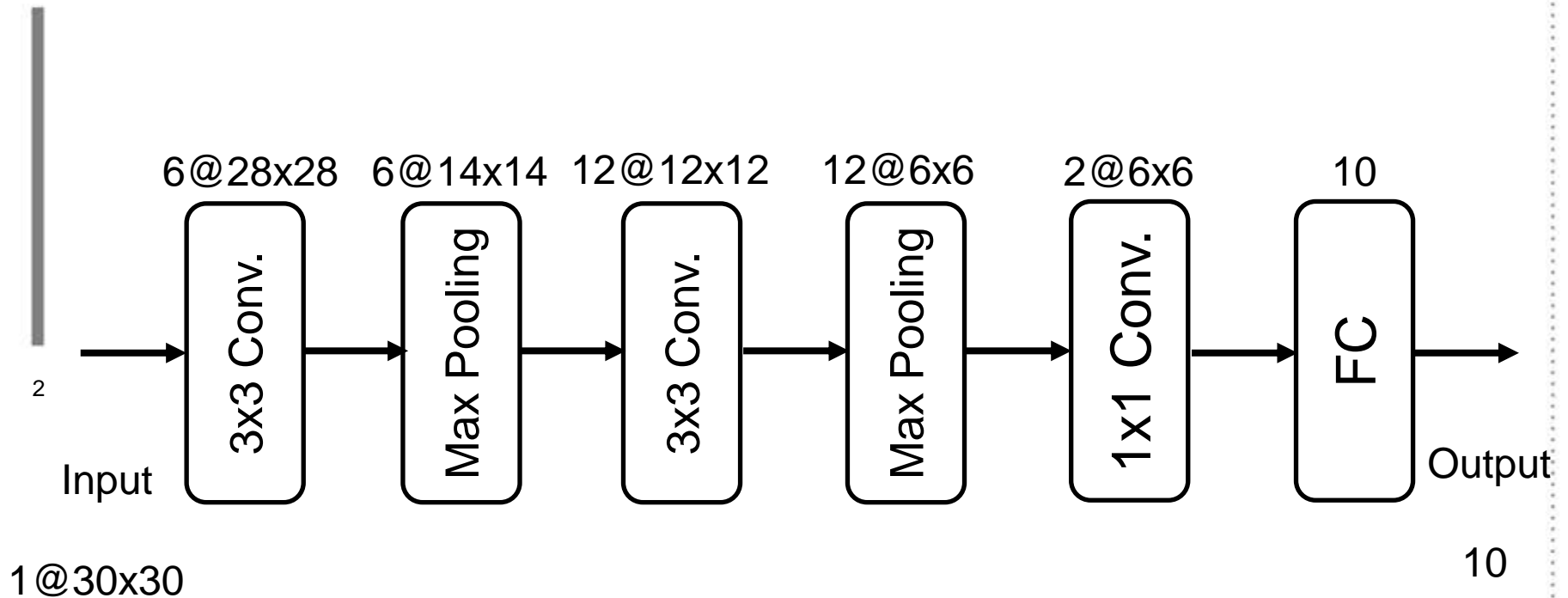


Hardware Circuit Design of Multi-frequency LeNet-5 Convolutional Neural Network

多頻率改良式LeNet-5
卷積神經網路之硬體電路設計

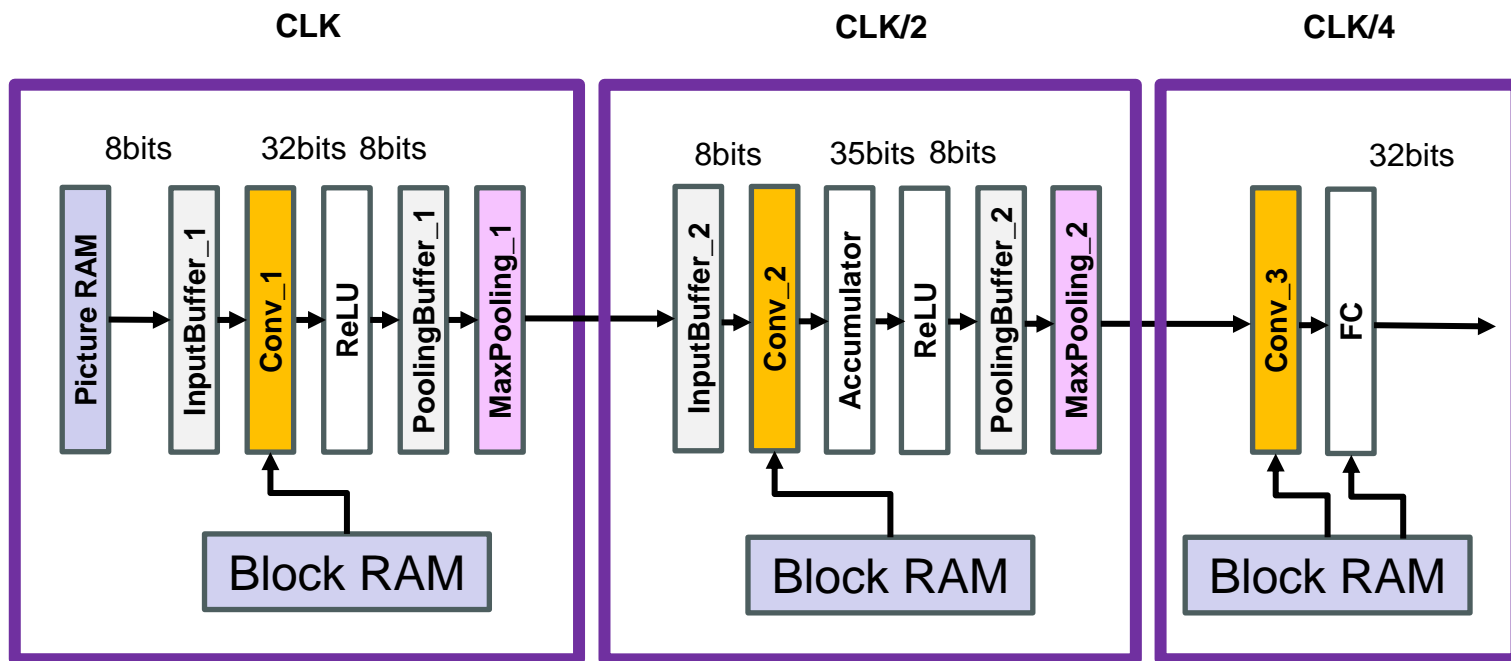
Introduction



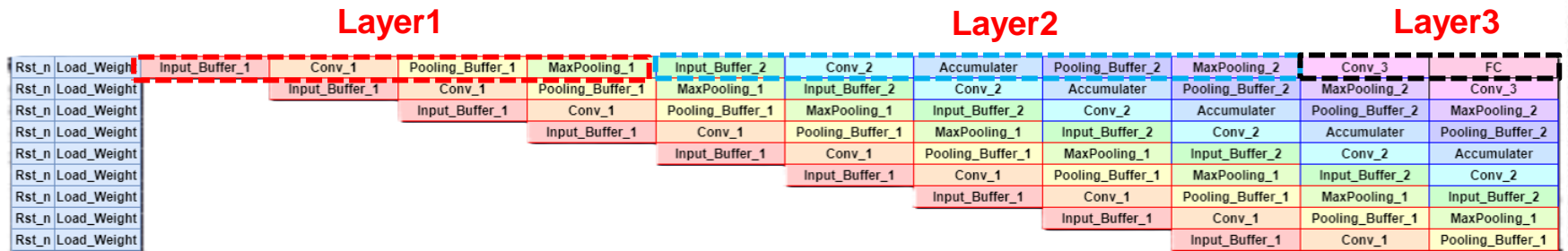
Introduction

| Layer Type | Output Feature Map Size | Number of Parameters |
|-----------------|-------------------------|--|
| Convolution 1 | 28×28×6 | $(3 \times 3 \times 6) + 6$ |
| Subsampling 1 | 14×14×6 | - |
| Convolution 2 | 12×12×12 | $(6 \times 3 \times 3 \times 12) + 12$ |
| Subsampling 2 | 6×6×12 | - |
| Convolution 3 | 6×6×2 | $(12 \times 1 \times 1 \times 2) + 2$ |
| Fully-Connected | 10 | $(72 \times 10) + 10$ |

