSL4\_3 as “01” and for mux 4\_4 from pin J2 by setting MSL4\_4 as “10”.
* For **CU9(PG 2)** inputs N9,R9 are taken from outputs of CU2 & CU5 . For this Mux’s 4\_5, 4\_6 are used. For mux 4\_5, pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. In mux 4\_6 pins J0,J1,J2 are connected to outputs S3,S4,S5 respectively, pin J3 is grounded. Mux 4\_5 gives output from pin J0 by setting MSL4\_5 as “00” and for mux 4\_6 from pin J2 by setting MSL4\_6 as “10”.
* For **CU10(NOOP)** inputs N10,R10 are taken from outputs of CU5 & CU5 . For this Mux’s 2\_3, 2\_4 are used. For mux 2\_3, pins K0,K1 are connected to outputs S4,S5 respectively. In mux 2\_4 pin K0 is connected to output S5, pin K1 is grounded. Mux 2\_3 gives output from pin K1by setting MSL2\_3 as “1” and for mux 2\_4 from pin K0 by setting MSL2\_4 as “0”.
* Now the output’s from CU6, CU7, CU8, CU9, CU10 are S6, S7, S8, S9, S10 respectively. These outputs are given as inputs to third row CU’s, CU11-CU15 by using mux’s.
* For **CU11(OR)** inputs N11,R11 are taken from outputs of CU6 & CU8 . For this Mux’s 8\_3, 8\_4 are used. For mux 8\_3, pins I0,I1,I2,I3 are grounded and pins I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9 respectively. In mux 8\_3 pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9,S10 respectively. Mux 8\_3 gives output from pin I4 by setting MSL8\_3 as “100” and for mux 8\_4 from pin I5 by setting MSL8\_4 as “101”.
* For **CU12(AND)** inputs N12,R12 are taken from outputs of CU7 & CU8 . For this Mux’s 4\_7, 4\_8 are used. For mux 4\_7, pins J1,J2,J3 are connected to outputs S6,S7,S8 respectively, pin J0 is grounded. In mux 4\_8 pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. Mux 4\_7 gives output from pin J2 by setting MSL4\_7 as “10” and for mux 4\_8 from pin J2 by setting MSL4\_8 as “10”.
* For **CU13(NAND)** inputs N13,R13 are taken from outputs of CU6 & CU9 . For this Mux’s 4\_9, 4\_10 are used. For mux 4\_9, pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. In mux 4\_10 pins J0,J1,J2,J3 are connected to outputs S7,S8,S9,S10 respectively. Mux 4\_9 gives output from pin J0 by setting MSL4\_9 as “00” and for mux 4\_10 from pin J2 by setting MSL4\_10 as “10”.
* For **CU14(NOOP)** inputs N14,R14 are taken from outputs of CU8 & CU9 . For this Mux’s 2\_5, 2\_6 are used. For mux 2\_5, pins K0,K1 are connected to outputs S8,S9 respectively. In mux 2\_6 pin K0,K1 are connected to outputs S9,S10. Mux 2\_5 gives output from pin K0 by setting MSL2\_5 as “0” and for mux 2\_4 from pin K0 by setting MSL2\_6 as “0”.
* For **CU15(NOOP)** inputs N15,R15 are taken from outputs of CU9 & CU10 . For this Mux’s 2\_7, 2\_8 are used. For mux 2\_7, pins K0,K1 are connected to outputs S9,S10 respectively. In mux 2\_8 pin K0 is connected to output S10, K1 is grounded. Mux 2\_7 gives output from pin K0 by setting MSL2\_7 as “0” and for mux 2\_8 from pin K0 by setting MSL2\_8 as “0”.
* Now the output’s from CU11, CU12, CU13, CU14, CU15 are S11, S12, S13, S14, S15 respectively. These outputs are given as inputs to fourth row CU’s, CU16-CU20 by using mux’s.
* For **CU16(XOR)** inputs N16,R16 are taken from outputs of CU11 & CU12 . For this Mux’s 4\_11, 4\_12 are used. For mux 4\_11, pins J0,J1 are grounded and pins J2,J3 are connected to outputs S11,S12 respectively. In mux 4\_12 pin J0 is grounded and pins J1,J2,J3 are connected to outputs S11,S12,S13 respectively. Mux 4\_ 11 gives output from pin J2 by setting MSL4\_11 as “10” and for mux 4\_12 from pin J2 by setting MSL4\_12 as “10”.
* For **CU17(NOR)** inputs N17,R17 are taken from outputs of CU12 & CU13 . For this Mux’s 2\_9, 2\_10 are used. For mux 2\_9, pins K0,K1 are connected to outputs S11,S12 respectively. In mux 2\_10 pin K0,K1 are connected to outputs S12,S13. Mux 2\_9 gives output from pin K1 by setting MSL2\_9 as “1” and for mux 2\_10 from pin K1 by setting MSL2\_10 as “1”.
* For **CU18(NOOP)** inputs N18,R18 are taken from outputs of CU12 & CU14 . For this Mux’s 2\_11, 2\_12 are used. For mux 2\_11, pins K0,K1 are connected to outputs S12,S13 respectively. In mux 2\_12 pin K0,K1 are connected to outputs S13,S14. Mux 2\_11 gives output from pin K0 by setting MSL2\_11 as “0” and for mux 2\_12 from pin K1 by setting MSL2\_12 as “1” .
* For **CU19(NOOP)** inputs N19,R19 are taken from outputs of CU13 & CU14 . For this Mux’s 2\_13, 2\_14 are used. For mux 2\_13, pins K0,K1 are connected to outputs S13,S14 respectively. In mux 2\_14 pin K0,K1 are connected to outputs S14,S15. Mux 2\_13 gives output from pin K0 by setting MSL2\_13 as “0” and for mux 2\_14 from pin K0 by setting MSL2\_14 as “0”.
* For **CU20(NOOP)** inputs N20,R20 are taken from outputs of CU14 & CU15 . For this Mux’s 2\_15, 2\_16 are used. For mux 2\_15, pins K0,K1 are connected to outputs S14,S15 respectively. In mux 2\_16 pin K0 is connected to output S15, and pin K1 is grounded. Mux 2\_15 gives output from pin K0 by setting MSL2\_15 as “0” and for mux 2\_16 from pin K0 by setting MSL2\_16 as “0”.
* The output’s from CU16, CU17, CU18, CU19, CU20 are S16, S17, S18, S19, S20 respectively. These outputs are given as inputs to fifth row CU’s, CU21-CU25 by using mux’s.
* For **CU21(PG 1)** inputs N21,R21 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_17, 2\_18 are used. For mux 2\_17, pin K0 is grounded and pin K1 is connected to output S16. In mux 2\_18 pins K0,K1 are connected to S16,S17 respectively. Mux 2\_17 gives output from pin K1 by setting MSL2\_17 as “1” and for mux 2\_18 from pin K1 by setting MSL2\_18 as “1”.
* For **CU22(PG 2)** inputs N22,R22 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_19, 2\_20 are used. For mux 2\_19, pins K0,K1 are connected to outputs S16,S17 respectively. In mux 2\_20 pin K0,K1 are connected to outputs S17,S18. Mux 2\_19 gives output from pin K0 by setting MSL2\_19 as “0” and for mux 2\_20 from pin K0 by setting MSL2\_20 as “0”.
* For **CU23(NOOP)** inputs N23,R23 are taken from outputs of CU17 & CU19 . For this Mux’s 2\_21, 2\_22 are used. For mux 2\_21, pins K0,K1 are connected to outputs S17,S18 respectively. In mux 2\_22 pin K,K1 are connected to outputs S18,S19. Mux 2\_22 gives output from pin K0 by setting MSL2\_21 as “0” and for mux 2\_22 from pin K1 by setting MSL2\_10 as “1”.
* For **CU24(NOOP)** inputs N24,R24 are taken from outputs of CU18 & CU19 . For this Mux’s 2\_23, 2\_24 are used. For mux 2\_23, pins K0,K1 are connected to outputs S18,S19 respectively. In mux 2\_24 pin K0,K1 are connected to outputs S19,S20. Mux 2\_23 gives output from pin K0 by setting MSL2\_23 as “0” and for mux 2\_24 from pin K0 by setting MSL2\_24 as “0”.
