COBIFIVE Datasheet

Five core quantum-inspired Ising solver chip

Version: 2024.11.19

Contents

1. Overview

COBIFIVE Ising Solver Chip

AXI Interface

- >50MHz AXI clock frequency
- Asynchronous read-write
- 16-bit write data bus
- 1-bit read data
- *_LAST signals included in the AXI interface

Input/Output Pads

- 25 input/output digital pins
  - Input pin configuration: Schmitt trigger
  - Output pin configuration: Hysteresis and pull-down, 12mA drive current per pin

Features

- Manufactured in 28nm
- 0.9V core voltage, 1.8V IO voltage
- Input data: 52 x 51 hex numbers = 52 x 51 x 4 = 10,608 bits
- Output data: 69 bits
  - 15b (best_ham) + 46b (best_spin) + 4b (core id) + 4b (problem_id)
  - First output: best_ham
  - Last output: problem_id
- Programmable on-chip clock frequency ranging from 150MHz to 2GHz

2. Pin Configuration

Fig. 2.1 illustrates the bonding diagram of COBIFIVE which is using QP-QFN48-6MM-.4MM package type as shown in Fig. 2.2.

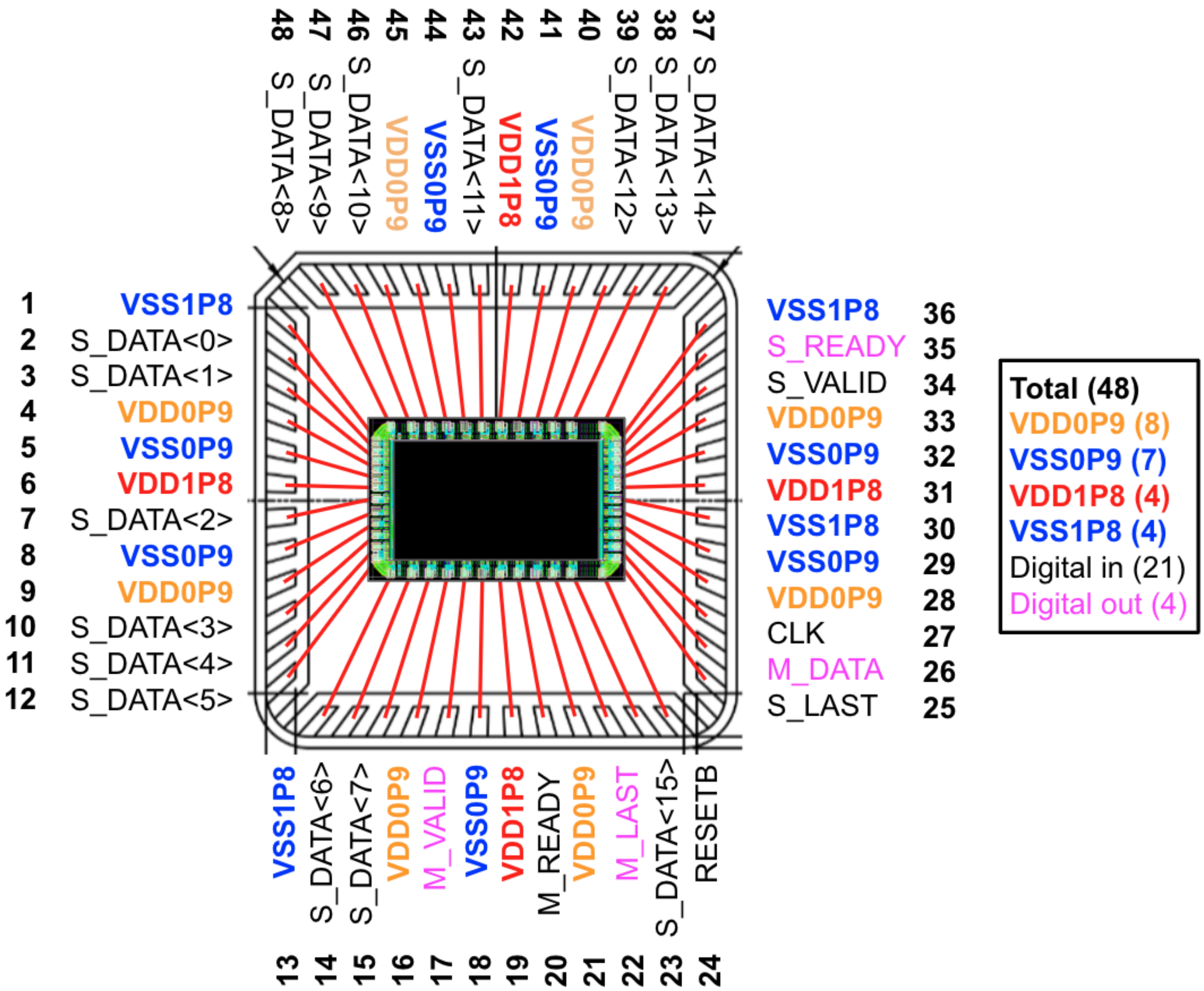


Fig. 2.1. COBIFIVE chip bonding diagram

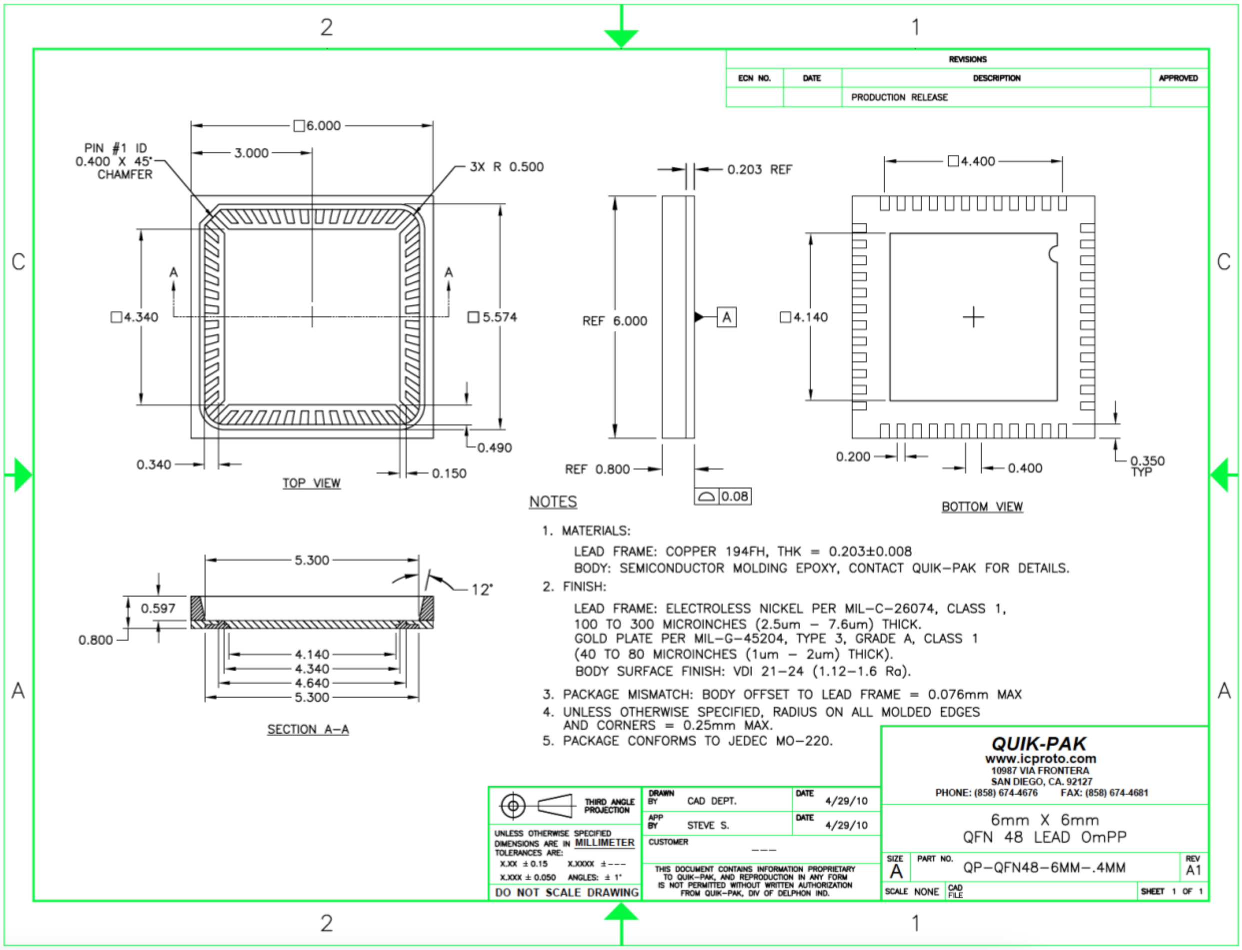


Fig. 2.2. COBIFIVE chip package diagram (QFN 48, 6mm x 6mm, 0.4mm pitch)

3. Pin Function

Table 3.1 describes the Pin Functions of COBIFIVE

Pin		I/O	Description	Activation Type
Name	Number			
Power/ Ground				
VDD1P8	6,19,31,42	PWR	I/O power supply 1.8V	NA
VSS1P8	1,13,30,36	PWR	I/O power supply 0V	NA
VDD0P9	4,9,16,21, 28,33,40,45	PWR	Core power supply 0.9V	NA
VSS0P9	5,8,18,29, 32,41,44	PWR	Core power supply 0V	NA
CLK, Reset				
CLK	27	Input	AXI clock used for both asynchronous read and write	Active High
RESETB	24	Input	Active low reset for entire chip	Active Low
AXI Data Transmission Interface				

S_DATA<0:15>	2,3,7,10,11,12,14,15,23,37,38,39,43,46,47,48	Input	Write Data, S_DATA<15> is MSB	Active High
