APLIKASI DETEKSI KUZUSHIJI
Ancient Japanese Handwritten Characters

Maurizfa (13216008)

Mikael Wahyu Diantama (13216014)

Robertsen Putra Sugianto (13216024)

EL4138 – SISTEM PERANCANGAN VLSI

PENDAHULUAN

Pada tugas kali ini, akan digunakan tensorflow sebagai *platform* untuk melatih sistem C*onvolutional Neural Network* (CNN) yang dibuat agar dapat dihasilkan suatu filter *Machine Learning*. Tujuan akhir dari kegiatan ini yaitu didapatkannya data berupa *weights* sebagai kernel yang akan digunakan untuk melakukan CNN pada FPGA.

DATASET KUZUSHIJI - KMNIST

Aplikasi dari tugas ini yaitu untuk klasifikasi karakter yang biasa digunakan pada manuskrip Jepang kuno. Dataset yang digunakan diambil dari *website* github berikut.

https://www.kaggle.com/anokas/kuzushiji

Isi dari dataset tersebut adalah 70000 gambar grayscale yang terdiri dari 10 kelas dan berukuran 28x28 piksel.

DATASET KUZUSHIJI - KMNIST

10 kelas, 60.000 training dataset, 10.000 test dataset

Class Map :

0 = お
1 = き
2 = す
3 = つ
4 = な
5 = は
6 = ま
7 = や
8 = れ
9 = を

HOW DO WE LOAD DATASET?

- Download from kaggle the “.npz”
- Using the load function from numpy library

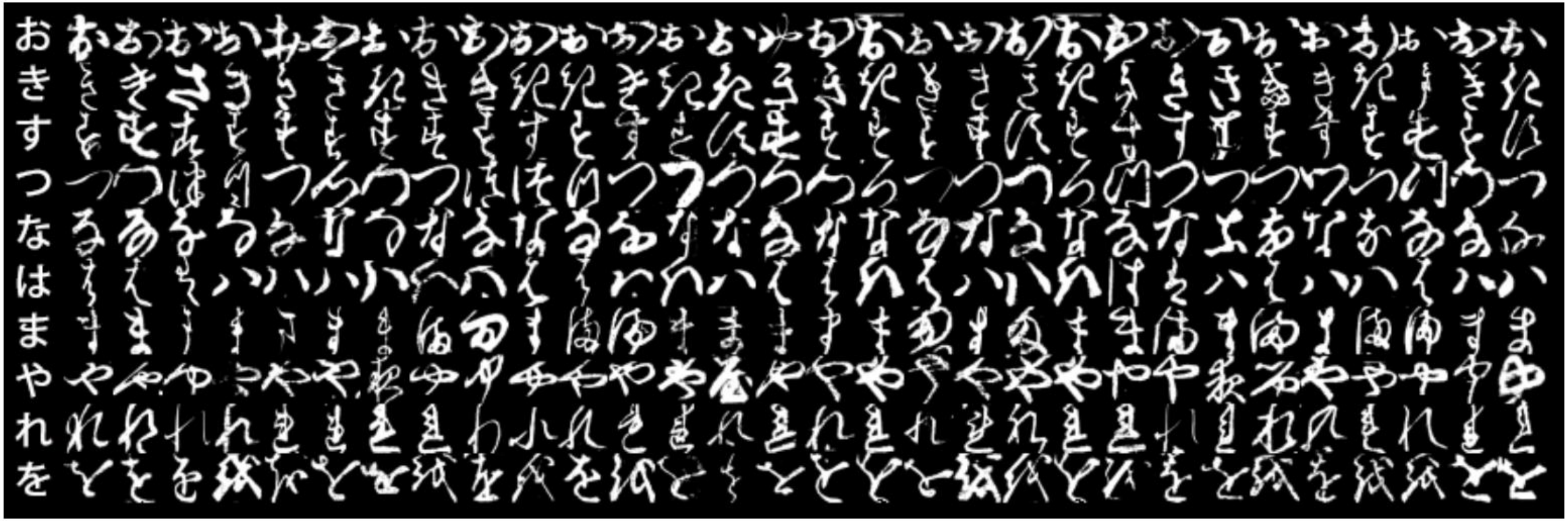
```
data = np.load('/content/drive/My Drive/Colab Notebooks/kmnist-test-imgs.npz')
test_images = data['arr_0']
data = np.load('/content/drive/My Drive/Colab Notebooks/kmnist-test-labels.npz')
test_labels = data['arr_0']
data = np.load('/content/drive/My Drive/Colab Notebooks/kmnist-train-imgs.npz')
train_images = data['arr_0']
data = np.load('/content/drive/My Drive/Colab Notebooks/kmnist-train-labels.npz')
train_labels = data['arr_0']
```

- Testing shape :

```
print(test_images.shape)
print(test_labels.shape)
print(train_images.shape)
print(train_labels.shape)
```

```
(10000, 28, 28)
(10000,)
(60000, 28, 28)
(60000,)
```

DATASET
KUZUSHIJI - MNIST



DEEP LEARNING MODEL

1. Layer 1 : CNN, 6 Kernel, 3x3, act_f = relu, no_bias
2. Maxpooling : 2x2
3. Layer 2 : CNN, 6 Kernel, 3x3, act_f = relu, no_bias
4. Maxpooling : 2x2
5. Flatten
6. Layer 3 : Dense Layer, 64 kernel, act_f = relu
7. Layer output : Dense Layer, 10 kernel, act_f = relu

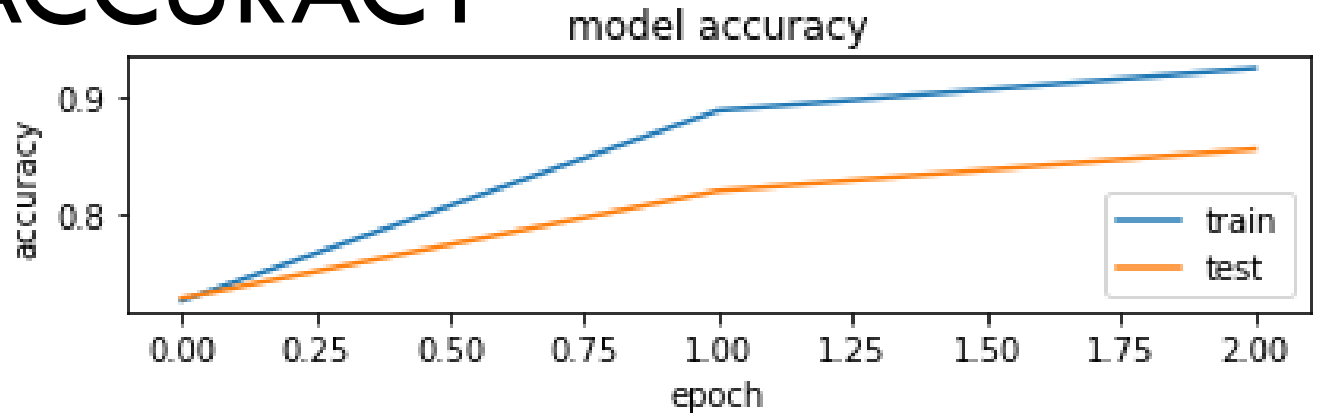
MODEL SUMMARY

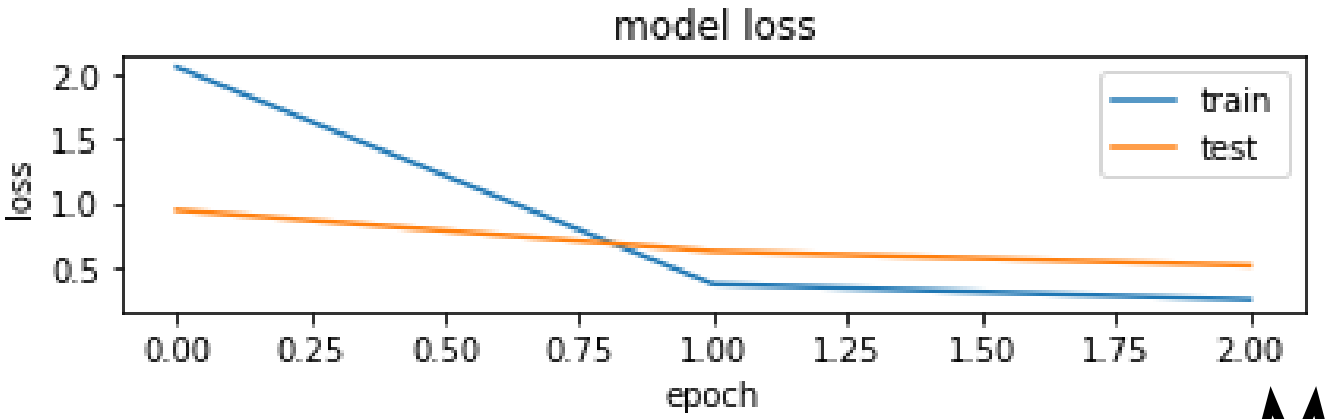
Layer (type)	Output Shape	Param #
layer_1 (Conv2D)	(None, 26, 26, 6)	54
max_pooling2d_2 (MaxPooling2	(None, 13, 13, 6)	0
layer_2 (Conv2D)	(None, 11, 11, 6)	324
max_pooling2d_3 (MaxPooling2	(None, 5, 5, 6)	0
flatten_1 (Flatten)	(None, 150)	0
layer_3 (Dense)	(None, 64)	9600
layer_Output (Dense)	(None, 10)	640

Total params: 10,618
Trainable params: 10,618
Non-trainable params: 0

MODEL ACCURACY

0.8556





MODEL LOSS

WEIGHT SHAPE

```
print(layer_1_data.shape)
print(layer_2_data.shape)
print(layer_3_data.shape)
print(layer_out_data.shape)
```

```
(3, 3, 1, 6)
(3, 3, 6, 6)
(150, 64)
(64, 10)
```

TEST ACCURACY OF QUANTIZED WEIGHT AND IMAGES

```
val_num_keras_model : 8556
val_num_quantized_model : 8558
val val_num_keras_model : 85.56 %
val quantized  : 85.58 %
```

WEIGHT VALUE

Weights Layer 1 :

```
[[[[ -1.  13. -36.]
   [  7.  12. -54.]
   [  4.  51.   1.]]]
 [[[ 18.  26.  44.]
   [ 27.  -2. -31.]
   [  4.  17.  25.]]]
 [[[ -1. -24. -70.]
   [-69.  24. -20.]
   [ 52. -69.  -3.]]]
 [[[  4.  37. -33.]
   [ 29.  10. -44.]
   [-29.  37. -12.]]]
 [[[-21. -75. -17.]
   [ 14. -35.  26.]
   [-12.   0.  17.]]]
 [[[ 25. -20. -19.]
   [ -9.  31. -20.]
   [ 25.  -1.  10.]]]]
```