* For **CU25(NOOP)** inputs N25,R25 are taken from outputs of CU19 & CU20 . For this Mux’s 2\_25, 2\_26 are used. For mux 2\_25, pins K0,K1 are connected to outputs S19,S20 respectively. In mux 2\_26 pin K0 is connected to output S20and K1 is grounded. Mux 2\_25 gives output from pin K0 by setting MSL2\_25 as “0” and for mux 2\_26 from pin K0 by setting MSL2\_26 as “0”.
* The output’s from CU21, CU22, CU23, CU24, CU25 are S21, S22, S23, S24, S25 respectively.
* For the DFG-1 we take outputs from CU21,CU22. i.e., S21&S22.
* **For DFG-2:** As given in the DFG the operations and connectivity for the CU’s are given accordingly. CU1 performs subtraction, CU2 performs multiplication, CU3-NOOP, CU4-addition, CU-5 multiplication, for the given set of inputs for each CU.
* Now the outputs from the first row CU’s i.e., S1,S2,S3,S4,S5 are given as inputs to the next row CU’s by using mux’s. The output’s from row 1 CU’s are first given as inputs to mux’s present below and the output’s from the mux’s based on the sel line of the mux(MSL) is given as input to next row CU.
* For **CU6(PG 1)** inputs N6,R6 are taken from outputs of CU1 & CU3. For this Mux’s 4\_1, 4\_2 are used. For mux 4\_1, pins J0,J1 are grounded. And J2 is connected to S1& J3 is connected to S2. And in mux 4\_2 J0 pin is grounded and pins J1,J2,J3 are connected to S1,S2,S3 respectively. Mux 4\_1 gives output from pin J2 by setting MSL4\_1 as “10”. And mux 4\_2 gives output from pin J3 by setting MSL4\_2 as “11”.
* For **CU7(ADD)** inputs N7,R7 are taken from outputs of CU1 & CU4 . For this Mux’s 8\_1, 8\_2 are used. For mux 8\_1, pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S1,S2,S3,S4,S5 respectively. In mux 8\_2 pins I0,I1,I7 are grounded and I2,I3,I4,I5,I6 are connected to outputs S1,S2,S3,S4,S5 respectively. Mux 8\_1 gives output from pin I3 by setting MSL8\_1 as “011” and for mux 8\_2 from pin I5 by setting MSL8\_2 as “101”.
* For **CU8(SUB)** inputs N8,R8 are taken from outputs of CU1 & CU5 . For this Mux’s 4\_3, 4\_4 are used. For mux 4\_3, pins J0,J1,J2,J3 are connected to outputs S1,S2,S3,S4 respectively. In mux 4\_4 pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. Mux 4\_3 gives output from pin J0 by setting MSL4\_3 as “00” and for mux 4\_4 from pin J3 by setting MSL4\_4 as “11”.
* For **CU9(ADD)** inputs N9,R9 are taken from outputs of CU2 & CU5 . For this Mux’s 4\_5, 4\_6 are used. For mux 4\_5, pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. In mux 4\_6 pins J0,J1,J2 are connected to outputs S3,S4,S5 respectively, pin J3 is grounded. Mux 4\_5 gives output from pin J0 by setting MSL4\_5 as “00” and for mux 4\_6 from pin J2 by setting MSL4\_6 as “10”.
* For **CU10(PG 1)** inputs N10,R10 are taken from outputs of CU4 & CU5 . For this Mux’s 2\_3, 2\_4 are used. For mux 2\_3, pins K0,K1 are connected to outputs S4,S5 respectively. In mux 2\_4 pin K0 is connected to output S5, pin K1 is grounded. Mux 2\_3 gives output from pin K0 by setting MSL2\_3 as “0” and for mux 2\_4 from pin K0 by setting MSL2\_4 as “0”.
* Now the output’s from CU6, CU7, CU8, CU9, CU10 are S6, S7, S8, S9, S10 respectively. These outputs are given as inputs to third row CU’s, CU11-CU15 by using mux’s.
* For **CU11(ROR)** inputs N11,R11 are taken from outputs of CU6 & CU9 . For this Mux’s 8\_3, 8\_4 are used. For mux 8\_3, pins I0,I1,I2,I3 are grounded and pins I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9 respectively. In mux 8\_3 pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9,S10 respectively. Mux 8\_3 gives output from pin I4 by setting MSL8\_3 as “100” and for mux 8\_4 from pin I6 by setting MSL8\_4 as “110”.
* For **CU12(PG 2)** inputs N12,R12 are taken from outputs of CU7 & CU8 . For this Mux’s 4\_7, 4\_8 are used. For mux 4\_7, pins J1,J2,J3 are connected to outputs S6,S7,S8 respectively, pin J0 is grounded. In mux 4\_8 pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. Mux 4\_7 gives output from pin J2 by setting MSL4\_7 as “10” and for mux 4\_8 from pin J2 by setting MSL4\_8 as “10”.
* For **CU13(LSL)** inputs N13,R13 are taken from outputs of CU7 & CU10 . For this Mux’s 4\_9, 4\_10 are used. For mux 4\_9, pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. In mux 4\_10 pins J0,J1,J2,J3 are connected to outputs S7,S8,S9,S10 respectively. Mux 4\_9 gives output from pin J1 by setting MSL4\_9 as “01” and for mux 4\_10 from pin J3 by setting MSL4\_10 as “11”.
* For **CU14(NOOP)** inputs N14,R14 are taken from outputs of CU8 & CU9 . For this Mux’s 2\_5, 2\_6 are used. For mux 2\_5, pins K0,K1 are connected to outputs S8,S9 respectively. In mux 2\_6 pin K0,K1 are connected to outputs S9,S10. Mux 2\_5 gives output from pin K0 by setting MSL2\_5 as “0” and for mux 2\_4 from pin K0 by setting MSL2\_6 as “0”.
* For **CU15(NOOP)** inputs N15,R15 are taken from outputs of CU9 & CU10 . For this Mux’s 2\_7, 2\_8 are used. For mux 2\_7, pins K0,K1 are connected to outputs S9,S10 respectively. In mux 2\_8 pin K0 is connected to output S10, K1 is grounded. Mux 2\_7 gives output from pin K0 by setting MSL2\_7 as “0” and for mux 2\_8 from pin K0 by setting MSL2\_8 as “0”.
* Now the output’s from CU11, CU12, CU13, CU14, CU15 are S11, S12, S13, S14, S15 respectively. These outputs are given as inputs to fourth row CU’s, CU16-CU20 by using mux’s.
* For **CU16(GREATER THAN)** inputs N16,R16 are taken from outputs of CU11 & CU13 . For this Mux’s 4\_11, 4\_12 are used. For mux 4\_11, pins J0,J1 are grounded and pins J2,J3 are connected to outputs S11,S12 respectively. In mux 4\_12 pin J0 is grounded and pins J1,J2,J3 are connected to outputs S11,S12,S13 respectively. Mux 4\_ 11 gives output from pin J2 by setting MSL4\_11 as “10” and for mux 4\_12 from pin J3 by setting MSL4\_12 as “11”.
* For **CU17(EQUAL TO)** inputs N17,R17 are taken from outputs of CU11 & CU12 . For this Mux’s 2\_9, 2\_10 are used. For mux 2\_9, pins K0,K1 are connected to outputs S11,S12 respectively. In mux 2\_10 pin K0,K1 are connected to outputs S12,S13. Mux 2\_9 gives output from pin K0 by setting MSL2\_9 as “0” and for mux 2\_10 from pin K0 by setting MSL2\_10 as “0”.
* For **CU18(NOOP)** inputs N18,R18 are taken from outputs of CU12 & CU14 . For this Mux’s 2\_11, 2\_12 are used. For mux 2\_11, pins K0,K1 are connected to outputs S12,S13 respectively. In mux 2\_12 pin K0,K1 are connected to outputs S13,S14. Mux 2\_11 gives output from pin K0 by setting MSL2\_11 as “0” and for mux 2\_12 from pin K1 by setting MSL2\_12 as “1” .
* For **CU19(NOOP)** inputs N19,R19 are taken from outputs of CU13 & CU14 . For this Mux’s 2\_13, 2\_14 are used. For mux 2\_13, pins K0,K1 are connected to outputs S13,S14 respectively. In mux 2\_14 pin K0,K1 are connected to outputs S14,S15. Mux 2\_13 gives output from pin K0 by setting MSL2\_13 as “0” and for mux 2\_14 from pin K0 by setting MSL2\_14 as “0”.