S_VALID	34	Input	Indicates S_DATA input is valid	Active High
S_LAST	25	Input	Toggled active for 1 CLK cycle on the last S_DATA stream in	Active High
S_READY	35	Output	When active, COBIFIVE is ready to receive write data	Active High
M_DATA	26	Output	Read Data	Active High
M_VALID	17	Output	COBIFIVE indicating M_DATA is valid	Active High
M_LAST	22	Output	Toggled active for 1 CLK cycle on last M_DATA stream out	Active High
M_READY	20	Input	When active, chip will load read data	Active High

Table 3.1 Pin functions

4. Supply Voltage and Current

Table 4.1 shows absolute maximum ratings over operating free-air temperature range (unless otherwise noted).

Rating	Value	Unit
VDD1P8 Voltage	1.8	V
VSS1P8 Voltage	0	V
VDD1P8 Current	20 (max)	mA
VSS1P8 Current	20 (max)	mA
VDD0P9 Voltage	**0.9**	**V**
VSS0P9 Voltage	**0**	**V**
VDD0P9 Current	**140 (max)**	**mA**
VSS0P9 Current	**140 (max)**	**mA**
Digital I/O Voltage	1.8	V
Digital I/O Current per pin	12 (max)	mA

Table 4.1 Supply voltage and current consumption

5. Chip Block Diagram

Fig. 5.1 depicts the high level block diagram of the chip.

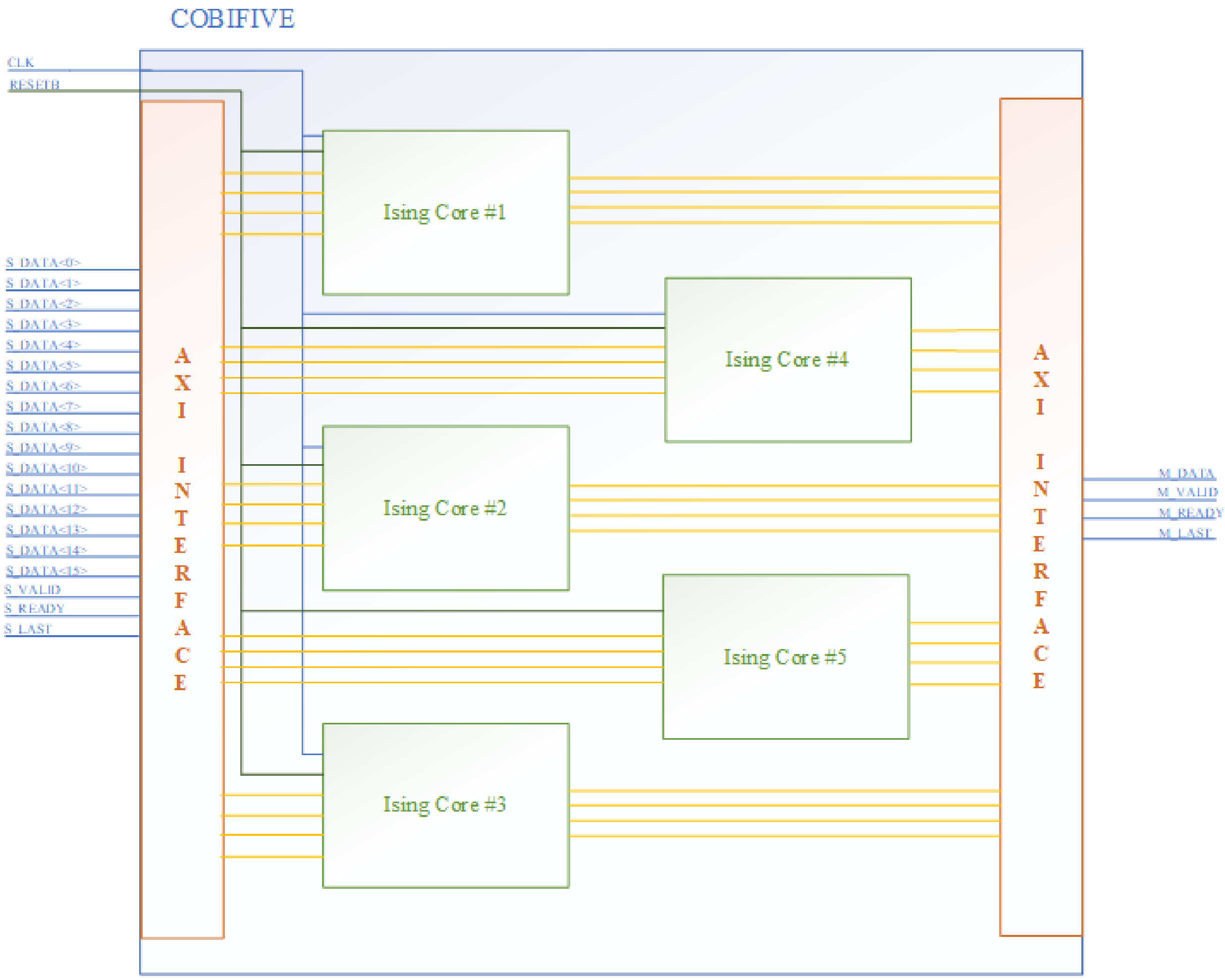


Fig. 5.1 COBIFIVE Block Diagram

6. Input format

There are four types of functional bits shown in Fig. 6.1, including calibration bits (red), SHIL (blue), control bits (yellow), dummy bits (green), short bits (gray) and data (white). The chip is configured and operates under various conditions by assigning different values to the above functional bits. In order to comply with the 16-bit AXI transaction requirements, two additional random data elements are inserted at the beginning of each line. For the actual input data, it is recommended to replace these random values with zeros.