Weights Layer 2 ke-0 :

```
[[[[ 15. -15. -14.]
   [  6. -54.  19.]
   [ 25. -19. -12.]]
  [[ 26.  28.  -6.]
   [-20.  -4.  -1.]
   [-16.  10. -53.]]
  [[-26. -26.  -5.]
   [ 25.  36. -31.]
   [ -8.  58.  16.]]
  [[-12.  31.  37.]
   [-41.  25. -19.]
   [-41.  -3. -14.]]
  [[ 24.  -7.   6.]
   [-40. -13.  15.]
   [-23.  10.   0.]]
  [[ 14.   6. -28.]
   [-12.  17.  10.]
   [  5. -35.   7.]]]
```

Weights Layer 3 :

```
[[ 10.   8.  23.  11.   0.  17. -15. -19.  14.  -1. -13.  -6.   5.   7.
  -20. -10.  -3.  18.  -5.  25.  16. -14. -17.  -9.  19.  14. -17. -13.
  -15. -19.   1. -29.   1.  -8.   7.   8.  14. -21. -19.  11.  23. -17.
   26. -20.  11. -15.  -8.   0. -11. -13.  -6.  -9.   6.  18.  23.  19.
  -18.  -1. -16.   1.  12.  20.   9.  -7.]
 [  9.   8.  -3. -14.   3. -20.  19. -21.  -6.   1. -16.   3.  -4.  21.
   -3.  18. -21.   5.   2.  11.  14.  18. -19. -15.  -3.  19. -23. -21.
  -17. -29. -13.   7. -15.  12.  28.   4.  -5.  16.  -8.  13.   7.   8.
    3.   5.  10.   9.  -5. -26. -16.   8.  19. -20.  -5. -31.  12.  -4.
   -5. -16.  -1. -19.   7.   6. -20.  16.]
 [-14. -16.  24. -29.   8. -22.  -8. -29.  -8.  -7. -10.  13. -12. -12.
  -21. -16.  33.   1. -21.  -1.  12. -15.   7. -24.  18.  -8.  -9.  -1.
    9. -18.  -4. -10.  20. -22. -12.   5.  -7.  15.  -2. -27.   3. -23.
   -6.   7.   0.   3. -11.  -9.  10. -30.  -5.  21.  17.   7.   3. -19.
  -13.  -6.   5. -14.   3.  -2.  11.   6.]
```

Weights Layer 4 :

```
[[ -7.  23. -35.   9. -28. -13. -36.   4.  -7. -42.]
 [  4. -18.  12.  23. -27.  35. -11.   2.  43. -29.]
 [-20. -24.  23.   0.  -8.  25.  31.  23. -15.  23.]
 [-49.  41. -19.   4. -32.  40.  -4. -46.  54.  -8.]
 [-12.   3. -18.  11. -32. -39.  -2. -32. -23.  34.]
 [ 19.  13.   4.  28.  19. -14.  41.  45.  13.  14.]
 [ 37. -29. -10. -35. -29.  23. -11.  11.  -2.  11.]
 [ 35.  54.  11. -30.  31. -15. -39.   3.  27.   2.]
 [-41. -22. -27.  -6. -14.   0. -41. -15.  11. -27.]
 [ 24. -42. -20.  14. -43. -53.  32. -42. -36.  28.]
 [ 14. -12.  50.  24. -32.   3.  47.  19. -29.   2.]
 [ 33. -21.  33.   1.  34.  19.   0.  19. -17. -15.]
 [ 19. -10. -37.   5. -12.  36.  25.  11.  10.  -9.]
 [ 38.  15.  17.  29. -11. -40. -49.  42.  -3. -16.]
 [ 28.  -4.  -2.  -9. -35. -31. -47. -50.  21. -33.]
 [-24.   7. -33.  20.  51. -36.  -1.   1.   4. -24.]
```

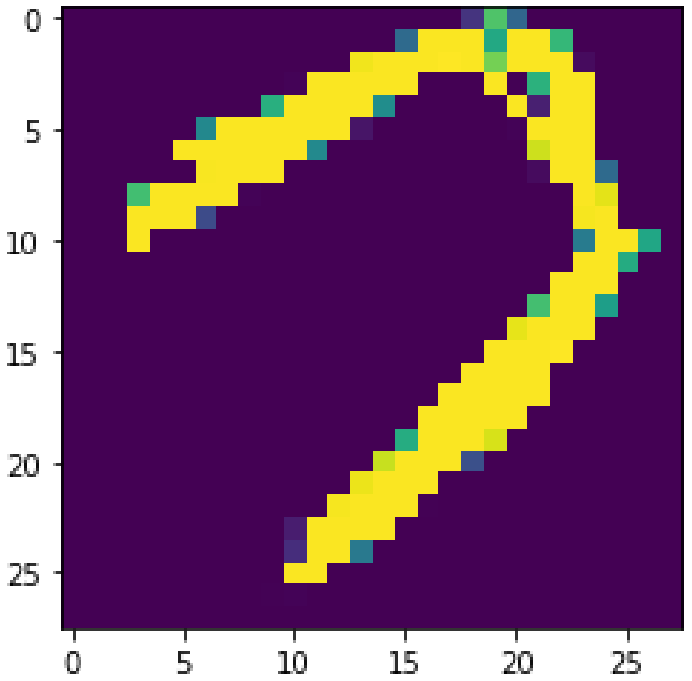
(array([0.09881388, 0.09752722, 0.09821551, 0.10697497, 0.10182809, 0.10083442, 0.10087133, 0.09974821, 0.09546809, 0.09971828]),)

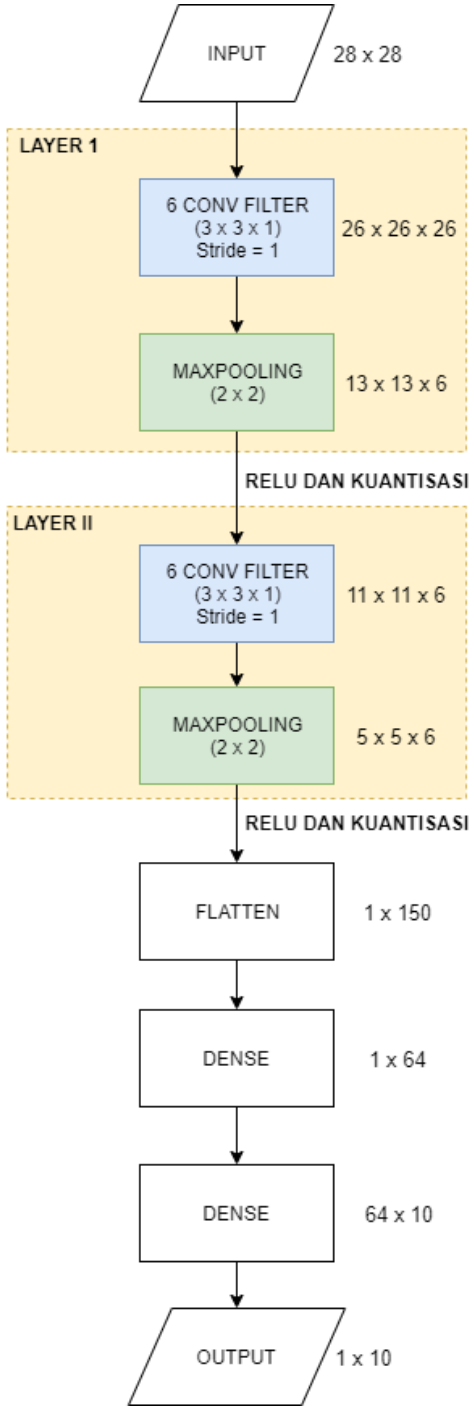
Testing with image from user

```
#Train from file Label 3

indata = timg3/255
res = Model2(indata.reshape(1,28,28))
plt.imshow(timg3)
print("Gambar ini diklasifikasikan sebagai :")
print(np.argmax(res))
```

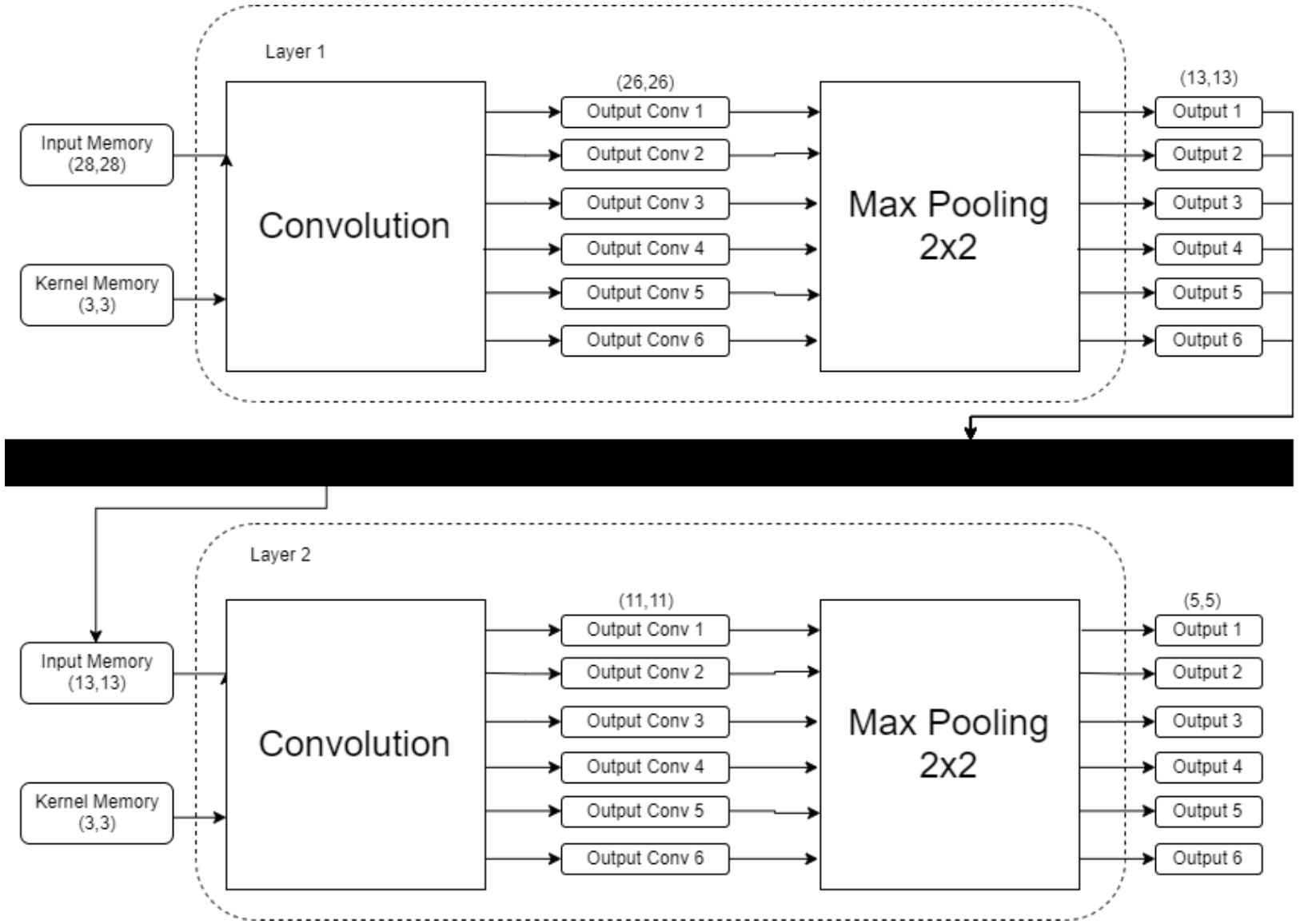
```
Gambar ini diklasifikasikan sebagai :
3
```