* For **CU20(NOOP)** inputs N20,R20 are taken from outputs of CU14 & CU15 . For this Mux’s 2\_15, 2\_16 are used. For mux 2\_15, pins K0,K1 are connected to outputs S14,S15 respectively. In mux 2\_16 pin K0 is connected to output S15, and pin K1 is grounded. Mux 2\_15 gives output from pin K0 by setting MSL2\_15 as “0” and for mux 2\_16 from pin K0 by setting MSL2\_16 as “0”.
* The output’s from CU16, CU17, CU18, CU19, CU20 are S16, S17, S18, S19, S20 respectively. These outputs are given as inputs to fifth row CU’s, CU21-CU25 by using mux’s.
* For **CU21(PG 1)** inputs N21,R21 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_17, 2\_18 are used. For mux 2\_17, pin K0 is grounded and pin K1 is connected to output S16. In mux 2\_18 pins K0,K1 are connected to S16,S17 respectively. Mux 2\_17 gives output from pin K1 by setting MSL2\_17 as “1” and for mux 2\_18 from pin K1 by setting MSL2\_18 as “1”.
* For **CU22(PG 2)** inputs N22,R22 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_19, 2\_20 are used. For mux 2\_19, pins K0,K1 are connected to outputs S16,S17 respectively. In mux 2\_20 pin K0,K1 are connected to outputs S17,S18. Mux 2\_19 gives output from pin K0 by setting MSL2\_19 as “0” and for mux 2\_20 from pin K0 by setting MSL2\_20 as “0”.
* For **CU23(NOOP)** inputs N23,R23 are taken from outputs of CU17 & CU19 . For this Mux’s 2\_21, 2\_22 are used. For mux 2\_21, pins K0,K1 are connected to outputs S17,S18 respectively. In mux 2\_22 pin K,K1 are connected to outputs S18,S19. Mux 2\_22 gives output from pin K0 by setting MSL2\_21 as “0” and for mux 2\_22 from pin K1 by setting MSL2\_10 as “1”.
* For **CU24(NOOP)** inputs N24,R24 are taken from outputs of CU18 & CU19 . For this Mux’s 2\_23, 2\_24 are used. For mux 2\_23, pins K0,K1 are connected to outputs S18,S19 respectively. In mux 2\_24 pin K0,K1 are connected to outputs S19,S20. Mux 2\_23 gives output from pin K0 by setting MSL2\_23 as “0” and for mux 2\_24 from pin K0 by setting MSL2\_24 as “0”.
* For **CU25(NOOP)** inputs N25,R25 are taken from outputs of CU19 & CU20 . For this Mux’s 2\_25, 2\_26 are used. For mux 2\_25, pins K0,K1 are connected to outputs S19,S20 respectively. In mux 2\_26 pin K0 is connected to output S20and K1 is grounded. Mux 2\_25 gives output from pin K0 by setting MSL2\_25 as “0” and for mux 2\_26 from pin K0 by setting MSL2\_26 as “0”.
* The output’s from CU21, CU22, CU23, CU24, CU25 are S21, S22, S23, S24, S25 respectively.
* For the DFG-2 we take outputs from CU21,CU22. i.e., S21&S22.
* **For DFG-3:** As given in the DFG the operations and connectivity for the CU’s are given accordingly. CU1 performs addition, CU2 performs subtraction, CU3-multiplication, CU4-multiplication, CU-5 NOOP, for the given set of inputs for each CU.
* Now the outputs from the first row CU’s i.e., S1,S2,S3,S4,S5 are given as inputs to the next row CU’s by using mux’s. The output’s from row 1 CU’s are first given as inputs to mux’s present below and the output’s from the mux’s based on the sel line of the mux(MSL) is given as input to next row CU.
* For **CU6(SUB)** inputs N6,R6 are taken from outputs of CU1 & CU2. For this Mux’s 4\_1, 4\_2 are used. For mux 4\_1, pins J0,J1 are grounded. And J2 is connected to S1& J3 is connected to S2. And in mux 4\_2 J0 pin is grounded and pins J1,J2,J3 are connected to S1,S2,S3 respectively. Mux 4\_1 gives output from pin J2 by setting MSL4\_1 as “10”. And mux 4\_2 gives output from pin J2 by setting MSL4\_2 as “10”.
* For **CU7(PG 2)** inputs N7,R7 are taken from outputs of CU1 & CU3 . For this Mux’s 8\_1, 8\_2 are used. For mux 8\_1, pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S1,S2,S3,S4,S5 respectively. In mux 8\_2 pins I0,I1,I7 are grounded and I2,I3,I4,I5,I6 are connected to outputs S1,S2,S3,S4,S5 respectively. Mux 8\_1 gives output from pin I3 by setting MSL8\_1 as “011” and for mux 8\_2 from pin I4 by setting MSL8\_2 as “100”.
* For **CU8(ADD)** inputs N8,R8 are taken from outputs of CU2 & CU4 . For this Mux’s 4\_3, 4\_4 are used. For mux 4\_3, pins J0,J1,J2,J3 are connected to outputs S1,S2,S3,S4 respectively. In mux 4\_4 pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. Mux 4\_3 gives output from pin J1 by setting MSL4\_3 as “01” and for mux 4\_4 from pin J2 by setting MSL4\_4 as “10”.
* For **CU9(SUB)** inputs N9,R9 are taken from outputs of CU2 & CU4 . For this Mux’s 4\_5, 4\_6 are used. For mux 4\_5, pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. In mux 4\_6 pins J0,J1,J2 are connected to outputs S3,S4,S5 respectively, pin J3 is grounded. Mux 4\_5 gives output from pin J0 by setting MSL4\_5 as “00” and for mux 4\_6 from pin J1 by setting MSL4\_6 as “01”.
* For **CU10(NOOP)** inputs N10,R10 are taken from outputs of CU5 & CU5 . For this Mux’s 2\_3, 2\_4 are used. For mux 2\_3, pins K0,K1 are connected to outputs S4,S5 respectively. In mux 2\_4 pin K0 is connected to output S5, pin K1 is grounded. Mux 2\_3 gives output from pin K1by setting MSL2\_3 as “1” and for mux 2\_4 from pin K0 by setting MSL2\_4 as “0”.
* Now the output’s from CU6, CU7, CU8, CU9, CU10 are S6, S7, S8, S9, S10 respectively. These outputs are given as inputs to third row CU’s, CU11-CU15 by using mux’s.
* For **CU11(NOR)** inputs N11,R11 are taken from outputs of CU6 & CU7 . For this Mux’s 8\_3, 8\_4 are used. For mux 8\_3, pins I0,I1,I2,I3 are grounded and pins I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9 respectively. In mux 8\_3 pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9,S10 respectively. Mux 8\_3 gives output from pin I4 by setting MSL8\_3 as “100” and for mux 8\_4 from pin I4 by setting MSL8\_4 as “100”.
* For **CU12(NAND)** inputs N12,R12 are taken from outputs of CU8 & CU9 . For this Mux’s 4\_7, 4\_8 are used. For mux 4\_7, pins J1,J2,J3 are connected to outputs S6,S7,S8 respectively, pin J0 is grounded. In mux 4\_8 pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. Mux 4\_7 gives output from pin J3 by setting MSL4\_7 as “11” and for mux 4\_8 from pin J3 by setting MSL4\_8 as “11”.
* For **CU13(NOOP)** inputs N13,R13 are taken from outputs of CU8 & CU9 . For this Mux’s 4\_9, 4\_10 are used. For mux 4\_9, pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. In mux 4\_10 pins J0,J1,J2,J3 are connected to outputs S7,S8,S9,S10 respectively. Mux 4\_9 gives output from pin J2 by setting MSL4\_9 as “10” and for mux 4\_10 from pin J2 by setting MSL4\_10 as “10”.
* For **CU14(NOOP)** inputs N14,R14 are taken from outputs of CU8 & CU9 . For this Mux’s 2\_5, 2\_6 are used. For mux 2\_5, pins K0,K1 are connected to outputs S8,S9 respectively. In mux 2\_6 pin K0,K1 are connected to outputs S9,S10. Mux 2\_5 gives output from pin K0 by setting MSL2\_5 as “0” and for mux 2\_4 from pin K0 by setting MSL2\_6 as “0”.