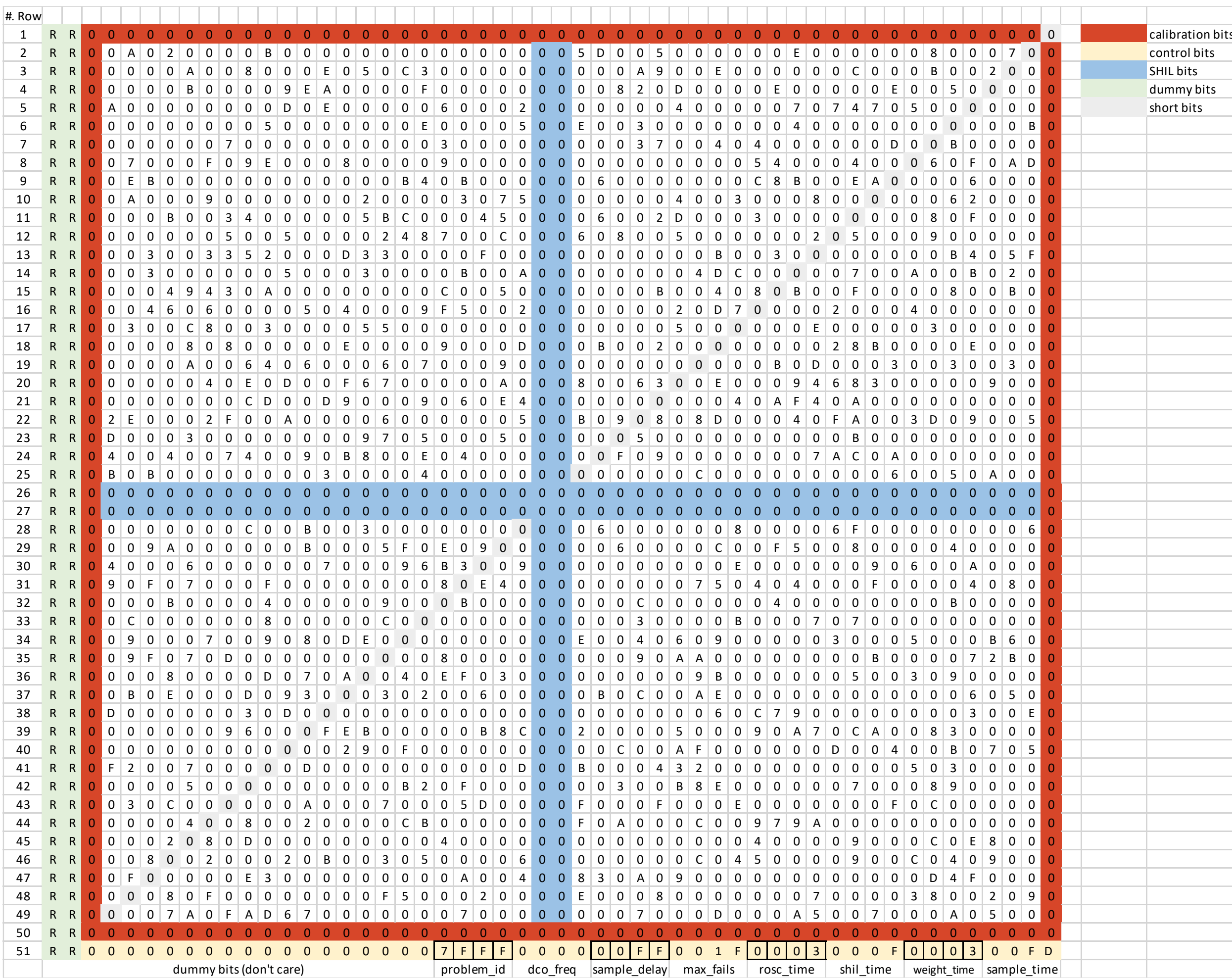


Fig. 6.1 Input Graph Format

Control bits	Width	Description	Range Values	Suggested default
sample_time	16b	Parameter in controller, time duration between two sample signal, would better if greater than 8C which is used for pre-silicon verification	0x0000 ~ 0xFFFF	0x00FD

weight_time	16b	Parameter in controller, time duration between two weight_enb (weight enable) signals, usually the same as shil_time	0x0000 ~ 0xFFFF	0x0003
shil_time	16b	Parameter in controller, time duration between two shil_enb (shil enable) signal, usually the same as weight_time_off	0x0000 ~ 0xFFFF	0x000F
rosc_time	16b	Not used	0x0000 ~ 0xFFFF	0x0003
max_fails	16b	Parameter in accelerator, a static sampling parameter, should be no less than 1	0x0000 ~ 0xFFFF	0x001F
sample_delay	16b	Parameter in accelerator, delay parameter from Ising core to accelerator	0x0000 ~ 0xFFFF	0x00FF
dco_freq	4b	Frequency setting for dco, used for configuring different dco frequency a. Chip will only function correctly when **dco_freq = 0x0000** or it will result in intermittent stalls	0x0000 ~ 0x000F	**0x0000 (USE THIS VALUE ONLY)**
problem_id	16b	The id of problems, special meaning for the highest bit a. problem_id[15] = 1'b1 -> bypass gradient search (use 0 as default)	0x0000 ~ 0xFFFF	0x0000 ~ 0x00FF

Table 6.1 Last row control bits explanation

Write Text File Conversion (Hexadecimal to Binary)

Here is an example of how the 4-Character Hexadecimal data is written to the chip through the AXI stream bus protocol:

4-Character Hexadecimal data = 000A

S_DATA<15:0> = 0000 0000 0000 1010

0 0 0 A

OR

S_DATA <15> = 0
S_DATA <14> = 0
S_DATA <13> = 0
S_DATA <12> = 0
S_DATA <11> = 0
S_DATA <10> = 0
S_DATA <9> = 0
S_DATA <8> = 0
S_DATA <7> = 0
S_DATA <6> = 0
S_DATA <5> = 0

S_DATA <4> = 0
S_DATA <3> = 1
S_DATA <2> = 0
S_DATA <1> = 1
S_DATA <0> = 0

The following example graph demonstrates how hexadecimal bits are grouped to form 16-bit segments and transmitted via the AXI interface. Consider the last three rows from Fig. 6.1 Input Graph as an example. These rows correspond to data, calibration, short, and control bits, respectively. In reality, the input data will transfer from the first row to the 51st row.

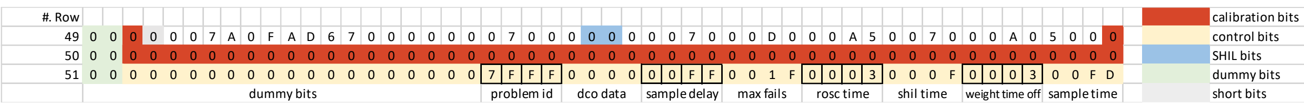


Fig. 6.2 Last two rows' data from *Fig. 6.1 Input Graph Format*

Figure 6.3 demonstrates how the input graph data is transferred to COBIFIVE through the AXI interface. The transfer always begins from right to left for each row, as illustrated in Figure 6.4.