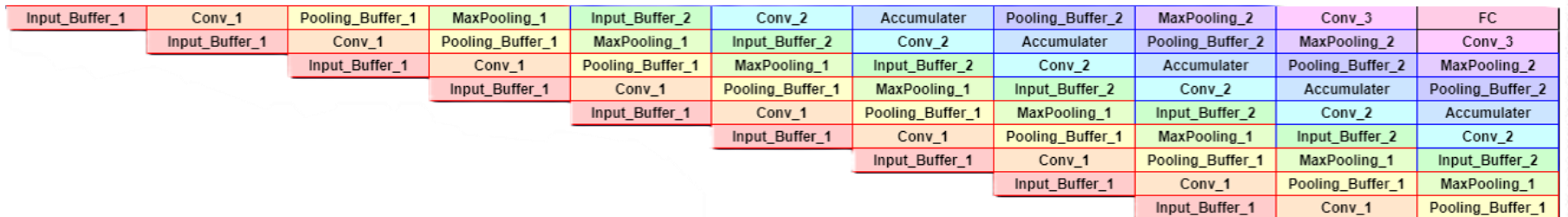
Introduction



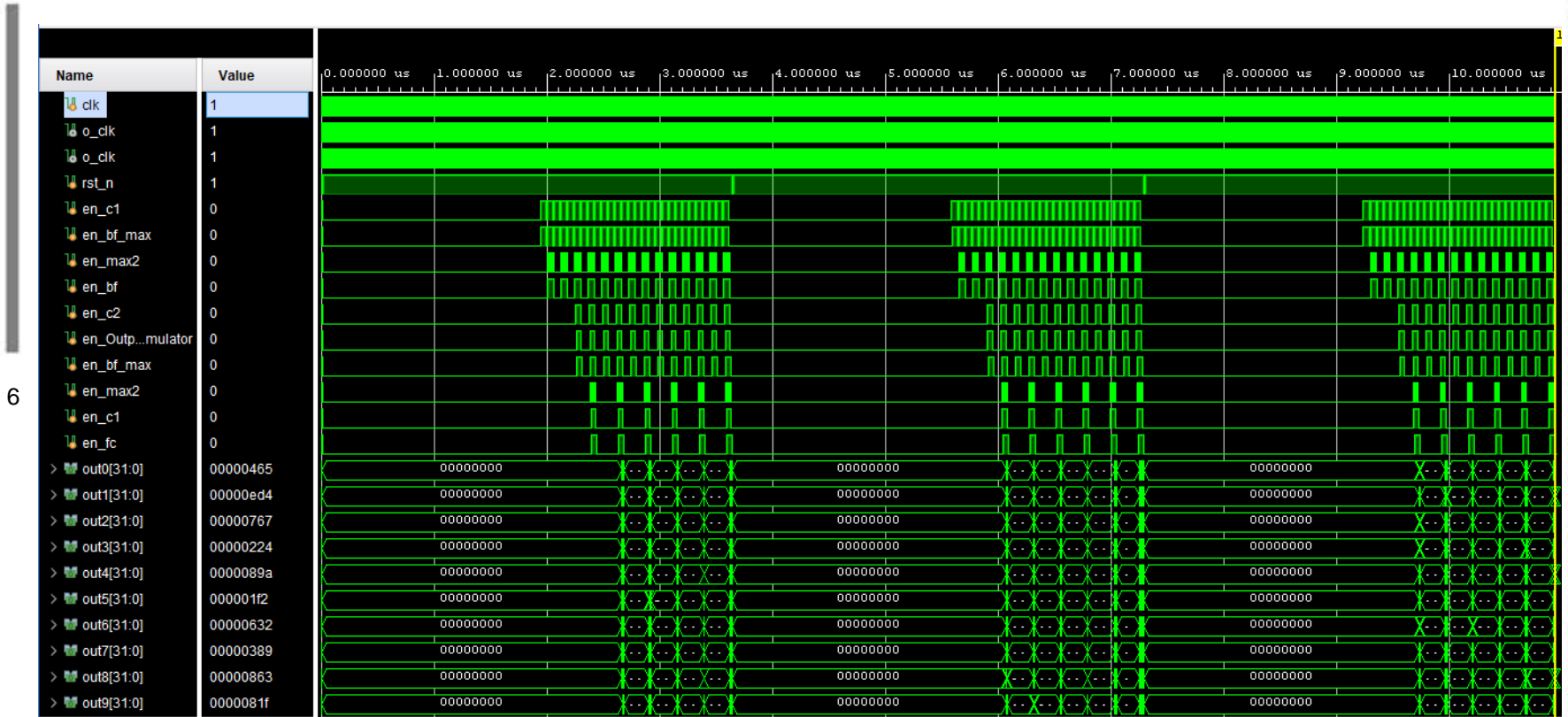
Pipeline



5



Waveform



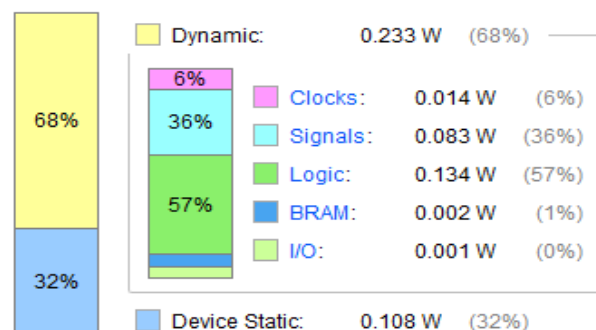
Results

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power: 0.342 W
Design Power Budget: Not Specified
Process: typical
Power Budget Margin: N/A
Junction Temperature: 28.9°C
Thermal Margin: 56.1°C (4.7 W)
Ambient Temperature: 25.0 °C
Effective θ_{JA} : 11.5°C/W
Power supplied to off-chip devices: 0 W
Confidence level: Medium

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



| Resource | Estimation | Available | Utilization % |
|----------|------------|-----------|---------------|
| LUT | 69422 | 53200 | 130.49 |
| LUTRAM | 226 | 17400 | 1.30 |
| FF | 24102 | 106400 | 22.65 |
| IO | 330 | 125 | 264.00 |
| BUFG | 3 | 32 | 9.38 |

```
create_clock -period 26.000 -name clk_26ns -waveform {0.000 13.000} [get_ports clk]
```

| Setup | Hold | Pulse Width |
|--------------------------------------|---------------------------------|---|
| Worst Negative Slack (WNS): 0.380 ns | Worst Hold Slack (WHS): NA | Worst Pulse Width Slack (WPWS): 12.020 ns |
| Total Negative Slack (TNS): 0.000 ns | Total Hold Slack (THS): NA | Total Pulse Width Negative Slack (TPWS): 0.000 ns |
| Number of Failing Endpoints: 0 | Number of Failing Endpoints: NA | Number of Failing Endpoints: 0 |
| Total Number of Endpoints: 39997 | Total Number of Endpoints: NA | Total Number of Endpoints: 20182 |

All user specified timing constraints are met.

Max _ Frequency: 39MHz