* For **CU15(NOOP)** inputs N15,R15 are taken from outputs of CU9 & CU10 . For this Mux’s 2\_7, 2\_8 are used. For mux 2\_7, pins K0,K1 are connected to outputs S9,S10 respectively. In mux 2\_8 pin K0 is connected to output S10, K1 is grounded. Mux 2\_7 gives output from pin K0 by setting MSL2\_7 as “0” and for mux 2\_8 from pin K0 by setting MSL2\_8 as “0”.
* Now the output’s from CU11, CU12, CU13, CU14, CU15 are S11, S12, S13, S14, S15 respectively. These outputs are given as inputs to fourth row CU’s, CU16-CU20 by using mux’s.
* For **CU16(PG 1)** inputs N16,R16 are taken from outputs of CU11 & CU12 . For this Mux’s 4\_11, 4\_12 are used. For mux 4\_11, pins J0,J1 are grounded and pins J2,J3 are connected to outputs S11,S12 respectively. In mux 4\_12 pin J0 is grounded and pins J1,J2,J3 are connected to outputs S11,S12,S13 respectively. Mux 4\_ 11 gives output from pin J2 by setting MSL4\_11 as “10” and for mux 4\_12 from pin J2 by setting MSL4\_12 as “10”.
* For **CU17(PG 2)** inputs N17,R17 are taken from outputs of CU11 & CU12 . For this Mux’s 2\_9, 2\_10 are used. For mux 2\_9, pins K0,K1 are connected to outputs S11,S12 respectively. In mux 2\_10 pin K0,K1 are connected to outputs S12,S13. Mux 2\_9 gives output from pin K0 by setting MSL2\_9 as “0” and for mux 2\_10 from pin K0 by setting MSL2\_10 as “0”.
* For **CU18(NOOP)** inputs N18,R18 are taken from outputs of CU12 & CU14 . For this Mux’s 2\_11, 2\_12 are used. For mux 2\_11, pins K0,K1 are connected to outputs S12,S13 respectively. In mux 2\_12 pin K0,K1 are connected to outputs S13,S14. Mux 2\_11 gives output from pin K0 by setting MSL2\_11 as “0” and for mux 2\_12 from pin K1 by setting MSL2\_12 as “1” .
* For **CU19(NOOP)** inputs N19,R19 are taken from outputs of CU13 & CU14 . For this Mux’s 2\_13, 2\_14 are used. For mux 2\_13, pins K0,K1 are connected to outputs S13,S14 respectively. In mux 2\_14 pin K0,K1 are connected to outputs S14,S15. Mux 2\_13 gives output from pin K0 by setting MSL2\_13 as “0” and for mux 2\_14 from pin K0 by setting MSL2\_14 as “0”.
* For **CU20(NOOP)** inputs N20,R20 are taken from outputs of CU14 & CU15 . For this Mux’s 2\_15, 2\_16 are used. For mux 2\_15, pins K0,K1 are connected to outputs S14,S15 respectively. In mux 2\_16 pin K0 is connected to output S15, and pin K1 is grounded. Mux 2\_15 gives output from pin K0 by setting MSL2\_15 as “0” and for mux 2\_16 from pin K0 by setting MSL2\_16 as “0”.
* The output’s from CU16, CU17, CU18, CU19, CU20 are S16, S17, S18, S19, S20 respectively. These outputs are given as inputs to fifth row CU’s, CU21-CU25 by using mux’s.
* For **CU21(PG 1)** inputs N21,R21 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_17, 2\_18 are used. For mux 2\_17, pin K0 is grounded and pin K1 is connected to output S16. In mux 2\_18 pins K0,K1 are connected to S16,S17 respectively. Mux 2\_17 gives output from pin K1 by setting MSL2\_17 as “1” and for mux 2\_18 from pin K1 by setting MSL2\_18 as “1”.
* For **CU22(PG 2)** inputs N22,R22 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_19, 2\_20 are used. For mux 2\_19, pins K0,K1 are connected to outputs S16,S17 respectively. In mux 2\_20 pin K0,K1 are connected to outputs S17,S18. Mux 2\_19 gives output from pin K0 by setting MSL2\_19 as “0” and for mux 2\_20 from pin K0 by setting MSL2\_20 as “0”.
* For **CU23(NOOP)** inputs N23,R23 are taken from outputs of CU17 & CU19 . For this Mux’s 2\_21, 2\_22 are used. For mux 2\_21, pins K0,K1 are connected to outputs S17,S18 respectively. In mux 2\_22 pin K,K1 are connected to outputs S18,S19. Mux 2\_22 gives output from pin K0 by setting MSL2\_21 as “0” and for mux 2\_22 from pin K1 by setting MSL2\_10 as “1”.
* For **CU24(NOOP)** inputs N24,R24 are taken from outputs of CU18 & CU19 . For this Mux’s 2\_23, 2\_24 are used. For mux 2\_23, pins K0,K1 are connected to outputs S18,S19 respectively. In mux 2\_24 pin K0,K1 are connected to outputs S19,S20. Mux 2\_23 gives output from pin K0 by setting MSL2\_23 as “0” and for mux 2\_24 from pin K0 by setting MSL2\_24 as “0”.
* For **CU25(NOOP)** inputs N25,R25 are taken from outputs of CU19 & CU20 . For this Mux’s 2\_25, 2\_26 are used. For mux 2\_25, pins K0,K1 are connected to outputs S19,S20 respectively. In mux 2\_26 pin K0 is connected to output S20and K1 is grounded. Mux 2\_25 gives output from pin K0 by setting MSL2\_25 as “0” and for mux 2\_26 from pin K0 by setting MSL2\_26 as “0”.
* The output’s from CU21, CU22, CU23, CU24, CU25 are S21, S22, S23, S24, S25 respectively.
* For the DFG-3 we take outputs from CU21,CU22. i.e., S21&S22.
* **For DFG-4:** As given in the DFG the operations and connectivity for the CU’s are given accordingly. CU1 performs multiplication, CU2 performs addition, CU3-subtraction, CU4-multiplication, CU-5 NOOP, for the given set of inputs for each CU.
* Now the outputs from the first row CU’s i.e., S1,S2,S3,S4,S5 are given as inputs to the next row CU’s by using mux’s. The output’s from row 1 CU’s are first given as inputs to mux’s present below and the output’s from the mux’s based on the sel line of the mux is given as input to next row CU.
* For **CU6(ADD)** inputs N6,R6 are taken from outputs of CU1 & CU3. For this Mux’s 4\_1, 4\_2 are used. For mux 4\_1, pins J0,J1 are grounded. And J2 is connected to S1& J3 is connected to S2. And in mux 4\_2 J0 pin is grounded and pins J1,J2,J3 are connected to S1,S2,S3 respectively. Mux 4\_1 gives output from pin J2 by setting MSL4\_1 as “10”. And mux 4\_2 gives output from pin J3 by setting MSL4\_2 as “11”.
* For **CU7(ADD)** inputs N7,R7 are taken from outputs of CU2 & CU4 . For this Mux’s 8\_1, 8\_2 are used. For mux 8\_1, pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S1,S2,S3,S4,S5 respectively. In mux 8\_2 pins I0,I1,I7 are grounded and I2,I3,I4,I5,I6 are connected to outputs S1,S2,S3,S4,S5 respectively. Mux 8\_1 gives output from pin I4 by setting MSL8\_1 as “100” and for mux 8\_2 from pin I5 by setting MSL8\_2 as “101”.
* For **CU8(SUB)** inputs N8,R8 are taken from outputs of CU3 & CU4 . For this Mux’s 4\_3, 4\_4 are used. For mux 4\_3, pins J0,J1,J2,J3 are connected to outputs S1,S2,S3,S4 respectively. In mux 4\_4 pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. Mux 4\_3 gives output from pin J2 by setting MSL4\_3 as “10” and for mux 4\_4 from pin J2 by setting MSL4\_4 as “10”.
* For **CU9(NOOP)** inputs N9,R9 are taken from outputs of CU2 & CU4 . For this Mux’s 4\_5, 4\_6 are used. For mux 4\_5, pins J0,J1,J2,J3 are connected to outputs S2,S3,S4,S5 respectively. In mux 4\_6 pins J0,J1,J2 are connected to outputs S3,S4,S5 respectively, pin J3 is grounded. Mux 4\_5 gives output from pin J0 by setting MSL4\_5 as “00” and for mux 4\_6 from pin J1 by setting MSL4\_6 as “01”.