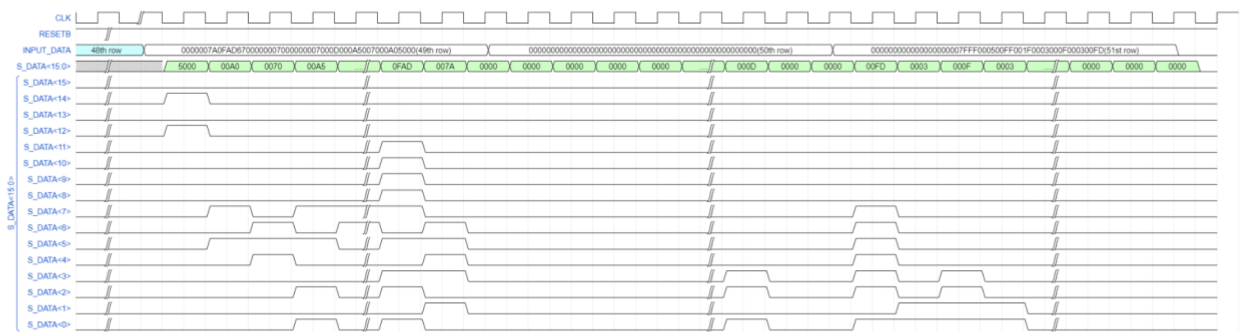


Fig. 6.3 Hex Bits Transition Via 16-bit AXI

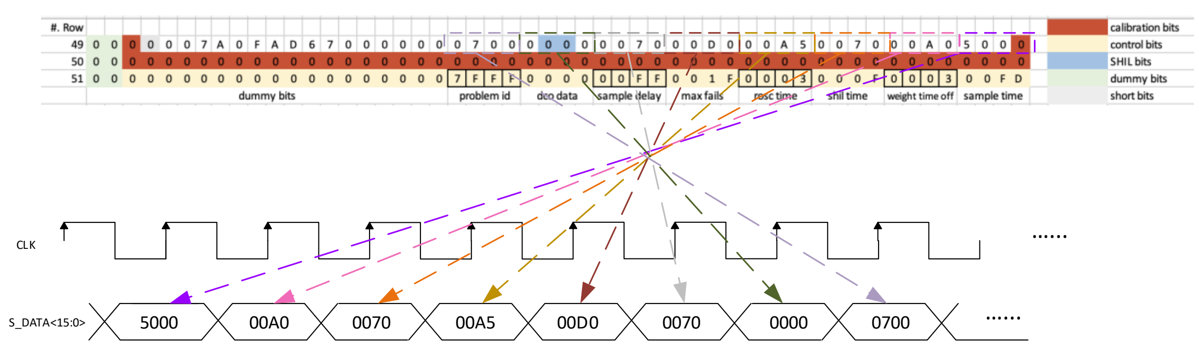


Fig. 6.4 Sequential Data Transfer Across Rows with Bit Mapping

7. Output Format

COBIFIVE outputs 69 bits when each core completes the computation. The breakdown of the output bits from left to right is:

Best_Ham[14:0], Best_Spins[45:0], Core_ID[3:0], Problem_ID[3:0] (only last hex digit)

Here's an example output bit stream.

000000000000000RRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRR10001000

R: random 1's and 0's, changes every time

8 Reset Timing and Control

Table 8.1 provides the definition, typical values and maximum clock frequency.

Pin	Description	Symbol	Min	Typ	Max	Unit
CLK	AXI Write and Read Clock Frequency ($t_{cyc} = 1/f_{Bus}$)	f_{Bus}	dc	125	200	MHz

Table 8.1 AXI clock frequency

RESETB will be activated low to initialize COBIFIVE at the beginning, and then set to high while waiting for the next rising edge of CLK.

Fig. 8.1 COBIFIVE Startup/Reset

9. Application Information

9.1 Write Timing and Control

A write pattern within the COBIFIVE consists of 663 writes of 16 bits (S_DATA is 16 bits). At the last write cycle, S_LAST will be toggled high. A text file similar to Fig. 6.1, consisting of 663 lines of data with each line containing 16 bits in hexadecimal, represents the written pattern.

Data and signals to the COBIFIVE are to be switched on negative CLK edges to prevent setup and hold time violations.

Writing to the chip occurs asynchronously of reading. Writing can occur during reading.

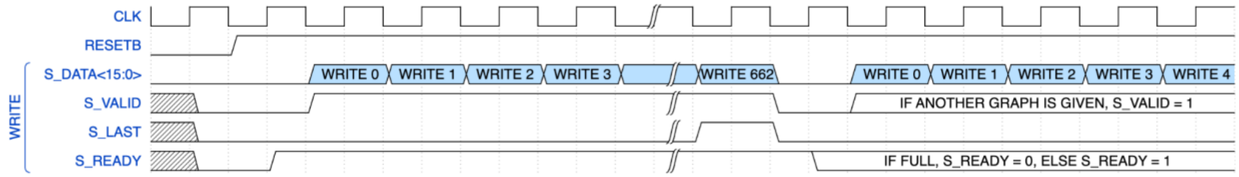


Fig. 9.1.1 Writing Directly After Reset

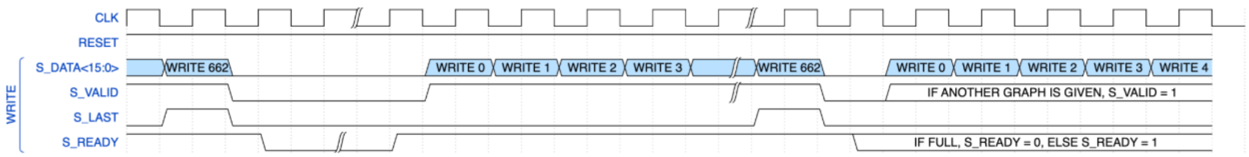


Fig. 9.1.2 Write After Waiting for S_READY High

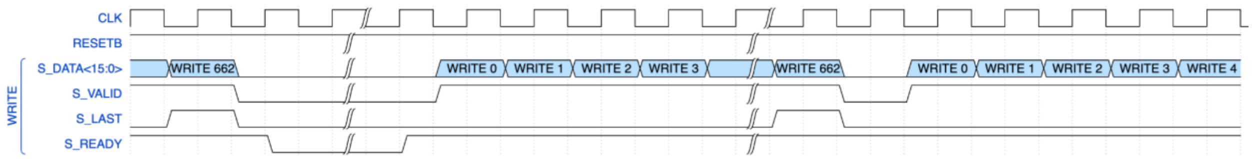


Fig. 9.1.3 Write Directly If both S_READY and S_VALID Stays High

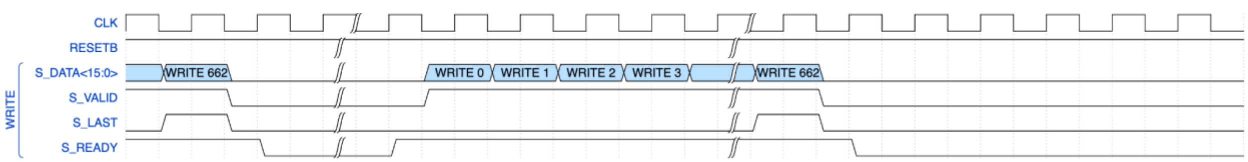


Fig. 9.1.4 No Write If S_READY Goes Low

NOTE: After S_LAST is toggled, the COBIFIVE may or may not be able to accept more data. If both S_VALID and S_READY stays **HIGH**, continue to the next write pattern. Otherwise, if S_READY goes **LOW** after S_LAST is toggled, wait until S_READY goes **HIGH** again. Both scenarios are shown in "**Writing Directly After Reset"** and "**Write After Waiting for S_READY High**". "**Write Directly If both S_READY and S_VALID Stays High"** shows the continuous write mode. "**No Write If S_READY Goes Low"** shows the stop writing mode.