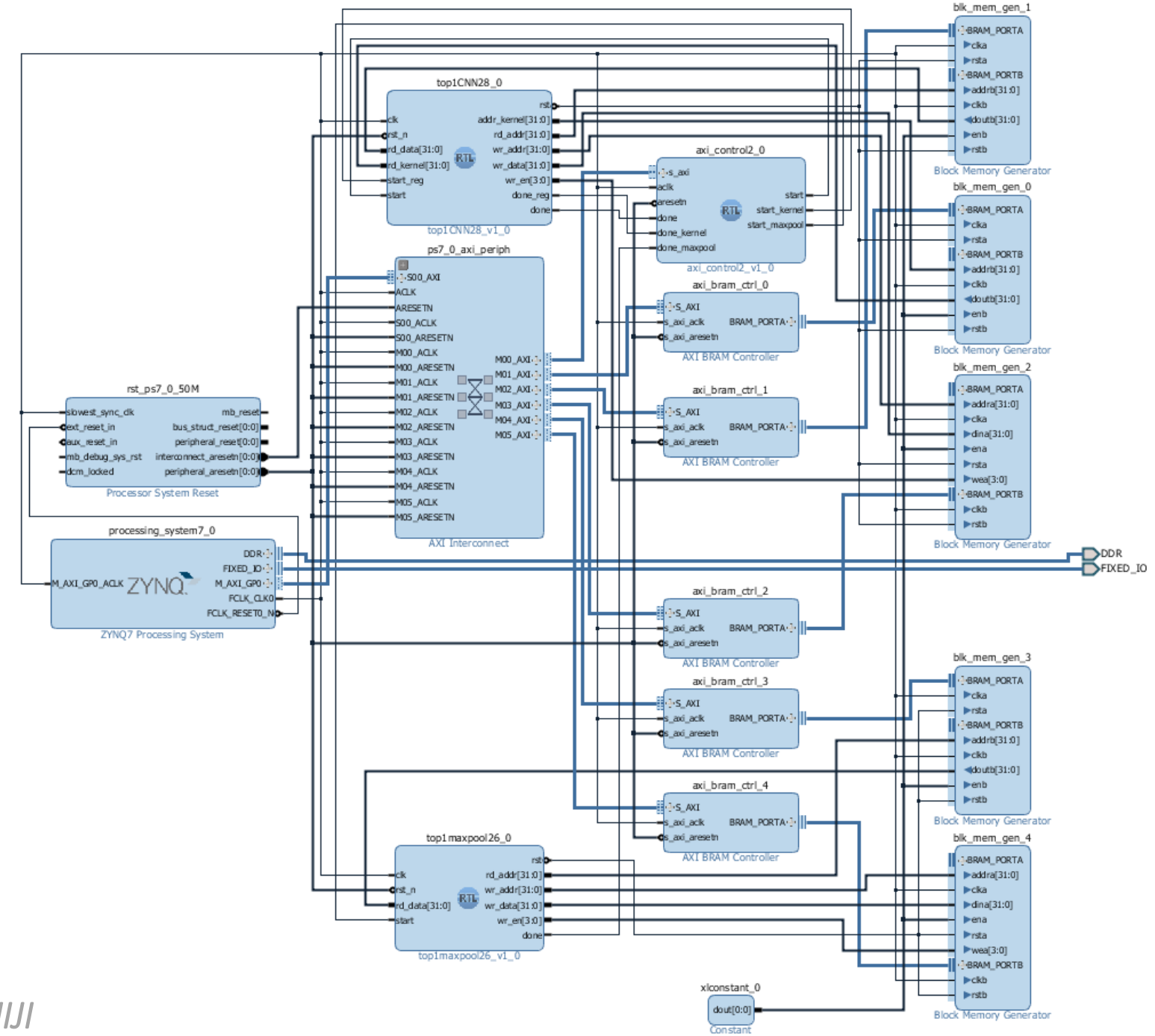

INPUT
28 x 28
LAYER 1
6 CONV FILTER
(3 x 3 x 1)
Stride = 1
26 x 26 x 26
MAXPOOLING
(2 x 2)
13 x 13 x 6
RELU DAN KUANTISASI
LAYER II
6 CONV FILTER
(3 x 3 x 1)
Stride = 1
11 x 11 x 6
MAXPOOLING
(2 x 2)
5 x 5 x 6
RELU DAN KUANTISASI
FLATTEN
1 x 150
DENSE
1 x 64
DENSE
64 x 10
OUTPUT
1 x 10