* For **CU10(NOOP)** inputs N10,R10 are taken from outputs of CU5 & CU5 . For this Mux’s 2\_3, 2\_4 are used. For mux 2\_3, pins K0,K1 are connected to outputs S4,S5 respectively. In mux 2\_4 pin K0 is connected to output S5, pin K1 is grounded. Mux 2\_3 gives output from pin K1by setting MSL2\_3 as “1” and for mux 2\_4 from pin K0 by setting MSL2\_4 as “0”.
* Now the output’s from CU6, CU7, CU8, CU9, CU10 are S6, S7, S8, S9, S10 respectively. These outputs are given as inputs to third row CU’s, CU11-CU15 by using mux’s.
* For **CU11(LSR)** inputs N11,R11 are taken from outputs of CU6 & CU7 . For this Mux’s 8\_3, 8\_4 are used. For mux 8\_3, pins I0,I1,I2,I3 are grounded and pins I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9 respectively. In mux 8\_3 pins I0,I1,I2 are grounded and pins I3,I4,I5,I6,I7 are connected to outputs S6,S7,S8,S9,S10 respectively. Mux 8\_3 gives output from pin I4 by setting MSL8\_3 as “100” and for mux 8\_4 from pin I4 by setting MSL8\_4 as “100”.
* For **CU12(ROL)** inputs N12,R12 are taken from outputs of CU6 & CU8 . For this Mux’s 4\_7, 4\_8 are used. For mux 4\_7, pins J1,J2,J3 are connected to outputs S6,S7,S8 respectively, pin J0 is grounded. In mux 4\_8 pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. Mux 4\_7 gives output from pin J1 by setting MSL4\_7 as “01” and for mux 4\_8 from pin J2 by setting MSL4\_8 as “10”.
* For **CU13(ASL)** inputs N13,R13 are taken from outputs of CU7 & CU8 . For this Mux’s 4\_9, 4\_10 are used. For mux 4\_9, pins J0,J1,J2,J3 are connected to outputs S6,S7,S8,S9 respectively. In mux 4\_10 pins J0,J1,J2,J3 are connected to outputs S7,S8,S9,S10 respectively. Mux 4\_9 gives output from pin J1 by setting MSL4\_9 as “01” and for mux 4\_10 from pin J1 by setting MSL4\_10 as “01”.
* For **CU14(NOOP)** inputs N14,R14 are taken from outputs of CU8 & CU9 . For this Mux’s 2\_5, 2\_6 are used. For mux 2\_5, pins K0,K1 are connected to outputs S8,S9 respectively. In mux 2\_6 pin K0,K1 are connected to outputs S9,S10. Mux 2\_5 gives output from pin K0 by setting MSL2\_5 as “0” and for mux 2\_4 from pin K0 by setting MSL2\_6 as “0”.
* For **CU15(NOOP)** inputs N15,R15 are taken from outputs of CU9 & CU10 . For this Mux’s 2\_7, 2\_8 are used. For mux 2\_7, pins K0,K1 are connected to outputs S9,S10 respectively. In mux 2\_8 pin K0 is connected to output S10, K1 is grounded. Mux 2\_7 gives output from pin K0 by setting MSL2\_7 as “0” and for mux 2\_8 from pin K0 by setting MSL2\_8 as “0”.
* Now the output’s from CU11, CU12, CU13, CU14, CU15 are S11, S12, S13, S14, S15 respectively. These outputs are given as inputs to fourth row CU’s, CU16-CU20 by using mux’s.
* For **CU16(XOR)** inputs N16,R16 are taken from outputs of CU11 & CU12 . For this Mux’s 4\_11, 4\_12 are used. For mux 4\_11, pins J0,J1 are grounded and pins J2,J3 are connected to outputs S11,S12 respectively. In mux 4\_12 pin J0 is grounded and pins J1,J2,J3 are connected to outputs S11,S12,S13 respectively. Mux 4\_ 11 gives output from pin J2 by setting MSL4\_11 as “10” and for mux 4\_12 from pin J2 by setting MSL4\_12 as “10”.
* For **CU17(XNOR)** inputs N17,R17 are taken from outputs of CU12 & CU13 . For this Mux’s 2\_9, 2\_10 are used. For mux 2\_9, pins K0,K1 are connected to outputs S11,S12 respectively. In mux 2\_10 pin K0,K1 are connected to outputs S12,S13. Mux 2\_9 gives output from pin K1 by setting MSL2\_9 as “1” and for mux 2\_10 from pin K1 by setting MSL2\_10 as “1”.
* For **CU18(NOOP)** inputs N18,R18 are taken from outputs of CU12 & CU14 . For this Mux’s 2\_11, 2\_12 are used. For mux 2\_11, pins K0,K1 are connected to outputs S12,S13 respectively. In mux 2\_12 pin K0,K1 are connected to outputs S13,S14. Mux 2\_11 gives output from pin K0 by setting MSL2\_11 as “0” and for mux 2\_12 from pin K1 by setting MSL2\_12 as “1” .
* For **CU19(NOOP)** inputs N19,R19 are taken from outputs of CU13 & CU14 . For this Mux’s 2\_13, 2\_14 are used. For mux 2\_13, pins K0,K1 are connected to outputs S13,S14 respectively. In mux 2\_14 pin K0,K1 are connected to outputs S14,S15. Mux 2\_13 gives output from pin K0 by setting MSL2\_13 as “0” and for mux 2\_14 from pin K0 by setting MSL2\_14 as “0”.
* For **CU20(NOOP)** inputs N20,R20 are taken from outputs of CU14 & CU15 . For this Mux’s 2\_15, 2\_16 are used. For mux 2\_15, pins K0,K1 are connected to outputs S14,S15 respectively. In mux 2\_16 pin K0 is connected to output S15, and pin K1 is grounded. Mux 2\_15 gives output from pin K0 by setting MSL2\_15 as “0” and for mux 2\_16 from pin K0 by setting MSL2\_16 as “0”.
* The output’s from CU16, CU17, CU18, CU19, CU20 are S16, S17, S18, S19, S20 respectively. These outputs are given as inputs to fifth row CU’s, CU21-CU25 by using mux’s.
* For **CU21(LESS THAN)** inputs N21,R21 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_17, 2\_18 are used. For mux 2\_17, pin K0 is grounded and pin K1 is connected to output S16. In mux 2\_18 pins K0,K1 are connected to S16,S17 respectively. Mux 2\_17 gives output from pin K1 by setting MSL2\_17 as “1” and for mux 2\_18 from pin K1 by setting MSL2\_18 as “1”.
* For **CU22(NOOP)** inputs N22,R22 are taken from outputs of CU16 & CU17 . For this Mux’s 2\_19, 2\_20 are used. For mux 2\_19, pins K0,K1 are connected to outputs S16,S17 respectively. In mux 2\_20 pin K0,K1 are connected to outputs S17,S18. Mux 2\_19 gives output from pin K0 by setting MSL2\_19 as “0” and for mux 2\_20 from pin K0 by setting MSL2\_20 as “0”.
* For **CU23(NOOP)** inputs N23,R23 are taken from outputs of CU17 & CU19 . For this Mux’s 2\_21, 2\_22 are used. For mux 2\_21, pins K0,K1 are connected to outputs S17,S18 respectively. In mux 2\_22 pin K,K1 are connected to outputs S18,S19. Mux 2\_22 gives output from pin K0 by setting MSL2\_21 as “0” and for mux 2\_22 from pin K1 by setting MSL2\_10 as “1”.
* For **CU24(NOOP)** inputs N24,R24 are taken from outputs of CU18 & CU19 . For this Mux’s 2\_23, 2\_24 are used. For mux 2\_23, pins K0,K1 are connected to outputs S18,S19 respectively. In mux 2\_24 pin K0,K1 are connected to outputs S19,S20. Mux 2\_23 gives output from pin K0 by setting MSL2\_23 as “0” and for mux 2\_24 from pin K0 by setting MSL2\_24 as “0”.
* For **CU25(NOOP)** inputs N25,R25 are taken from outputs of CU19 & CU20 . For this Mux’s 2\_25, 2\_26 are used. For mux 2\_25, pins K0,K1 are connected to outputs S19,S20 respectively. In mux 2\_26 pin K0 is connected to output S20and K1 is grounded. Mux 2\_25 gives output from pin K0 by setting MSL2\_25 as “0” and for mux 2\_26 from pin K0 by setting MSL2\_26 as “0”.
* The output’s from CU21, CU22, CU23, CU24, CU25 are S21, S22, S23, S24, S25 respectively.
* For the DFG-4 we take output from CU21 . i.e., S21.