9.2 Read Timing and Control

A read pattern within the COBIFIVE consists of 69 writes of 1 bit (M_DATA is 1 bits). At the 69th write, M_LAST will be toggled high. Read 0 is the first line of the text file. The last line is Read 68.

Data and signals from the COBIFIVE are to be recorded on negative CLK edges to ensure data stability.

Reading from the chip occurs asynchronously of writing. Reading can occur during writing.

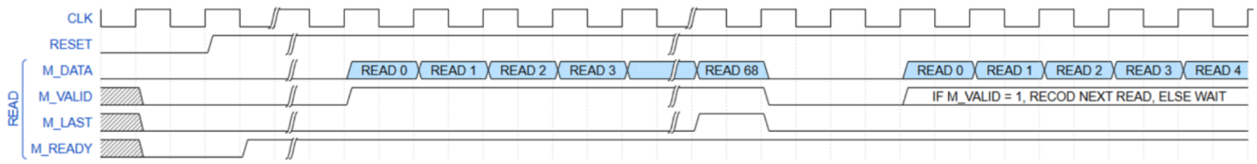


Fig. 9.2.1 Read After Reset

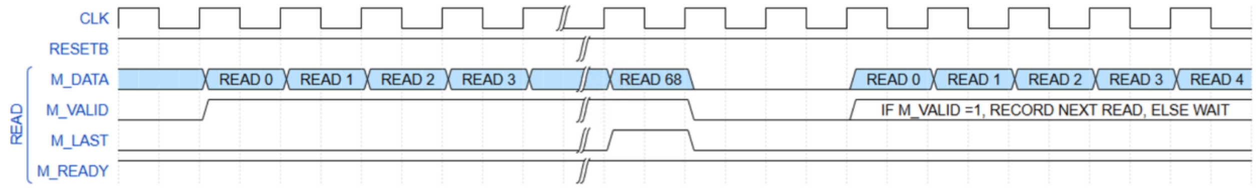


Fig. 9.2.2 Read After Waiting for M_VALID

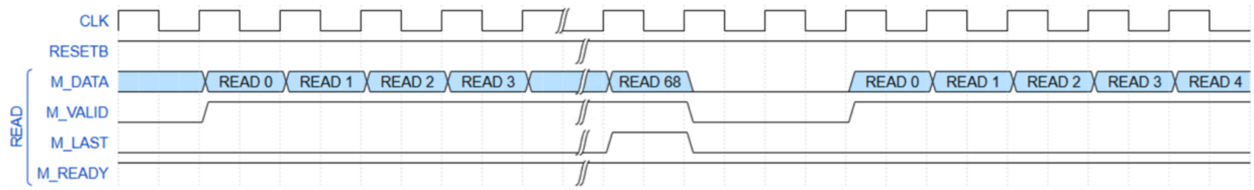


Fig. 9.2.3 Read If M_VALID Stays HIGH

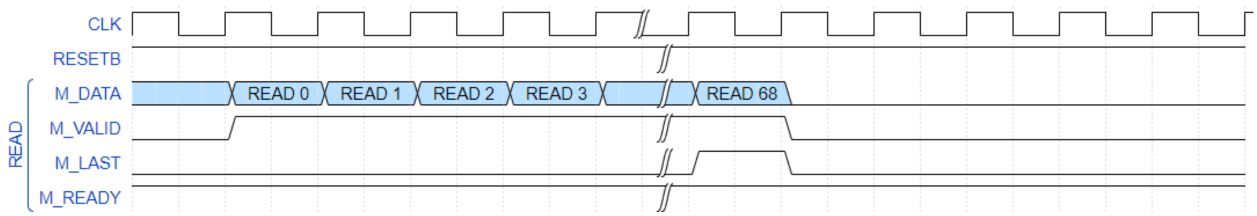


Fig. 9.2.4 Read If M_VALID Goes Low

NOTE: After M_LAST is toggled, the COBIFIVE may or may not be able to read more data. If both M_VALID stays **HIGH**, continue to the next read-out pattern. Otherwise, if M_VALID goes **LOW** after M_LAST is toggled, wait until M_VALID goes **HIGH** again. Both scenarios are shown in "**Read After Reset"** and "**Read After Waiting for M_VALID**". "**Read If M_VALID Stays HIGH"** shows the continuous write mode. "**Read If M_VALID Goes Low"** shows the stop writing mode.