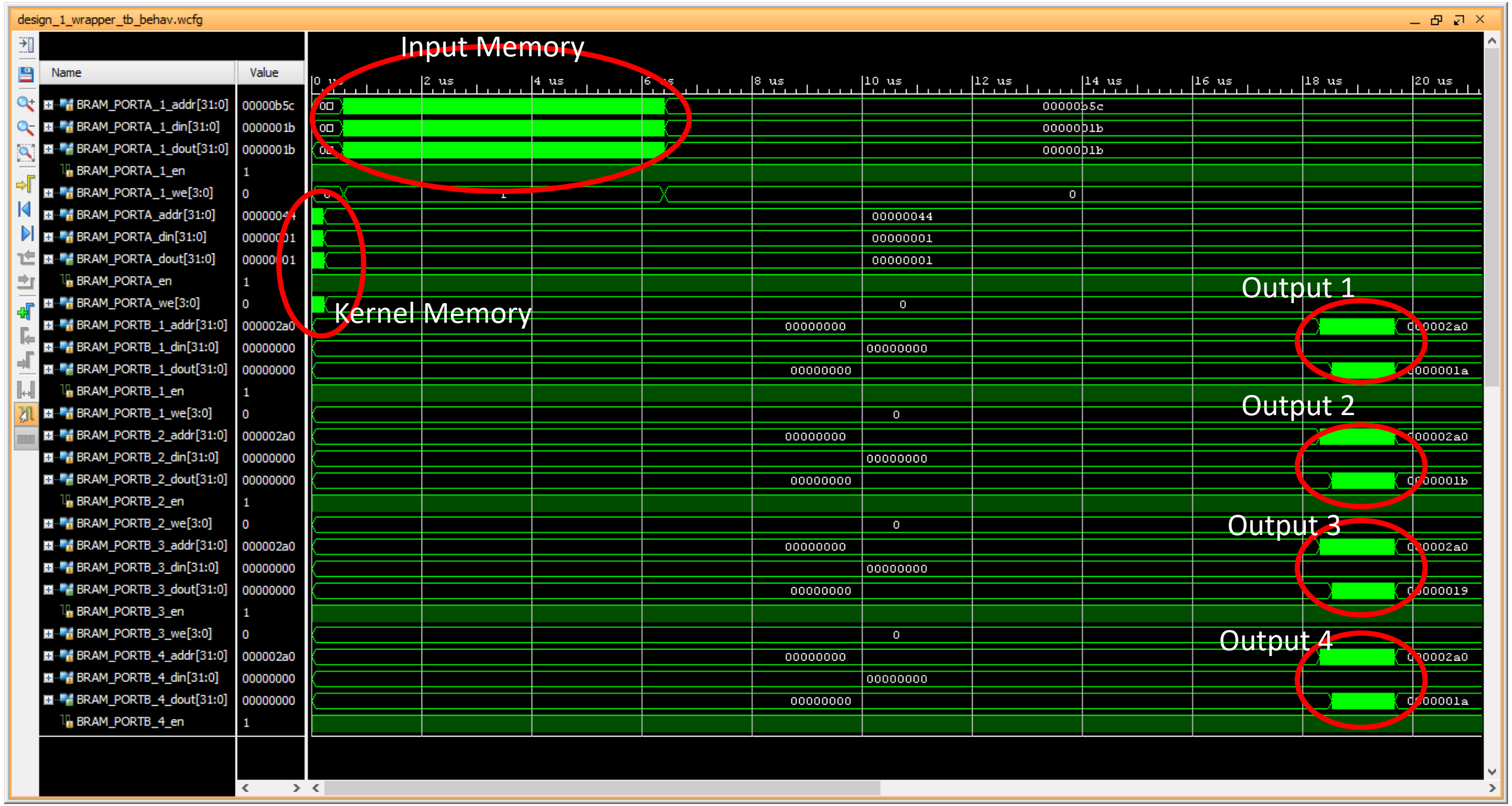
FLOWCHART

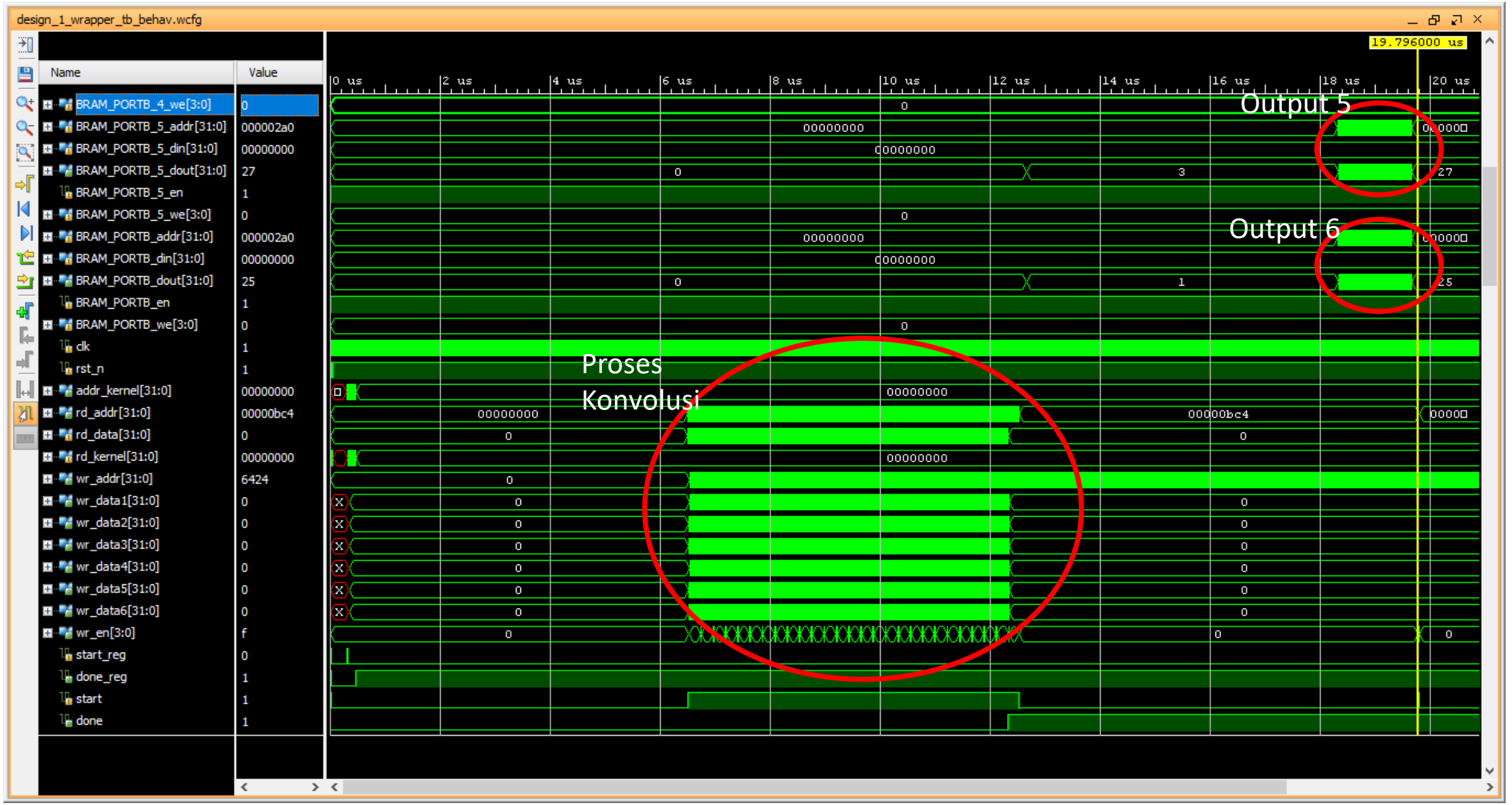
DESAIN 1 PARALLEL



BLOCK DIAGRAM


blk_mem_gen_1
BRAM_PORTA
clka
rsta
BRAM_PORTB
addrb[31:0]
clkb
doutb[31:0]
enb
rstb
Block Memory Generator
top1CNN28_0
rst
addr_kernel[31:0]
rd_addr[31:0]
wr_addr[31:0]
wr_data[31:0]
wr_en[3:0]
done_reg
done
clk
rst_n
rd_data[31:0]
rd_kernel[31:0]
start_reg
start
RTL
top1CNN28_v1_0
axi_control2_0
s_axi
aclk
aresetn
done
done_kernel
done_maxpool
start
start_kernel
start_maxpool
axi_control2_v1_0
blk_mem_gen_0
ps7_0_axi_periph
S00_AXI
ACLK
ARESETN
S00_ACLK
S00_ARESETN
M00_ACLK
M00_ARESETN
M01_ACLK
M01_ARESETN
M02_ACLK
M02_ARESETN
M03_ACLK
M03_ARESETN
M04_ACLK
M04_ARESETN
M05_ACLK
M05_ARESETN
M00_AXI
M01_AXI
M02_AXI
M03_AXI
M04_AXI
M05_AXI
AXI Interconnect
axi_bram_ctrl_0
S_AXI
s_axi_aclk
s_axi_aresetn
BRAM_PORTA
AXI BRAM Controller
axi_bram_ctrl_1
blk_mem_gen_2
addra[31:0]
dina[31:0]
ena
wea[3:0]
rst_ps7_0_50M
slowest_sync_clk
ext_reset_in
aux_reset_in
mb_debug_sys_rst
dcm_locked
mb_reset
bus_struct_reset[0:0]
peripheral_reset[0:0]
interconnect_aresetn[0:0]
peripheral_aresetn[0:0]
Processor System Reset
processing_system7_0
DDR
FIXED_IO
M_AXI_GP0
FCLK_CLK0
FCLK_RESET0_N
M_AXI_GP0_ACLK
ZYNQ
ZYNQ7 Processing System
DDR
FIXED_IO
axi_bram_ctrl_2
axi_bram_ctrl_3
blk_mem_gen_3
axi_bram_ctrl_4
blk_mem_gen_4
top1maxpool26_0
rd_addr[31:0]
wr_addr[31:0]
wr_data[31:0]
wr_en[3:0]
done
clk
rst_n
rd_data[31:0]
start
top1maxpool26_v1_0
xlconstant_0
dout[0:0]
Constant


design_1_wrapper_tb_behav.wcfg
Input Memory
Kernel Memory
Output 1
Output 2
Output 3
Output 4
Name
Value
BRAM_PORTA_1_addr[31:0]
BRAM_PORTA_1_din[31:0]
BRAM_PORTA_1_dout[31:0]
BRAM_PORTA_1_en
BRAM_PORTA_1_we[3:0]
BRAM_PORTA_addr[31:0]
BRAM_PORTA_din[31:0]
BRAM_PORTA_dout[31:0]
BRAM_PORTA_en
BRAM_PORTA_we[3:0]
BRAM_PORTB_1_addr[31:0]
BRAM_PORTB_1_din[31:0]
BRAM_PORTB_1_dout[31:0]
BRAM_PORTB_1_en
BRAM_PORTB_1_we[3:0]
BRAM_PORTB_2_addr[31:0]
BRAM_PORTB_2_din[31:0]
BRAM_PORTB_2_dout[31:0]
BRAM_PORTB_2_en
BRAM_PORTB_2_we[3:0]
BRAM_PORTB_3_addr[31:0]
BRAM_PORTB_3_din[31:0]
BRAM_PORTB_3_dout[31:0]
BRAM_PORTB_3_en
BRAM_PORTB_3_we[3:0]
BRAM_PORTB_4_addr[31:0]
BRAM_PORTB_4_din[31:0]
BRAM_PORTB_4_dout[31:0]
BRAM_PORTB_4_en
2 us
4 us
8 us
10 us
12 us
14 us
16 us
18 us
20 us


design_1_wrapper_tb_behav.wcfg
Name
Value
BRAM_PORTB_4_we[3:0] 0
BRAM_PORTB_5_addr[31:0] 000002a0
BRAM_PORTB_5_din[31:0] 00000000
BRAM_PORTB_5_dout[31:0] 27
BRAM_PORTB_5_en 1
BRAM_PORTB_5_we[3:0] 0
BRAM_PORTB_addr[31:0] 000002a0
BRAM_PORTB_din[31:0] 00000000
BRAM_PORTB_dout[31:0] 25
BRAM_PORTB_en 1
BRAM_PORTB_we[3:0] 0
clk 1
rst_n 1
addr_kernel[31:0] 00000000
rd_addr[31:0] 00000bc4
rd_data[31:0] 0
rd_kernel[31:0] 00000000
wr_addr[31:0] 6424
wr_data1[31:0] 0
wr_data2[31:0] 0
wr_data3[31:0] 0
wr_data4[31:0] 0
wr_data5[31:0] 0
wr_data6[31:0] 0
wr_en[3:0] f
start_reg 0
done_reg 1
start 1
done 1
19.796000 us
0 us
2 us
4 us
6 us
8 us
10 us
12 us
14 us
16 us
18 us
20 us
Output 5
Output 6
Proses
Konvolusi

```
Connected to COM16 at 115200
00000000
filter 1: 000001 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
filter 2: 000000 | 000001 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
filter 3: 000000 | 000000 | 000001 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
filter 4: 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000001 | 000000 | 000000 |
filter 5: 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000001 | 000000 |
filter 6: 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000001 |

Kernel:
filter 1: 010000 | 000000 | 000000 |
filter 2: 000100 | 000000 | 000000 |
filter 3: 000001 | 000000 | 000000 |
filter 4: 000000 | 000000 | 010000 |
filter 5: 000000 | 000000 | 000100 |
filter 6: 000000 | 000000 | 000001 |
00000008
00000008

Input:
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
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000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
0000000a
0000002a
```

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Output 1:
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000b | 00000d | 00000f | 000011 | 000013 | 000015 | 000017 | 000019 |