### Arithmetic handling:

* Arithmetic operations Addition, Subtraction & Multiplication were given in the CU for a specific opcode as mentioned in the above table.
* Overflow of bits(extra bits) is truncated by only considering second half bits.

### Shift Operations:

* Shift operations ASL, LSL, LSR, ROR, ROL were used in the CU’s. These operations are performed based on the opcode given as specified in the above table.
* For shift operations the first input gets shifted by the second input number of bits.

### Comparison operations:

* Comparison operations used are Greater than, less than, Equal to.
* For the given inputs, if they satisfy the operation given then it is considered as TRUE condition then the generated output for that particular CU will be “1111”.
* For the given inputs, if they don’t satisfy the operation given then it is considered as FALSE condition then the generated output for that particular CU will be “0000”.

# Results

## Generated RTL Schematic

A picture containing graphical user interface

Description automatically generated

Figure 2 – Generated RTL Schematic of the 5 X 5 Fabric

* The generated RTL schematic(fig.2) elaborated design is same as to the block diagram(fig.1) that we have designed.
* The RTL schematic generated has 25 CU’s in a 5 x 5 architecture.
* The CU’s are connected with the help of 8:1,4:1,2:1 mux’s.
* Also the mux’s are connected by using mirroring concept as shown in our block diagram and RTL schematic.
* Input’s are given for CU1(N1,R1),CU2(N2,R2),CU3(N3,R3),CU4(N4,R4),CU5(N5,R5) and outputs are taken from CU21(S21),CU22(S22),CU23(S23),CU24(S24),CU25(S25). This is the same that was shown in the block diagram and elaborated design.
* It is clearly evident that both the Block diagram and generated RTL schematic are same.