Multiple boards, multiple chips, and multiple core operation example

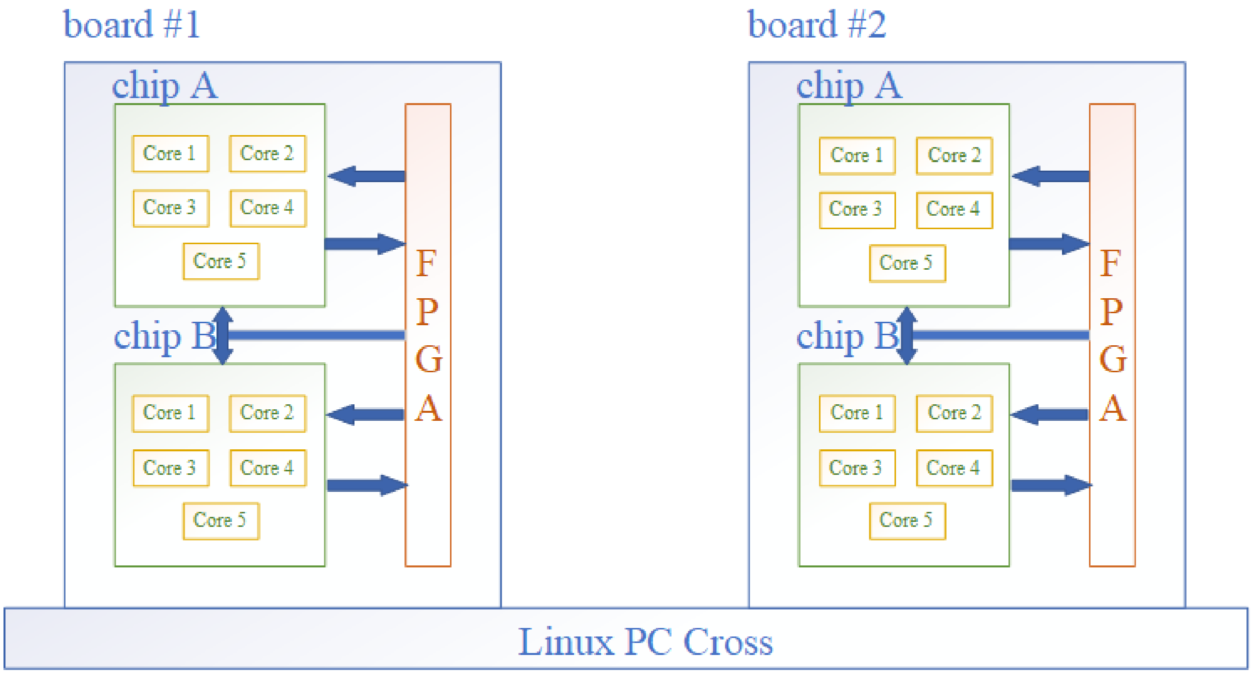
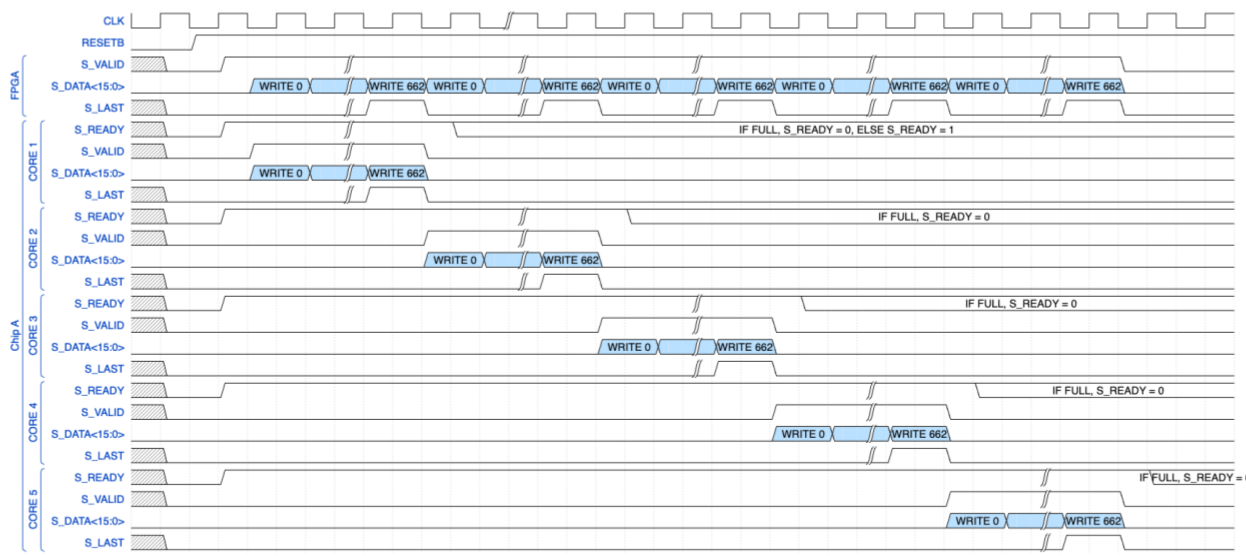


Fig. 9.4 Multiple Chips controlled by FPGA



Appendix A

Input data (52 columns x 51 rows x 4b)

All 0 weight graph example

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0000000000000000000000000000000000000000000000000000
0000000000000000000000000FF0000000000000000000000000
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0000000000000000000000000FF0000000000000000000000000
0000000000000000000000000FF0000000000000000000000000
0000000000000000000000000FF0000000000000000000000000
0000000000000000000000000FF0000000000000000000000000
0000000000000000000000000FF0000000000000000000000000
0000000000000000000000000FF0000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

All +7 weight graph example

```
0000000000000000000000000FF0000000000000000000000000
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF00
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0F0
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0FF0
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0FFF0
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0FFFF0
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0FFFFF0
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000FFF0FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
000FF0FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
000F0FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
0000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
0000000000000000000000000FF0000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph example


```
0000000000000000000000000000000000000000000000000000
0000000009800000900700000000B000000000209003070002000
00000000E060D070228000000006070807000000CB00000635000
00003000500C004070CE0000000B2D005020002A000000000000
0000000040E020C02E000006C0000C0080000000E00750A00CA0
000200C0000000060AA500300000D0D0000007B0000070000800
00000000000000A00030070A0009B60000B0030D000000000000
0000000000000000000000050000000000000000700300000900 0
00000D00000004700A00700000000000880060 02D0200B5800000
000000000D07BC0000E0B00000000000000F0070D000000A0000
0000F080000909D60042700B00000407C0000C0000000000B020
000900002000000D5C3B0200800200600B00000000A0000F0400
00000000CE0902000000000040000C0060009E3000000E460090
000903000600C0900074007000000DD000000E00000000C86000
000000000D0B00570A0424F000000040A7003000000000000400
000CA00000D00000000FF00B000000F0000000000B0000000500
0000C000000300E0C00E092000000E000070000000206800000000
0000282D0000C04000000000000C000A0000000B0000E0E0B000
0000B00009B0F00D00000F00000000800005420020D008000000
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0000000009003908 0000D00A000000E002000000E00000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000050204 0000B0000004CB00000000F006EA00000700000A00
000B000080050000000000A00000F000000000B0000809000000
0000E000BF000E0E000300000000E0D0E9C000C000000DD00000
000000082002FA007000000000000000D0040C60AE00950008AC00
00000056080A0090C00000623000030500908000030090D00000
00060EE000000070000000000000500002000000B008D00000700
0000000000002B00000004000000000B0E0000D4090000000400
000000E000000A008000000000000050EC0940000000 40E0000D3550
00003E04000000000D090CB00000009C05000000D00900408000
000C000000000000E000000A000000000C00000B0390F0600500
0000000000008000000F70000D0000E0000200B000500030000 00
00005B000002000000009000000000000000A000000000069500
00000A0000B00005D00B00400000030390F0009D000060000000
00008000030000 0A000990000000040000A09000000006000000 00
0009C4006000D0000008000200009002 00F6200022000 0B03070
00050000D000009009 03900F200000007C000040000C0E000EB0
000000004000E0609000B000FC00E07000000000800A09000000A0
000000000400700070005000500A6D0095000000000A070C0000
000D0B0000300006060040D7000877F090000000000000000800
000000000B00000B00020000000000030050D0000000000300000
0006000000F00C000C0E0400000073005AE9030000000000700000
0000300500000B80004000080000C0F00B02B0000000060D0E00
0000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Expected output from chip (69 bits)

Best_Ham[14:0], Best_Spins[45:0], Core_ID[3:0], Problem_ID[3:0]

All 0 weight graph example

Take core 0 as an example when problem_id[15] = 1'b0
000000000000000 1111111111111111111111111111111111111111111111 0000 0001
Best_Spins[45:0] should look like random 0's and 1's

All + 7 weight graph example

Take core 0 as an example when problem_id[15] = 1'b0
100011101100110 0000000000000000000000000000000000000000000000 0000 0001
Best_Spins[45:0] should be all 0's

Random weight graph example
(energy might be differ but similar to -650 as max_fails is set to tb 2 for boosting the simulation speed)

Take core 0 as an example when problem_id[15] = 1'b0
111110101110110 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx 0000 0001
(around -650) Best_Spins[45:0] will be random since it is an analog circuit

Appendix B

Input data examples (52 columns x 51 rows x 4b) including random, all +3, all +2, and all +1 graphs, for additional testing and verification.