Output 2:
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
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Output 3:
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000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
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000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
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Output 4:
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
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000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
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Output 5:
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Output 6:
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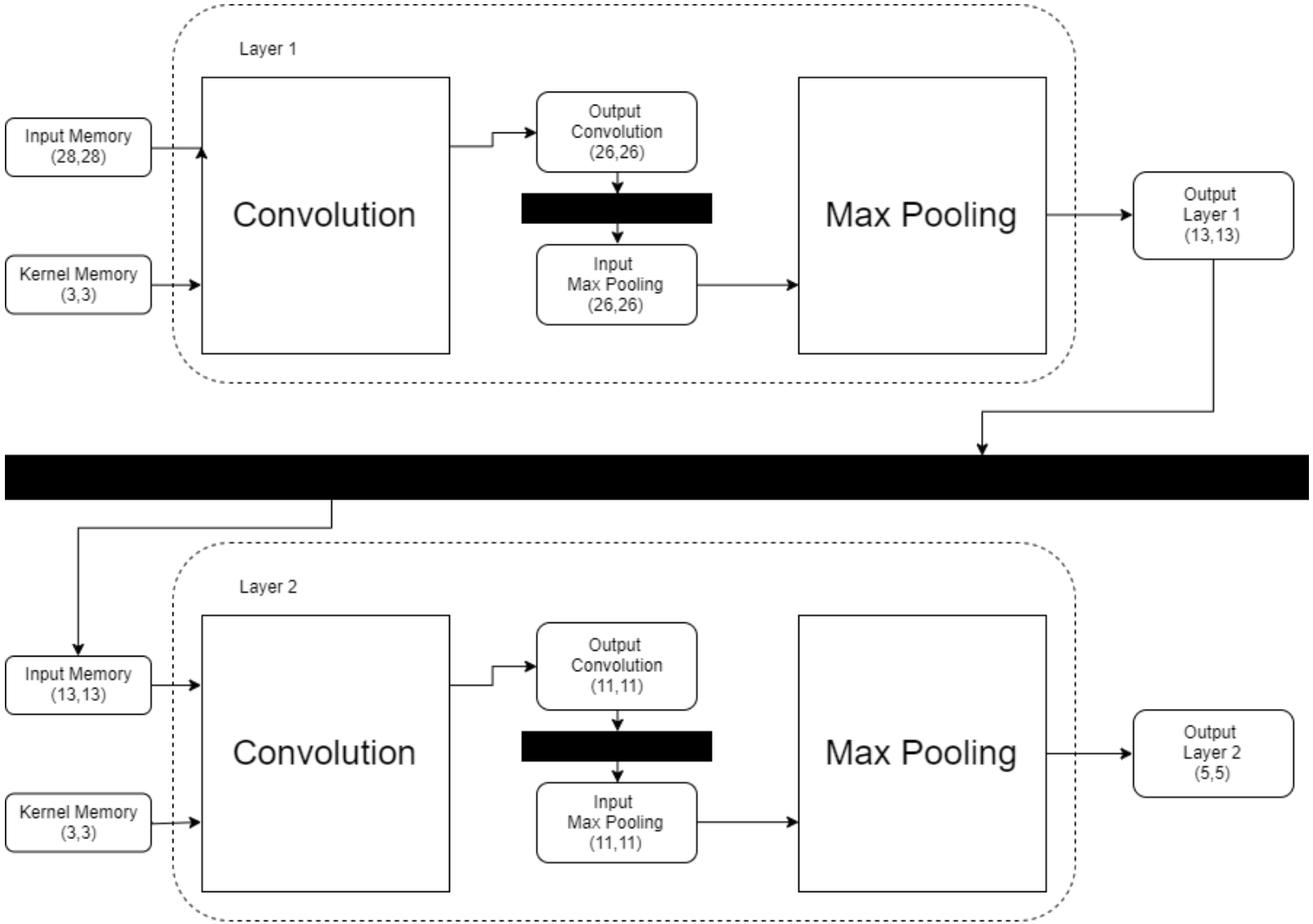
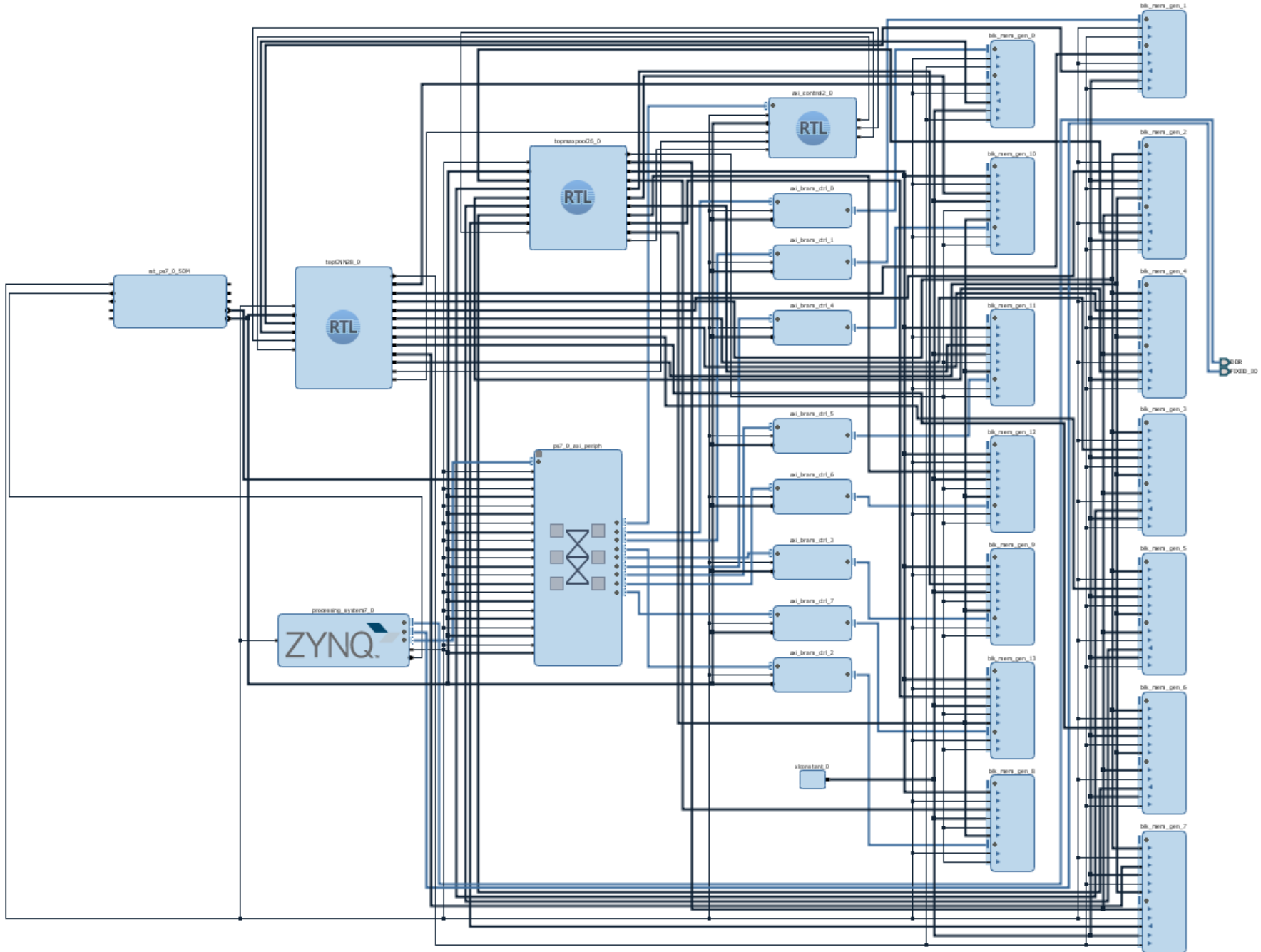
```

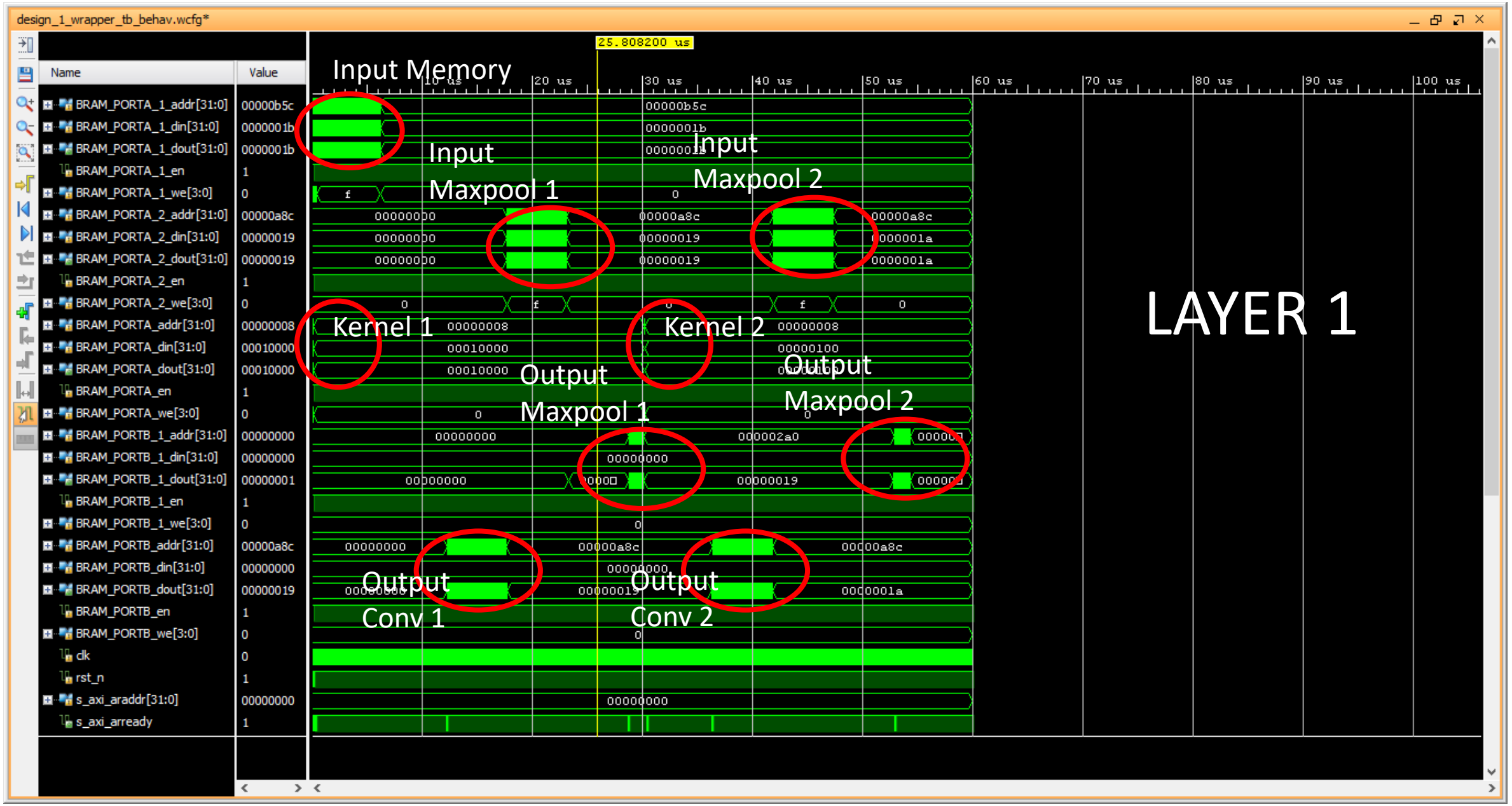
DESAIN 2

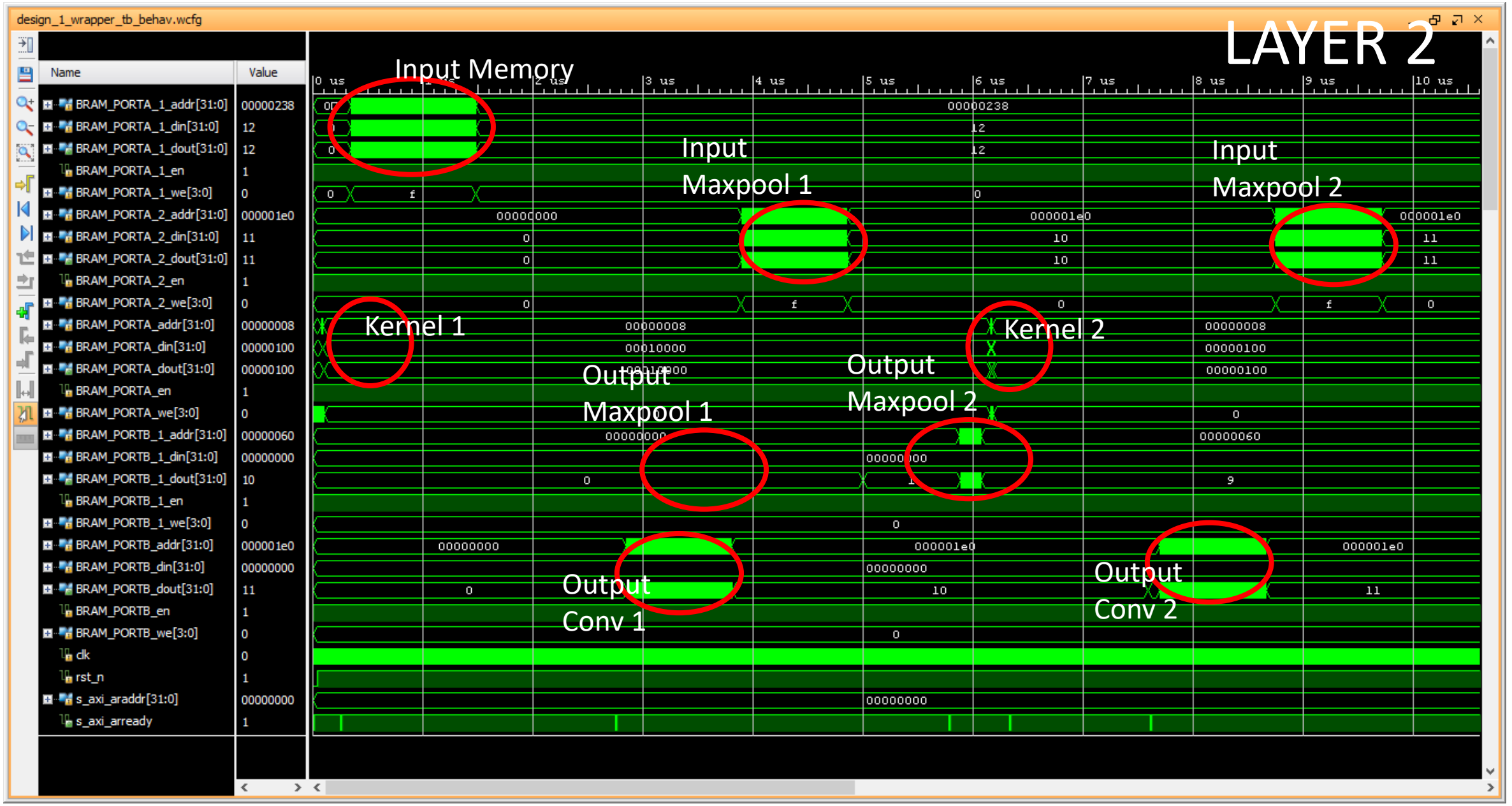


BLOCK DIAGRAM



APLIKASI DETEKSI KUZUSHIJI


design_1_wrapper_tb_behav.wcfg*
Name
Value
BRAM_PORTA_1_addr[31:0] 00000b5c
BRAM_PORTA_1_din[31:0] 0000001b
BRAM_PORTA_1_dout[31:0] 0000001b
BRAM_PORTA_1_en 1
BRAM_PORTA_1_we[3:0] 0
BRAM_PORTA_2_addr[31:0] 00000a8c
BRAM_PORTA_2_din[31:0] 00000019
BRAM_PORTA_2_dout[31:0] 00000019
BRAM_PORTA_2_en 1
BRAM_PORTA_2_we[3:0] 0
BRAM_PORTA_addr[31:0] 00000008
BRAM_PORTA_din[31:0] 00010000
BRAM_PORTA_dout[31:0] 00010000
BRAM_PORTA_en 1
BRAM_PORTA_we[3:0] 0
BRAM_PORTB_1_addr[31:0] 00000000
BRAM_PORTB_1_din[31:0] 00000000
BRAM_PORTB_1_dout[31:0] 00000001
BRAM_PORTB_1_en 1
BRAM_PORTB_1_we[3:0] 0
BRAM_PORTB_addr[31:0] 00000a8c
BRAM_PORTB_din[31:0] 00000000
BRAM_PORTB_dout[31:0] 00000019
BRAM_PORTB_en 1
BRAM_PORTB_we[3:0] 0
clk 0
rst_n 1
s_axi_araddr[31:0] 00000000
s_axi_aready 1
25.808200 us
10 us
20 us
30 us
40 us
50 us
60 us
70 us
80 us
90 us
100 us
Input Memory
Input Maxpool 1
Input Maxpool 2
Kernel 1
Kernel 2
Output Maxpool 1
Output Maxpool 2
Output Conv 1
Output Conv 2
LAYER 1


design_1_wrapper_tb_behav.wcfg
LAYER 2
Input Memory
Input Maxpool 1
Input Maxpool 2
Kernel 1
Kernel 2
Output Maxpool 1
Output Maxpool 2
Output Conv 1
Output Conv 2
Name
Value
BRAM_PORTA_1_addr[31:0]
BRAM_PORTA_1_din[31:0]
BRAM_PORTA_1_dout[31:0]
BRAM_PORTA_1_en
BRAM_PORTA_1_we[3:0]
BRAM_PORTA_2_addr[31:0]
BRAM_PORTA_2_din[31:0]
BRAM_PORTA_2_dout[31:0]
BRAM_PORTA_2_en
BRAM_PORTA_2_we[3:0]
BRAM_PORTA_addr[31:0]
BRAM_PORTA_din[31:0]
BRAM_PORTA_dout[31:0]
BRAM_PORTA_en
BRAM_PORTA_we[3:0]
BRAM_PORTB_1_addr[31:0]
BRAM_PORTB_1_din[31:0]
BRAM_PORTB_1_dout[31:0]
BRAM_PORTB_1_en
BRAM_PORTB_1_we[3:0]
BRAM_PORTB_addr[31:0]
BRAM_PORTB_din[31:0]
BRAM_PORTB_dout[31:0]
BRAM_PORTB_en
BRAM_PORTB_we[3:0]
clk
rst_n
s_axi_araddr[31:0]
s_axi_arready