Diagram, schematic

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Diagram, schematic

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Diagram

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Diagram, schematic

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## Waveforms

**For DFG-1**

A screenshot of a computer

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A screenshot of a computer

Description automatically generated with medium confidence

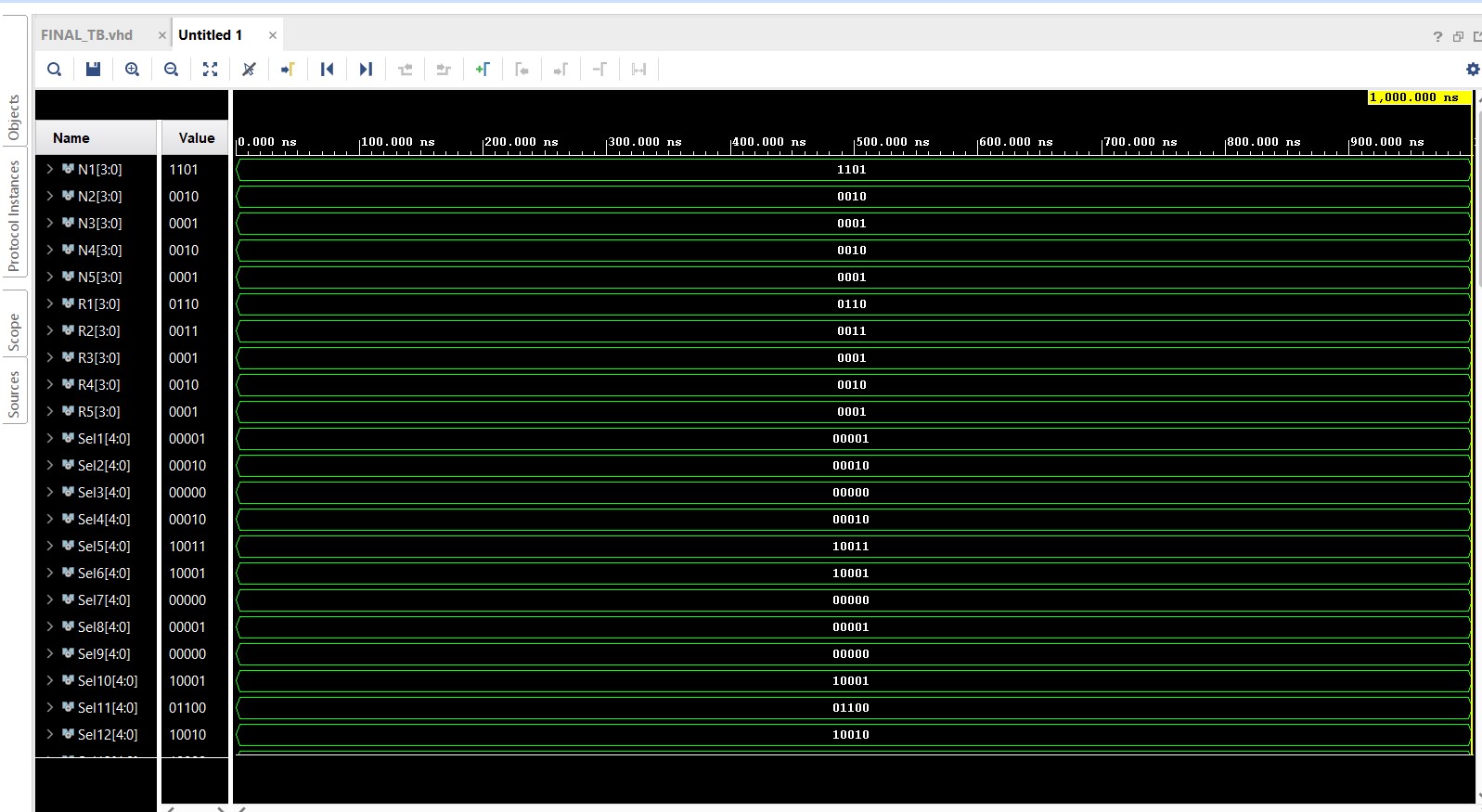
A picture containing background pattern

Description automatically generated

Chart

Description automatically generated with low confidence

**For DFG-2**

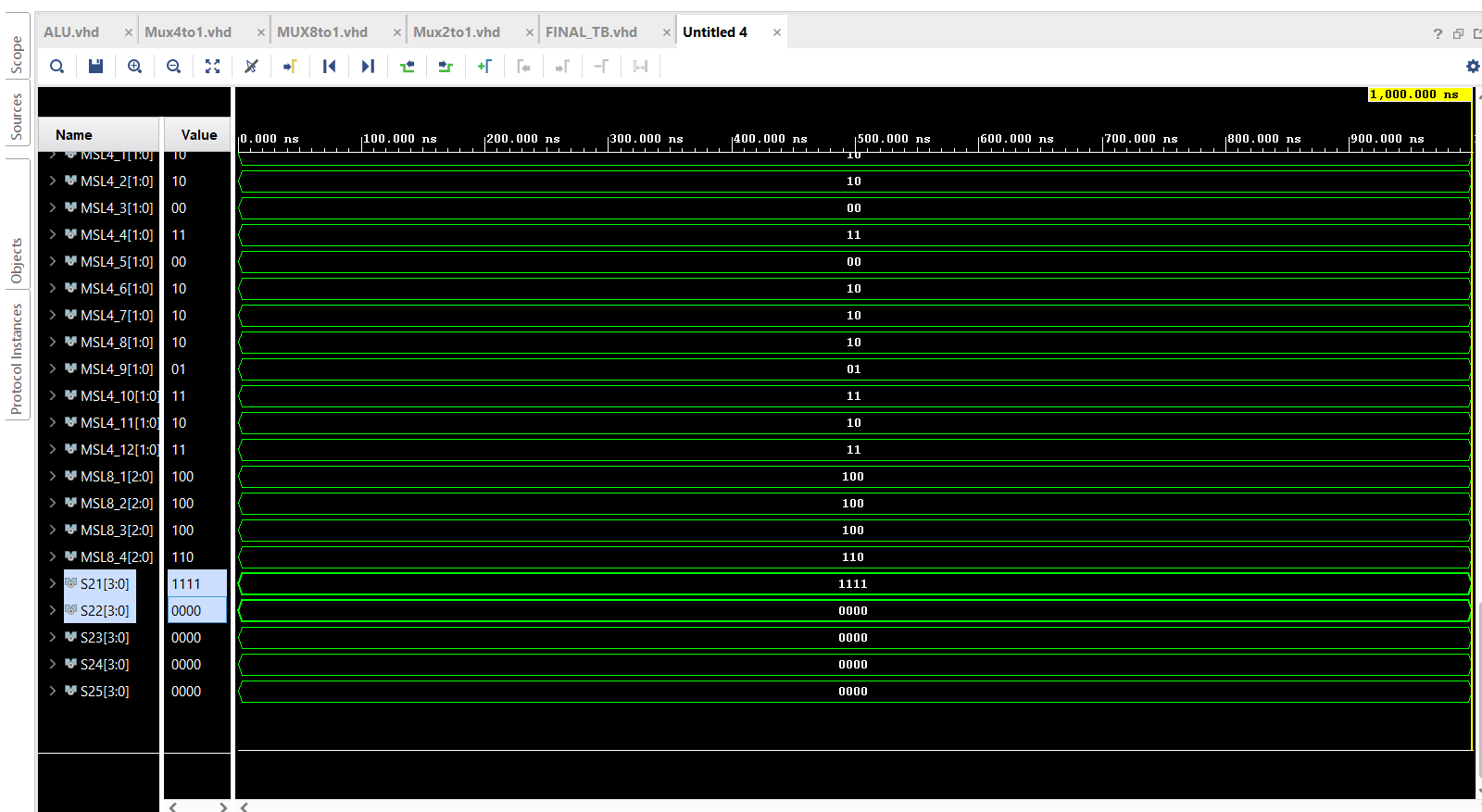


A picture containing graphical user interface

Description automatically generated

A picture containing background pattern

Description automatically generated



**For DFG-3**

A screenshot of a computer

Description automatically generated with medium confidence

A picture containing chart

Description automatically generated

A picture containing background pattern

Description automatically generated

A picture containing timeline

Description automatically generated

**For DFG-4**

A picture containing timeline

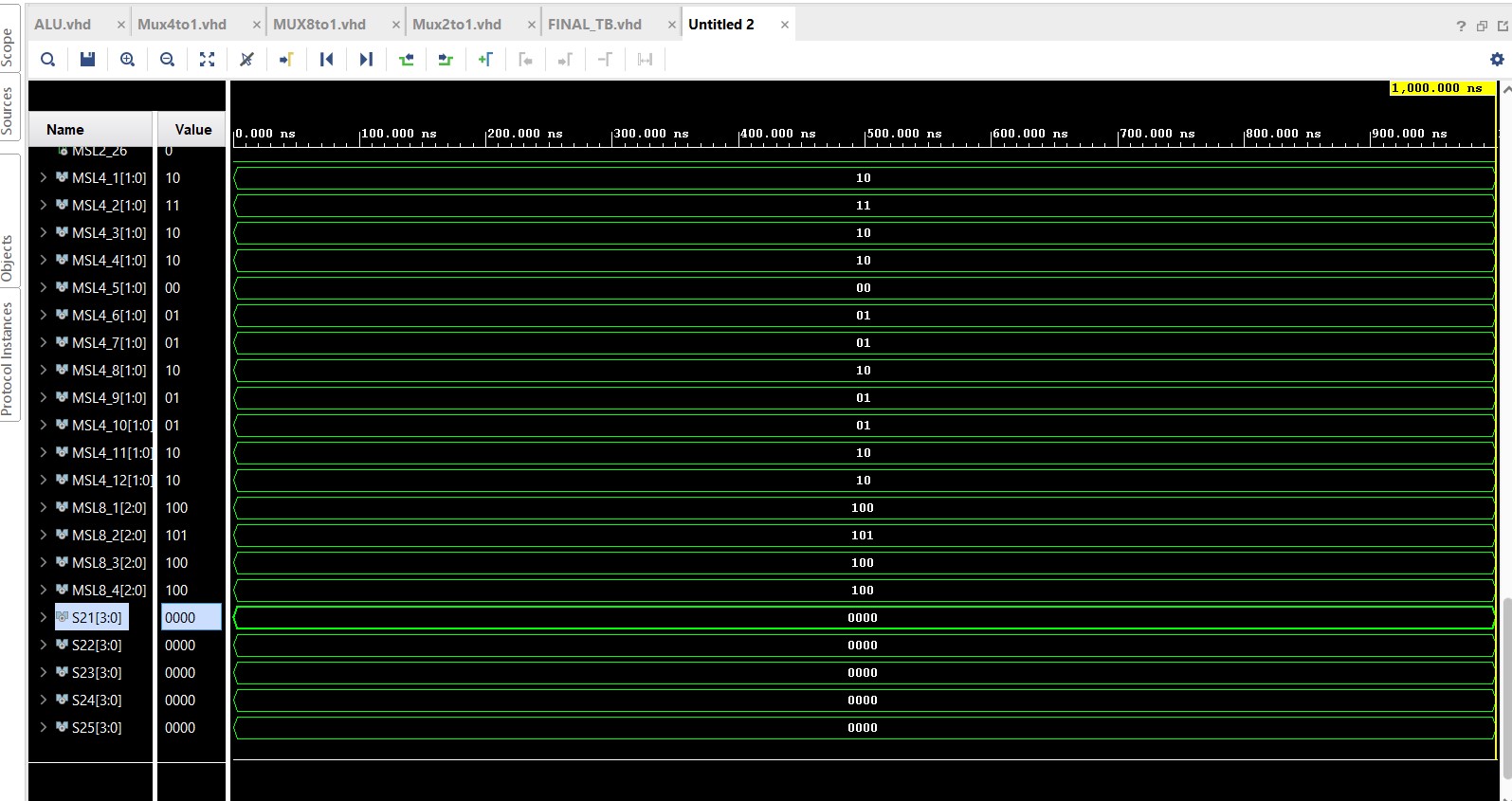
Description automatically generated

A picture containing graphical user interface

Description automatically generated

A picture containing background pattern

Description automatically generated



## 

## Table/Calculations

Dataflow1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CU# | Input 1 | Input 2 | 1 | 2 | Operation | Calculated  O/p | Simulated O/p | Match |
| CU 1 | N1 | R1 | 1001 | 0110 | ADD | 1111 | 1111 | Yes |
| CU 2 | N2 | R2 | 0100 | 0011 | MULTIPLY | 1100 | 1100 | Yes |
| CU 3 | N3 | R3 | 0010 | 0111 | ADD | 1001 | 1001 | Yes |
| CU 4 | N4 | R4 | 1111 | 1101 | SUB | 0010 | 0010 | Yes |
| CU 5 | N5 | R5 | 0001 | 0001 | MULTIPLY | 0001 | 0001 | Yes |
| CU 6 | N6 | R6 | 1111 | 1001 | SUB | 0010 | 0010 | Yes |
| CU 7 | N7 | R7 | 1001 | 0001 | ADD | 1010 | 1010 | Yes |
| CU 8 | N8 | R8 | 1100 | 0010 | SUB | 1010 | 1010 | Yes |
| CU 9 | N9 | R9 | 1100 | 0001 | PASS GATE 2 | 0001 | 0001 | Yes |
| CU 10 | N10 | R10 | 0001 | 0001 | NOOP | 0000 | 0000 | Yes |
| CU 11 | N11 | R11 | 0010 | 1010 | OR | 1110 | 1110 | Yes |
| CU 12 | N12 | R12 | 1010 | 1010 | AND | 1010 | 1010 | Yes |
| CU 13 | N13 | R13 | 0110 | 0001 | NAND | 0111 | 0111 | Yes |
| CU 14 | N14 | R14 | 1010 | 0001 | NOOP | 0000 | 0000 | Yes |
| CU 15 | N15 | R15 | 0001 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 16 | N16 | R16 | 1110 | 1010 | XOR | 0100 | 0100 | Yes |
| CU 17 | N17 | R17 | 1010 | 0111 | NOR | 0000 | 0000 | Yes |
| CU 18 | N18 | R18 | 1010 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 19 | N19 | R19 | 0111 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 20 | N20 | R20 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 21 | N21 | R21 | 0100 | 0000 | PASS GATE 1 | 0100 | 0100 | Yes |
| CU 22 | N22 | R22 | 0100 | 0000 | PASS GATE 2 | 0000 | 0000 | Yes |
| CU 23 | N23 | R23 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 24 | N24 | R24 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 25 | N25 | R25 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |

Diagram

Description automatically generated

Dataflow 2

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CU# | Input 1 | Input 2 | 1 | 2 | Operation | Calculated  O/p | Simulated O/p | Match |
| CU 1 | N1 | R1 | 1101 | 0110 | SUB | 0111 | 0111 | Yes |
| CU 2 | N2 | R2 | 0010 | 0011 | MULTIPLY | 0110 | 0110 | Yes |
| CU 3 | N3 | R3 | 0001 | 0001 | NOOP | 0000 | 0000 | Yes |
| CU 4 | N4 | R4 | 0001 | 0001 | ADD | 0010 | 0010 | Yes |
| CU 5 | N5 | R5 | 0010 | 0010 | MULTIPLY | 0100 | 0100 | Yes |
| CU 6 | N6 | R6 | 0111 | 0110 | PASS GATE 1 | 0111 | 0111 | Yes |
| CU 7 | N7 | R7 | 0111 | 0010 | ADD | 1001 | 1001 | Yes |
| CU 8 | N8 | R8 | 0111 | 0100 | SUB | 0011 | 0011 | Yes |
| CU 9 | N9 | R9 | 0110 | 0100 | ADD | 1010 | 1010 | Yes |
| CU 10 | N10 | R10 | 0010 | 0000 | PASS GATE 1 | 0010 | 0010 | Yes |
| CU 11 | N11 | R11 | 0111 | 1010 | ROR | 1101 | 1101 | Yes |
| CU 12 | N12 | R12 | 1001 | 0011 | PASS GATE 2 | 0011 | 0011 | Yes |
| CU 13 | N13 | R13 | 1001 | 0010 | LSL | 0100 | 0100 | Yes |
| CU 14 | N14 | R14 | 0011 | 1010 | NOOP | 0000 | 0000 | Yes |
| CU 15 | N15 | R15 | 1010 | 0010 | NOOP | 0000 | 0000 | Yes |
| CU 16 | N16 | R16 | 1101 | 0100 | GREATER THAN | 1111 | 1111 | Yes |
| CU 17 | N17 | R17 | 1101 | 0011 | EQUAL TO | 0000 | 0000 | Yes |
| CU 18 | N18 | R18 | 0011 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 19 | N19 | R19 | 0100 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 20 | N20 | R20 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 21 | N21 | R21 | 1111 | 1111 | PASS GATE 1 | 1111 | 1111 | Yes |
| CU 22 | N22 | R22 | 1111 | 0000 | PASS GATE 2 | 0000 | 0000 | Yes |
| CU 23 | N23 | R23 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 24 | N24 | R24 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 25 | N25 | R25 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |

Diagram

Description automatically generated with low confidence

Dataflow 3

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CU# | Input 1 | Input 2 | 1 | 2 | Operation | Calculated  O/p | Simulated O/p | Match |
| CU 1 | N1 | R1 | 1000 | 0101 | MULT | 1101 | 1101 | Yes |
| CU 2 | N2 | R2 | 1110 | 1000 | SUB | 0110 | 0110 | Yes |
| CU 3 | N3 | R3 | 0001 | 0100 | MULT | 0100 | 0100 | Yes |
| CU 4 | N4 | R4 | 0011 | 0010 | MULT | 0110 | 0110 | Yes |
| CU 5 | N5 | R5 | 0001 | 0001 | NOOP | 0000 | 0000 | Yes |
| CU 6 | N6 | R6 | 1101 | 0110 | SUB | 0111 | 0111 | Yes |
| CU 7 | N7 | R7 | 0110 | 0100 | PASS GATE 2 | 0100 | 0100 | Yes |
| CU 8 | N8 | R8 | 0110 | 0110 | ADD | 1100 | 1100 | Yes |
| CU 9 | N9 | R9 | 0110 | 0110 | SUB | 0000 | 0000 | Yes |
| CU 10 | N10 | R10 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 11 | N11 | R11 | 0111 | 0100 | NOR | 1000 | 1000 | Yes |
| CU 12 | N12 | R12 | 1100 | 0000 | NAND | 1111 | 1111 | Yes |
| CU 13 | N13 | R13 | 1100 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 14 | N14 | R14 | 1100 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 15 | N15 | R15 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 16 | N16 | R16 | 1000 | 1000 | PASS GATE 1 | 1000 | 1000 | Yes |
| CU 17 | N17 | R17 | 1000 | 1111 | PASS GATE 2 | 1111 | 1111 | Yes |
| CU 18 | N18 | R18 | 1111 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 19 | N19 | R19 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 20 | N20 | R20 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 21 | N21 | R21 | 1000 | 1000 | PASS GATE 1 | 1000 | 1000 | Yes |
| CU 22 | N22 | R22 | 1000 | 1111 | PASS GATE 2 | 1111 | 1111 | Yes |
| CU 23 | N23 | R23 | 1111 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 24 | N24 | R24 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 25 | N25 | R25 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |

Diagram

Description automatically generated

Dataflow 4

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CU# | Input 1 | Input 2 | 1 | 2 | Operation | Calculated  O/p | Simulated O/p | Match |
| CU 1 | N1 | R1 | 0100 | 0010 | MULT | 1000 | 1000 | Yes |
| CU 2 | N2 | R2 | 0011 | 0100 | ADD | 0111 | 0111 | Yes |
| CU 3 | N3 | R3 | 1111 | 1010 | SUB | 0101 | 0101 | Yes |
| CU 4 | N4 | R4 | 0010 | 0010 | MULT | 0100 | 0100 | Yes |
| CU 5 | N5 | R5 | 0001 | 0001 | NOOP | 0000 | 0000 | Yes |
| CU 6 | N6 | R6 | 1000 | 0101 | ADD | 1101 | 1101 | Yes |
| CU 7 | N7 | R7 | 0111 | 0100 | ADD | 1011 | 1011 | Yes |
| CU 8 | N8 | R8 | 0101 | 0100 | SUB | 0001 | 0001 | Yes |
| CU 9 | N9 | R9 | 0111 | 0100 | NOOP | 0000 | 0000 | Yes |
| CU 10 | N10 | R10 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 11 | N11 | R11 | 1101 | 1011 | LSR | 0000 | 0000 | Yes |
| CU 12 | N12 | R12 | 1101 | 0001 | R0L | 1011 | 1011 | Yes |
| CU 13 | N13 | R13 | 1011 | 0001 | ASL | 0110 | 0110 | Yes |
| CU 14 | N14 | R14 | 0001 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 15 | N15 | R15 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 16 | N16 | R16 | 0000 | 1011 | XOR | 1011 | 1011 | Yes |
| CU 17 | N17 | R17 | 1011 | 0110 | XNOR | 0010 | 0010 | Yes |
| CU 18 | N18 | R18 | 1011 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 19 | N19 | R19 | 0110 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 20 | N20 | R20 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 21 | N21 | R21 | 1011 | 0010 | LESS THAN | 0000 | 0000 | Yes |
| CU 22 | N22 | R22 | 1011 | 0010 | NOOP | 0000 | 0000 | Yes |
| CU 23 | N23 | R23 | 0010 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 24 | N24 | R24 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |
| CU 25 | N25 | R25 | 0000 | 0000 | NOOP | 0000 | 0000 | Yes |

Diagram

Description automatically generated with medium confidence