All +3 weight graph example

```
0000000000000000000000000000000000000000000000000000
0007777777777777777777777FF777777777777777777777777770
0007777777777777777777777FF777777777777777777777777770
0007777777777777777777777FF777777777777777777777777770
0007777777777777777777777FF777777777777777777777777770
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0007777777777777777777777FF777777777777777777777777770
0007777777777777777777777FF777777777777777777777777770
0007777777777777777777777FF777777777777777777777777770
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0007777777777777777777777FF777777777777777777777777770
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0007777777777777777777777FF777777777777777777777777770
0007777777777777777777777FF777777777777777777777777770
0000000000000000000000000FF0000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

All +2 weight graph example

```
0000000000000000000000000000000000000000000000000000
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
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0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
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0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
0005555555555555555555555FF5555555555555555555555550
```

All +1 weight graph example

```
0000000000000000000000000000000000000000000000000000
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
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0003333333333333333333333FF3333333333333333333333330
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0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
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0003333333333333333333333FF3333333333333333333333330
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0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
0003333333333333333333333FF3333333333333333333333330
```

Random weight graph 1 example

```
0000000000000000000000000000000000000000000000000000
0000070B00BA8000A504E2090000060C000BC60003000C300700
00000CE06040B60004300006000B000B00800280F00000000000
000000F00006F004C0000000800B000030200000A0940000DF0
00005C000009A0060DCE0002600002E03D0000A0080302600000
0000000000A00000000C000000000E5D0004008900707000420
000003000D0000DE0F00E00020000E0B050000000E0000000B00
00000300A0E9F02A529300F0000BB4E0003C0B0000AA00057620
0007005E200C03700000D00E400E530000002069B0C0F0000080
00009CFF00007DE00D0B07C2000A000A40B00000050000000020
000A000090000C00000002B05000000B020000750000007000000
0000400000000000000600000B00000D00400202A0040040000720
000F705008D0000070E0300F00060000000009000B00F020A020
00000BF00200007700000000F00000F060088000004008000009000
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000B00007850400000050000400030D00BAF506000000000000F0
0000A08C99000004C20400C0000F00000000003A0F0B03B00800
00080D00000F0B00000070E000000300000024B00E0D0A000000
0000700009E6F000B0050060F00066000000000900500000340
00080000006B3E0040009020000000003008C00003009C94B00400
000929F807640F003000F000000000300000000000D0C0200070D0
00000050E60A6FD7CF028040000450000A0D090000004E0E0000
0000C000B00000000080000D0000000800E00300000000E00000
000D000066A603A006500000000000B0B2004000050B000D3000
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0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
000B0008F0AF0D60008300000007000900000A4089F09400B0D0
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000066DC0068C00003C2000000000047000D0000BF088B90000040
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0000000972000400602000E000E0006000D0F600000000D0000
00000000C0E00000B20CDF85500B02020000308B0F0B00220600
00000400E0A0084C9000B000000B2020000006000684 0D000000
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0000007C5070D0700030A00A000000000000000890540000C000
0000000005040000A0FA04F00000500000005D60DB0900F0AC40
00000D090000008E0600A0000008000B7700200000000C040000
00003000AF000002070E0C00000F20000BB00009000720 02A00
0000F0000A0006C0C60400D0200070300B2000000000B00E0000
0000020F0000A00C8000000000070000E70C8006000080F09000
00000006A000E90000000A0090000D0047DB00002E8000000FD0
000200800000BA60043000000006000007000B00BC0700800000
000669C000002009300F00044000902080C0F05F0000E30604D0
00008004C060006BE00E5B0E000D6280CA0F000088E9BB00E000
00004000900008B7BA800A000000000470304000000000400000
0000005020B30400090604000000030D029705902E0707000000
0000000050D6000000C050F0200A04CCD0F05800B00D0B020200
0000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph 2 example

```
0000000000000000000000000000000000000000000000000000
00004C43758C6399846F0996A00F29DE953DA623EE4285068300
000C0B238303B46D4DD7F2DEF0092C7E255902A30E85D9246090
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00059605493E4E0833D766B600099DA493335249E0C47ED05A70
0003C6F04E5C9FF34F0953F03002DA74F52B7EBA0723B40DF920
000A06960C2FBEEFD58DE4AAE00D75F9653907A7E22C800F32B0
000F875F8058834E5AC3B882F00B55333C2C6D78EF2B0A359650
000B5368030A277EEB40E76940047F32EFAA077C82E05ED8F380
000A84BA7AC06222BE5344CAE0039344292B078A0809694B20F0
0003549A680D03A5CA6A2320700EDCEE0F0D305D305363500200
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0000CA3DC4F4030F40240E88C007FD864DE25AA0F5EF4FE3A650
0000DC5D864C2640964C27F7000CCA0C5568CE0A50CDA6A540B0
000487AB6868ED3403506CD37008B3DA8264C037EDE84A605700
000E52892E326BF620BDF26AC00FB09B77FF066D4C7CB7522230
0008FF0C607FE5CC4E026CB46000B5CDF64047BCF0C6606352C0
000B69862BBF6F29F8E07AB9700B0CA38A08D8A5CCBE5C4A8950
0003655EA30F84D49ED50D6AE008C5D2E084B323D39DCF2652A0
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00087BF7868CAABF8B6D7307600990A0D258DB45F368C424CDB0
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000D36C6F8BA4AB29AD2D3C200020024FCFB5D940C256CB7CFE0
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0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
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0008B40E2E5B9A2084C7680BF0050B20DA620D89FC94F83ABBE0
0007849736A2EDA5A45600CE600D9FB609B2A343AD5B84378AB0
0007D32F97A356AE7BC007E0F00FD3B8C0CA35AE0DBEA62AEB00
00020448822A5A24AB8042BF7002CBDE5D029436EF09D2328E40
00044CDF88A323E2FF06427BC00C47BF32B0B7FB3434A07442B0
000AA4097A5FD08D40BCA7B4E0070E5624A9020A7A30F04AB8E0
000D389BB56A3F6F05DBA22AE006899E29DEA0FED4808EC20FB0
000EED038E88C860FD7585CFA006B823DA97570942547E62D220
000468B3B930DA0730B07DBD200B0BB6CA8D8660830F08B2EA70
000D54B2B6C9B0F6F69BE2325005723B47F67F3C00B9BB6E26B0
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00023FF9CA708FAEDAD5B779200E9EED809E43FC0F0F675DFFE0
00062777D90095E343AFF905400D064A28F6BDCBD55009CE4640
00038A7570529525C44AEE4D000DCE052D66BBBECCDF07AA99A0
000AE65900F65C757608BB85600369DE64F82D9C0F7880C40B70
0003CA703CD88820ABC66584F0006A2982E784673D8C590E3850
000CC0054689582AF2465A88E00EE9CE35F7CA85DBFDDBD0B790
000CE09FD7FC36E058D5706C40088AD82E7E22345D0B9F5C09A0
000F0654FDC5F24B3F90E92F800F7ACEE3A54740FF90FC5A0080
00008DF0B25089ABAEC935A7800024650F2003B88D5FD6E0F400
0000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph 3 example