```
Input:
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |

Kernel 1:
010000 | 000000 | 000000 |
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```

```
Output CNN:
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000001 | 000002 | 000003 | 000004 | 000005 | 000006 | 000007 | 000008 | 000009 | 00000a | 00000b | 00000c | 00000d |
000010 | 000011 | 000012 | 000013 | 000014 | 000015 | 000016 | 000017 | 000018 | 000019 | 00001a | 00001b | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
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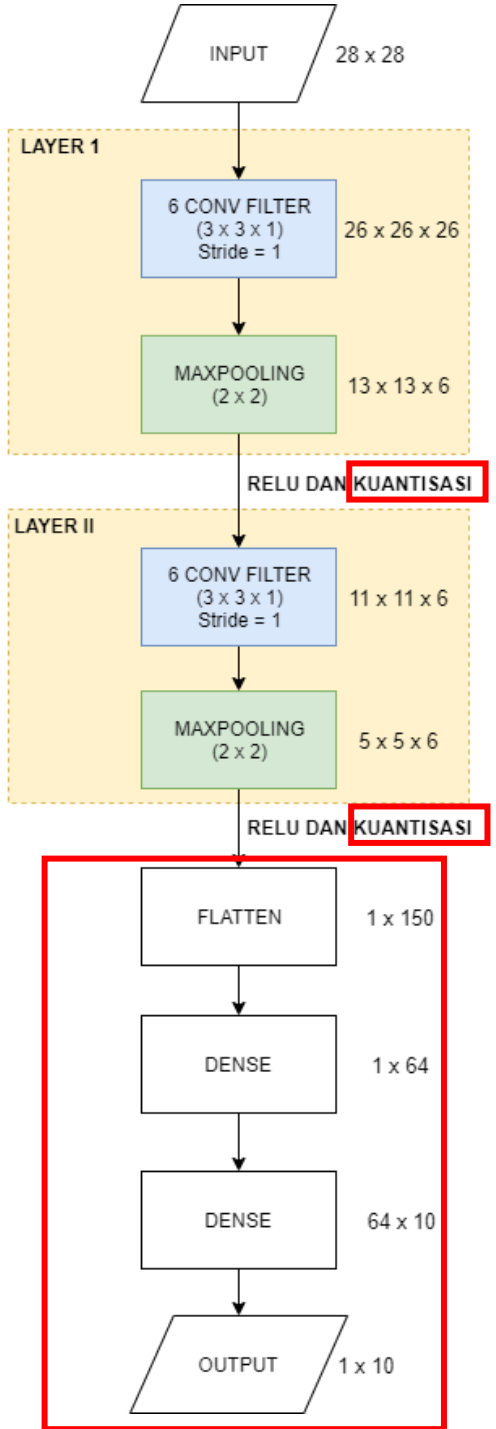
```

Software Xilink SDK (C)