```
0000000000000000000000000000000000000000000000000000
0000055080800000000000D000009400000B30000D0000000000
000A05E8E00000000000000000000000000060C090000007000
0000000F900000D0000440300000090000A0004000080E0000B0
000000000D000000F0000000000E000A0000000000F02000000
0000D0500000000000000000D00000000002000000000E000090000
00000000005000073C0000F00005050200007000B000000F00D0
00000B000040000E000F00000000000000680000004060000050
00000600000000000000000000000000009900000F005000000000
0000007402F0000003000000C000F00EC9000F000C0000097000
0000509000000000000000006000000060000000000000000D0050
0000000000050000000F0E0F00000400002A0000080000000000
000000000000B0000000E0F30000009008C00000000000F08000
000000000000000000A003000000C00000E000000000000000000
000E00002000000000DB000200000000005070000270003050000
000D00000000000000004C000000000000000000000000000000070
00000E00000DE00000060A600000000000000A3000000000000
00000B000000000000000F0000000000000000000000E08000000
000004000C0000000000000000000205000000000E0000000F00
0000B000050000000005000000000070000E6000000000000000400
00000000000000000200000000000700003020000000D00A07B000
00000000000000030F000000000000400000008D00B000000000
0000080000000000000000000000000000000000E005000000D7B00
00000000504000000000000000400000020000000000F40000A5000
0000000900009000000000600000000A070000000000000006007400
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
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00000000040F000000004000F0003000E000000000000000000E000
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00000D00007008 0F00000E90000070000050000000000040600000
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0000A055000000000002007070000900080004000000000005C0080
00000000000030000000B008000000000000000B00030000000006000
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000000000000000000090000000000000000830000070A0000000000
00002060090000000C0009F000000000000090D0000000000A200
000D0000A000000A0000C0200000000000000007000700000000000
00009000004 0000C000900000000000000000A00000000000005E0
000000B004000000000000720700E00008B0000000E700C000000
000BF0000E0C0040B00000350000080000000660000AB00005000
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000000000064000084002D000000E00800060000A05000800000
00000000000900300400AE025000000000B0000D00020009 00500
0000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph 4 example

```
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
000900000F090000000D00300000008BC000000000000000000
0000000B4040000000000703000009000 0A0E000000000000000
0000000C0000070000000000000000020000000000000000000
00000000B00000000000000000000000020D00000000000000
00007000E00000C00008000000000630000C0000000000000000
00000000000800000000000C0000000C00000E3000000000000
00040008F080000005000 0F0000000000000000000000000000
000000000F0000A00D0500C00000F004000000000000000000000
000004000000000E0000000000B0000D000000000000000000
0000F000004000000E00050000000B030040400000000000000000
000000000000C0000800099000000050008090B0000000000000
0002000000600B00000000B6000000008000000000000000000000
0000000000002D04000000450000000000000E0000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000870000000000030000000000A00A30CEF000000000000000
00000B00000000020000600C00000800E000BE700000000000000
0000000007000D0600000060000000009030000000000000000
0000000000A0000000000000000000000A0000000000000000
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000300000C000000000000007000050E0000400000000000000000
00000000A000000000000000000000000000000000000000000000
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00000000E080000000000006B004000B000000E30000000000000
0000D90E00008000005000F000000030060070060000000000000
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0008300000003000000000000000000000F00090000000000000000
0000000000000500000020000000009000060000000000000000
0000000000000000302000B00000000707A0200000000000000000
0000000D00000000000000050000000040A000000000000000000
00000400000000900404000000000000A000000000000000000
0000F06400E000000D00C000000F0000A000060000000000000000
000070000000007A00300000000000CA0B50070000000000000000
0000000000000700B00020F0000000A8000000000000000000000
00006000C000300000000000000030D00F20A300000000000000
00000040770B0000003000090000F0004700900000000000000000
00000B000000000000000B5D0000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph 5 example

```
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
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000000E009000600000000000000000000000000000000000000
0000602700940000000000000000000000000000000000000000
000000000000EE00000000000000000000000000000000000000
000000A0F020000A000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
000A0000000000000200000000000000000000000000000000000
00000000000000E0D00000000000000000000000000000000000
0000000300000000000000000000000000000000000000000000
000000000D0000F0000000000000000000000000000000000000
00000090A00004E0030000000000000000000000000000000000
0000C90A00000200000000000000000000000000000000000000
0006000000000000000000000000000000000000000000000000
0000002006070000000000000000000000000000000000000000
0000000023000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph 6 example

```
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
00000000006F60000000000000000000F0000000000000000000
000C000000000E003C00000CE000040340000000000000000000
000000000D0600000000B0005007000000000000000000000000
0000000D0000840500800900000D00A000C00000000000000000
000000000D000000000000000008F00000000000000000000000
0000000008002000000400000000A00000000000000000000000
0002C00700D60000800000D00C00000A000000000000000000000
000F00000C0000000700000700000000000C00000000000000000
0000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000
00000F0300050E000E000F000000000000000000000000000000
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000D50000000000000000000000000260A400000000000000000
00070005004000000000E0700000040000000000000000000000
0000000000600ED00BD000500000000C0B000000000000000000
000A0C0000000700000000000000000000000000000000000000
0000000000050400900800000000E000004E00000000000000000
000000000000000000000006000000E004000000000000000000
00000000000000000852060630008000000000000000000000000
0000000000000504005F0000A00B006090C00000000000000000
0000000000000000000007000008000000000000000000000000
00000000000C0000000000000000000000000000000000000000
0000000000009F000D0006040000800D00800000000000000000
000040000D0AE00E0900000000000F0000000000000000000000
000040000000000000040000B9000B0003B500000000000000000
0000070000600C0000004000000B000000000000000000000000
0000E000A000EB00000000F000000400000C00000000000000000
000000002000000700000DB00000000000000000000000000000
00000F0C000000BD00000000000D005000000000000000000000
0000C0000500060B000000000000000C00000000000000000000
0000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph 7 example

```
00000000000000000000000000000000000000000000000000000000
0000070B00BA8000A504E2090000060C000BC60003000C300700
00000CE06040B60004300006000B000B00800280F00000000000
000000F00006F004C0000000800B00000302000000A0940000DF0
00005C000009A0060DCE0002600002E03D0000A0080302600000
000000000A00000000C000000000E5D0004008900707000042 0
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00000300A0E9F02A529300F0000BB4E0003C0B0000AA00057620
0007005E200C03700000D00E400E530000002069B0C0F0000080
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00004000000000000006 00000B00000D00400202A004004000072 0
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000B00007850400000050000 40030D00BAF5060000000000000F0
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00080D00000F0B00000070E00000030000002 4B00E0D0A000000
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000929F807640F003000F0000000003000000000D0C0200070D0
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00000000000000000000000000000000000000000000000000000000
00000000000000000000000000000000000000000000000000000000
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0000009000C00700A000000000000407B00200500000060000900
00000009720004006020000E000E0006000D0F600000000D0000
00000000C0E00000B20CDF85500B02020000308B0F0B00220600
00000400E0A0084C9000B000000B20200000060006840D000000
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0000007C5070D0700030A00A0000000000000000890540000C000
0000000005040000A0FA04F00000500000005D60DB0900F0AC40
00000D090000008E0600A0000008000B7700200000000C040000
00003000AF0000002070E0C00000F20000BB000090007200 2A00
0000F0000A0006C0C60400D0200070300B200000000 0B00E0000
0000020F0000A00C800000000000070000E70C8006000080F09000
00000006A000E90000000A0090000D0047DB00002E8000000FD0
0000200800000BA6004300000006000007000B00BC0700800000
000669C000002009300F00044000902080C0F05F0000E30604D0
00008004C060006BE00E5B0E000D6280CA0F000088E9BB00E000
00004000900008B7BA800A000000000470304000000000400000
0000005020B30400090604000000030D029705902E0707000000
0000000050D6000000C050F0200A04CCD0F05800B00D0B020200
00000000000000000000000000000000000000000000000000000000
00AAAAAAAAAAAAAAAAAA0111000000FF001F0003000F000300FD
```

Random weight graph 8 example

```
00000000000000000000000000000000000000000000000000000000
0000000009800000900700000000B000000000209003070002000
00000000E060D07022800000000060708070000 0CB00000635000
00003000500C004070CE0000000B2D005020002A000000000000
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