Bagian yang dibuat di software
ditandai dengan kotak merah



```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include "weights.h"
#include "cnnfunction.h"
#include "data.h"       //untuk simulasi

int main(void)
{
   //Output Layer
   float layer_3_out[64];
   float layer_last_out[10];
   float result[10];
   int hasil;
   float max_hasil=0;
   //Konstanta pengali untuk output layer sebelum masuk kuantisasi  untuk input testing gambar 3
   float Scale_w1 =0.0032400540479524866;
   float Scale_d1 =0.007874015748031496;
   float Scale_w2 =0.004680760732785923;
   float Scale_d2=0;
   float Scale_w3 =0.006520035698657899;
   float Scale_d3=0;
   float Scale_w4 =0.005369161526987872;
   float Scale_d4=0;
   //Variabel input layer terkuantisasi
   //sebelum masuk layer 2
   int quantized_d2[6*13*13];
   int quantized_d3[150];     //sebelum masuk layer 3
   int quantized_d4[64];      //sebelum masuk layer 4
   float flat[150];
   int i,j,k;
   //Keluaran layer 1 dari HW (abis max pooling) masuk ke pengali skala
   scale3D(layer_1_out,Scale_d1,Scale_w1,1);
   // Kuantisasi Output Layer 2
   kuantisasi_float3d(layer_1_out,7,quantized_d2,6,13,13,&Scale_d2);
   // Passing ke HW hasil kuantisasi
   // Keluaran layer 2 dari HW (abis max pooling) masuk ke pengali skala
   scale3D(layer_2_out,Scale_d2,Scale_w2,2);
   int count=0;
   //Flatten
   for(i=0;i<5;i++){
      for(j=0;j<5;j++){
         for(k=0;k<6;k++){
            flat[count] = layer_2_out[i*5+j+k*25];
            count++;
         }
      }
   }
   //Quantize Flatten
   kuantisasi_float1d(flat,7,quantized_d3,150,&Scale_d3);
   //Perhitungan Layer 3 (Dense 1)
   matmul(quantized_d3,quantized_w3,150,64,Scale_d3,Scale_w3,layer_3_out);
   //Kuantisasi Output Layer 3
   kuantisasi_float1d(layer_3_out,7,quantized_d4,64,&Scale_d4);
   //Perhitungan Layer Output (Dense 2)

matmul(quantized_d4,quantized_w4,64,10,Scale_d4,Scale_w4,layer_last_out);
   softmax(layer_last_out,result);
   printf("\nProbabilitas setiap kelas :\n");
   for(i=0;i<10;i++){
      if(result[i] > max_hasil){
         hasil = i;
         max_hasil = result[i];
      }
      printf("Kelas ke-%d : ",i);
      printf("%.4f\n", result[i]);
   }
   printf("Jadi gambar ini di klasifikasikan menjadi kelas = %d\n",hasil);
}
```


main.c

```c
#include <math.h>
//Fungsi kuantisasi untuk matriks 3 dimensi
void kuantisasi_float3d(float *data_lama, int bits,int* output,int length1, int
length2, int length3,float *scale){
                        float max, min, temp;
                        float range_real;
                        int data_baru;
                        int l,m,n;
  // float scale;
  max = 0;
  min = 9999;
  //Cari maksimum
                        for ( l =0; l<length1; l++){
    for ( m =0; m<length2; m++){
      for(n=0;n<length3;n++){
        if (*(data_lama + n + (m*length3) + (l*length2*length3)) > max){
          max = *(data_lama + n + (m*length3) + (l*length2*length3));
        }
      }
    }
                        }
  //Cari minimum
                        for ( l =0; l<length1; l++){
    for ( m =0; m<length2; m++){
      for(n=0;n<length3;n++){
        if (*(data_lama + n + (m*length3) + (l*length2*length3)) < min){
          min = *(data_lama + n + (m*length3) + (l*length2*length3));
        }
      }
    }
                        }
  //Cari Range
                        range_real = max - min;
                        if (range_real == 0)
  {
    range_real = 1;
  }
  //Cari Skala
                        *(scale) = (range_real/(pow(2,bits)-1));
  //Kuantisasi
                        for ( l =0; l<length1; l++){
    for ( m =0; m<length2; m++){
      for(n=0;n<length3;n++){
                                                *(output + n +
(m*length3) + (l*length2*length3)) = round(*(data_lama + n + (m*length3) +
(l*length2*length3))/(*(scale)));
                                }
    }
                        }
}
```



```c
//Fungsi untuk kuantisasi matriks 1 dimensi (sesudah flattening)
void kuantisasi_float1d(float *data_lama, int bits, int *output, int length1,float *scale){
                        float max, min;
                        float range_real;
                        int data_baru;
                        int l,m,n;
  // float scale;
  max = 0;
  min = 9999;
  //Cari maximum
                        for (l=0;l<length1;l++){
    if (*(data_lama + l) > max){
      max = *(data_lama + l);
    }
                        }
                        for ( l=0;l<length1; l++){
    if (*(data_lama + l)< min){
      min = *(data_lama + l);
    }
                        }
  //Cari Range
                        range_real = max - min;
                        if(range_real == 0){
    range_real = 1;
  }
  //Cari Skala
                        *(scale) = (range_real/(pow(2,bits)-1));
                        //Kuantisasi
                        for ( l =0; l<length1; l++){
    *(output + l) = round(*(data_lama + l)/(*(scale)));
                        }
}

//Fungsi softmax
void softmax(float layer_last_out[10], float *output){
  float expo[10]= {0};
  float expo_sum=0;
  for(int i = 0;i<10;i++){
    expo[i]=exp(layer_last_out[i]);
    expo_sum += expo[i];
  }
  for(int i = 0;i<10;i++){
    *(output + i) = expo[i]/expo_sum;
  }
}

//Fungsi Rectifier Linear Unit
void relu(float *input){
  if(*input<0){
    *input=0;
  }
}
```

```c
//Fungsi Matrix Multiplication
void matmul(int *quantized_d, int *quantized_w, int sizein, int sizeout, float
Scale_d, float Scale_w, float *out){
  int i,j;
  for(i=0;i<sizeout;i++){
    float temp = 0;
    for(j=0;j<sizein;j++){
      temp = temp + (*(quantized_d + j) * *(quantized_w + i + (j * sizeout)));
    }
    if(sizein == 150){
      relu(&temp);
      *(out + i) = temp * Scale_d * Scale_w;
    }
    else{
      *(out + i) =  temp * Scale_d * Scale_w;
    }
  }
}

//Fungsi Perkalian Skalar
void scale3D(float *input, float scale_d, float scale_w,int layer){
  int l,m,n;
  int length1,length2,length3;
  if (layer == 1){
    length1= 6;
    length2= 13;
    length3= 13;
  }
  else if(layer ==2){
    length1= 6;
    length2= 5;
    length3= 5;
  }
  for(l=0;l<length1;l++){
    for(m=0;m<length2;m++){
      for(n=0;n<length3;n++){
        *(input + n + (m*length3) + (l*length3*length2)) = *(input + n +
(m*length3) + (l*length3*length2)) * scale_d * scale_w;
      }
    }
  }
}
```

Quantized_d2 dari input keluaran dari layer 1 di zybo

main.c

```
[Running] cd "c:\Users\rober\OneDrive\Tubes\" && gcc helloworld.c -o helloworld && "c:\Users\rober\OneDrive\Tubes\"helloworld
0	0	0	0	1	49	49	16	17	20	76	58	0
0	0	23	51	31	13	0	15	0	0	25	82	0
0	1	26	16	0	13	5	0	0	0	0	82	1
1	35	0	0	11	5	0	0	0	0	0	73	10
0	0	4	13	0	0	0	0	0	0	0	80	58
0	12	0	0	0	0	0	0	0	1	1	39	15
0	0	0	0	0	0	0	0	1	12	0	28	3
0	0	0	0	0	0	0	1	1	0	47	18	0
0	0	0	0	0	0	1	1	0	0	33	0	0
0	0	0	0	0	1	14	0	0	18	0	0	0
0	0	0	0	5	1	0	18	10	0	0	0	0
0	0	0	0	0	0	14	18	0	0	0	0	0
0	0	0	0	0	11	4	0	0	0	0	0	0
```

```
0	0	0	0	24	40	52	70	91	85	99	57	0
0	0	31	42	70	104	108	109	83	105	93	85	0
0	24	87	121	102	108	88	8	0	41	116	94	1
17	84	96	109	107	29	0	0	0	38	75	94	34
24	109	109	48	0	0	0	0	0	0	53	106	76
42	25	0	0	0	0	0	0	0	17	53	104	95
0	0	0	0	0	0	0	0	24	42	97	111	31
0	0	0	0	0	0	0	24	54	121	127	67	0
0	0	0	0	0	0	15	53	120	121	69	0	0
0	0	0	0	0	23	38	95	106	108	17	0	0
0	0	0	0	25	53	103	111	77	4	0	0	0
0	0	0	0	54	99	109	67	0	0	0	0	0
0	0	0	0	66	92	27	0	0	0	0	0	0
```

```
0	0	0	0	0	0	0	0	0	0	0	48	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	17
0	0	0	0	0	0	0	0	0	0	0	0	25
0	0	0	0	0	0	0	0	0	0	0	0	11
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
```

Tensorflow

```
[[[  0.   0.   0.   0.   1.  49.  49.  16.  17.  20.  76.  58.   0.]
  [  0.   0.  23.  51.  31.  13.   0.  15.   0.   0.  25.  82.   0.]
  [  0.   1.  26.  16.   0.  13.   5.   0.   0.   0.   0.  82.   1.]
  [  1.  35.   0.   0.  11.   5.   0.   0.   0.   0.   0.  73.  10.]
  [  0.   0.   4.  13.   0.   0.   0.   0.   0.   0.   0.  80.  58.]
  [  0.  12.   0.   0.   0.   0.   0.   0.   0.   1.   1.  39.  15.]
  [  0.   0.   0.   0.   0.   0.   0.   0.   1.  12.   0.  28.   3.]
  [  0.   0.   0.   0.   0.   0.   0.   1.   1.   0.  47.  18.   0.]
  [  0.   0.   0.   0.   0.   0.   1.   1.   0.   0.  33.   0.   0.]
  [  0.   0.   0.   0.   0.   1.  14.   0.   0.  18.   0.   0.   0.]
  [  0.   0.   0.   0.   5.   1.   0.  18.  10.   0.   0.   0.   0.]
  [  0.   0.   0.   0.   0.   0.  14.  18.   0.   0.   0.   0.   0.]
  [  0.   0.   0.   0.   0.  11.   4.   0.   0.   0.   0.   0.   0.]]
```

```
[[  0.   0.   0.   0.  24.  40.  52.  70.  91.  85.  99.  57.   0.]
 [  0.   0.  31.  42.  70. 104. 108. 109.  83. 105.  93.  85.   0.]
 [  0.  24.  87. 121. 102. 108.  88.   8.   0.  41. 116.  94.   1.]
 [ 17.  84.  96. 109. 107.  29.   0.   0.   0.  38.  75.  94.  34.]
 [ 24. 109. 109.  48.   0.   0.   0.   0.   0.   0.  53. 106.  76.]
 [ 42.  25.   0.   0.   0.   0.   0.   0.   0.  17.  53. 104.  95.]
 [  0.   0.   0.   0.   0.   0.   0.   0.  24.  42.  97. 111.  31.]
 [  0.   0.   0.   0.   0.   0.   0.  24.  54. 121. 127.  67.   0.]
 [  0.   0.   0.   0.   0.   0.  15.  53. 120. 121.  69.   0.   0.]
 [  0.   0.   0.   0.   0.  23.  38.  95. 106. 108.  17.   0.   0.]
 [  0.   0.   0.   0.  25.  53. 103. 111.  77.   4.   0.   0.   0.]
 [  0.   0.   0.   0.  54.  99. 109.  67.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.  66.  92.  27.   0.   0.   0.   0.   0.   0.]]
```

```
[[  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.  48.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.  17.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.  25.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.  11.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]]
```

Quantized_d3 hasil dari flattening dan keluaran zybo dari layer 2 :

main.c

```
[Running] cd "c:\Users\rober\OneDrive\Tubes\" && gcc helloworld.c -o helloworld && "c:\Users\rober\OneDrive\Tubes\"helloworld
0       0       127     0       24      65      0       0       122     0       43      0       62      17
73      0       93      0       51      81      0       0       80      0       42      0       0       0
95      0       30      5       83      0       61      0       71      45      0       0       90      0
80      47      0       0       83      0       39      53      4       0       38      25      0       10
6       0       36      55      86      45      0       0       56      0       88      35      0       0
34      0       0       0       17      0       0       26      0       0       74      0       15      90
0       0       99      0       35      86      0       0       0       0       0       0       0       0
17      0       0       26      0       0       54      0       13      75      0       0       114     0
16      96      26      0       89      0       89      0       0       0       0       0       0       0
0       0       47      0       30      88      0       0       105     0       16      76      7       0
64      0       76      0       51      57      0       0       99      0
```

Tensorflow

```
[  0.   0. 127.   0.  24.  65.   0.   0. 122.   0.  43.   0.  62.  17.
  73.   0.  93.   0.  51.  81.   0.   0.  80.   0.  42.   0.   0.   0.
  95.   0.  30.   5.  83.   0.  61.   0.  71.  45.   0.   0.  90.   0.
  80.  47.   0.   0.  83.   0.  39.  53.   4.   0.  38.  25.   0.  10.
   6.   0.  36.  55.  86.  45.   0.   0.  56.   0.  88.  35.   0.   0.
  34.   0.   0.   0.  17.   0.   0.  26.   0.   0.  74.   0.  15.  90.
   0.   0.  99.   0.  35.  86.   0.   0.   0.   0.   0.   0.   0.   0.
  17.   0.   0.  26.   0.   0.  54.   0.  13.  75.   0.   0. 114.   0.
  16.  96.  26.   0.  89.   0.  89.   0.   0.   0.   0.   0.   0.   0.
   0.   0.  47.   0.  30.  88.   0.   0. 105.   0.  16.  76.   7.   0.
  64.   0.  76.   0.  51.  57.   0.   0.  99.   0.]
```

Hasil Klasifikasi

```
[Running] cd "c:\Users\rober\OneDrive\Tubes\" && gcc helloworld.c -o helloworld && "c:\Users\rober\OneDrive\Tubes\"helloworld

Probabilitas setiap kelas :
Kelas ke-0 : 0.0988
Kelas ke-1 : 0.0975
Kelas ke-2 : 0.0982
Kelas ke-3 : 0.1070
Kelas ke-4 : 0.1018
Kelas ke-5 : 0.1008
Kelas ke-6 : 0.1009
Kelas ke-7 : 0.0997
Kelas ke-8 : 0.0955
Kelas ke-9 : 0.0997
Jadi gambar ini di klasifikasikan menjadi kelas = 3

[Done] exited with code=0 in 1.556 seconds
```

```
Kernel:
filter 1: 010101 | 010101 | 010101 |
filter 2: 000100 | 000000 | 000000 |
filter 3: 010001 | 000100 | 010001 |
filter 4: 010000 | 010000 | 010000 |
filter 5: 000100 | 000100 | 000100 |
filter 6: 000001 | 000001 | 000001 |
00000008

Input:
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |

000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
000000 | 010101 | 020202 | 030303 | 040404 | 050505 | 060606 | 070707 | 080808 | 090909 | 0a0a0a | 0b0b0b | 0c0c0c | 0d0d0d | 0e0e0e | 0f0f0f | 101010 | 111111 | 121212 | 131313 | 141414 | 151515 | 161616 | 171717 | 181818 | 191919 | 1a1a1a | 1b1b1b |
0000000b
00000038

Output 6:
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 | 000000 |
```

```
000008 | 00000c | 000010 | 00001c | 000020 | 000024 | 000028 | 00002c | 000004 | 000008 | 00000c | 000010 | 000014 |
000018 | 00001c | 000020 | 00002c | 000030 | 000034 | 000004 | 000008 | 000014 | 000018 | 00001c | 000020 | 00002c |
000028 | 00002c | 000030 | 000008 | 00000c | 000010 | 000014 | 000018 | 000024 | 000028 | 00002c | 000030 | 000008 |
000004 | 000008 | 00000c | 000018 | 00001c | 000020 | 000024 | 000030 | 000034 | 000004 | 000008 | 00000c | 000018 |
000014 | 000018 | 000024 | 000028 | 00002c | 000030 | 000034 | 00000c | 000010 | 000014 | 000018 | 00001c | 000028 |
000024 | 000028 | 000034 | 000004 | 000008 | 00000c | 000010 | 00001c | 000020 | 000024 | 000028 | 00002c | 000004 |
000034 | 000004 | 000010 | 000014 | 000018 | 00001c | 000020 | 00002c | 000030 | 000034 | 000004 | 000008 | 000014 |
000010 | 000014 | 000020 | 000024 | 000028 | 00002c | 000030 | 000008 | 00000c | 000010 | 000014 | 000020 | 000024 |
000020 | 000024 | 000030 | 000034 | 000004 | 000008 | 000014 | 000018 | 00001c | 000020 | 000024 | 000030 | 000034 |
000030 | 000008 | 00000c | 000010 | 000014 | 000018 | 000024 | 000028 | 00002c | 000030 | 000034 | 00000c | 000010 |
00000c | 000018 | 00001c | 000020 | 000024 | 000028 | 000034 | 000004 | 000008 | 00000c | 000010 | 00001c | 000020 |

Output 4:
000001 | 000007 | 000009 | 00000b | 00000d | 00000f | 000015 | 000017 | 000019 | 000001 | 000007 | 000009 | 00000b |
000009 | 00000f | 000011 | 000013 | 000015 | 000017 | 000003 | 000005 | 000007 | 000009 | 00000b | 000011 | 000013 |
000011 | 000017 | 000019 | 000001 | 000003 | 000005 | 00000b | 00000d | 00000f | 000011 | 000017 | 000019 | 000001 |
000019 | 000005 | 000007 | 000009 | 00000b | 000011 | 000013 | 000015 | 000017 | 000019 | 000005 | 000007 | 000009 |
00000b | 00000d | 00000f | 000011 | 000013 | 000019 | 000001 | 000003 | 000005 | 000007 | 00000d | 00000f | 000011 |
000013 | 000015 | 000017 | 000019 | 000001 | 000007 | 000009 | 00000b | 00000d | 00000f | 000015 | 000017 | 000019 |
000001 | 000003 | 000005 | 000007 | 000009 | 00000f | 000011 | 000013 | 000015 | 000017 | 000003 | 000005 | 000007 |
000009 | 00000b | 00000d | 00000f | 000011 | 000017 | 000019 | 000001 | 000003 | 000005 | 00000b | 00000d | 00000f |
000011 | 000013 | 000015 | 000017 | 000003 | 000005 | 000007 | 000009 | 00000b | 000011 | 000013 | 000015 | 000017 |
000019 | 000001 | 000003 | 000005 | 00000b | 00000d | 00000f | 000011 | 000013 | 000019 | 000001 | 000003 | 000005 |
000007 | 000009 | 00000b | 00000d | 000013 | 000015 | 000017 | 000019 | 000001 | 000007 | 000009 | 00000b | 00000d |
00000f | 000011 | 000013 | 000015 | 000001 | 000003 | 000005 | 000007 | 000009 | 00000f | 000011 | 000013 | 000015 |
000017 | 000019 | 000001 | 000003 | 000009 | 00000b | 00000d | 00000f | 000011 | 000017 | 000019 | 000001 | 000003 |

Output 3:
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Output 1:
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------------[ cut here ]------------
Kernel BUG at c025fc90 [verbose debug info unavailable]
Internal error: Oops - BUG: 0 [#1] PREEMPT SMP ARM
Modules linked in:
CPU: 1 PID: 21 Comm: kworker/1:1 Not tainted 3.10.0-xilinx-14974-gb286654-dirty #12
Workqueue: events phy_state_machine
task: de098480 ti: de0e6000 task.ti: de0e6000
PC is at mdiobus_read+0x30/0x68
LR is at 0xde0e7ec8
pc : [<c025fc90>]    lr : [<de0e7ec8>]    psr: 20000013
sp : de0e7ec8  ip : de0e6008  fp : 00000000
r10: ddb4b5f4  r9 : 00000000  r8 : 00000000
r7 : 00000001  r6 : 00000001  r5 : de0e6000  r4 : ddb4b800
r3 : 07ffff00  r2 : fffffffe  r1 : 07fffffe  r0 : ddb4b800
Flags: nzCv  IRQs on  FIQs on  Mode SVC_32  ISA ARM  Segment kernel
Control: 18c5387d  Table: 1d94004a  DAC: 00000015
Process kworker/1:1 (pid: 21, stack limit = 0xde0e6238)
Stack: (0xde0e7ec8 to 0xde0e8000)
7ec0:                   c025eabc ddb4b400 ddb4b400 ddb4b644 00000000 c025ea84
7ee0: ddb4b400 c025eac8 c025eabc ddb4b5f4 ddb4b400 ddb4b644 00000000 c025e80c
7f00: de0c8bc0 c09f9500 c09fc400 00000000 00000000 c0036534 de0c8bc0 ddb4b5f4
7f20: 00000001 de0c8bc0 c09f9500 de0c8bd8 c09f9500 00000000 00000000 00000009
7f40: 00000000 c0037224 00000000 de08bebc de0e6000 de0c8bc0 c0037008 00000000
7f60: 00000000 c003bd30 ff98732e 00000000 4adf83f4 de0c8bc0 00000000 00000000
7f80: de0e7f80 de0e7f80 00000000 00000000 de0e7f90 de0e7f90 de0e7fac de08bebc
7fa0: c003bc90 00000000 00000000 c000e298 00000000 00000000 00000000 00000000
```

TERIMA KASIH