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IEGULDĪJUMS TAVĀ NĀKOTNĒ!
EIROPAS SAVIENĪBA
VENTSPILS AUGSTSKOLA
Projekts tiek īstenots sadarbībā ar LIAA Latvijas Investīciju un attīstības aģentūra Investment and Development Agency of Latvia

Development of data compression block, using Huffman coding

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ACKNOWLEDGEMENTS
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Introduction

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Lossless data compression methods

Entropy type:

- Arithmetic;
- Huffman;
- Golomb;
- Range;
- Shannon-Fano;
- Fibonacci;
- etc.

Dictionary type:

- DEFLATE;
- Lempel-Ziv;
- Run-lenght encoding;
- etc.

Other types:

- Delta;
- Burrows–Wheeler;
- etc.

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Huffman coding

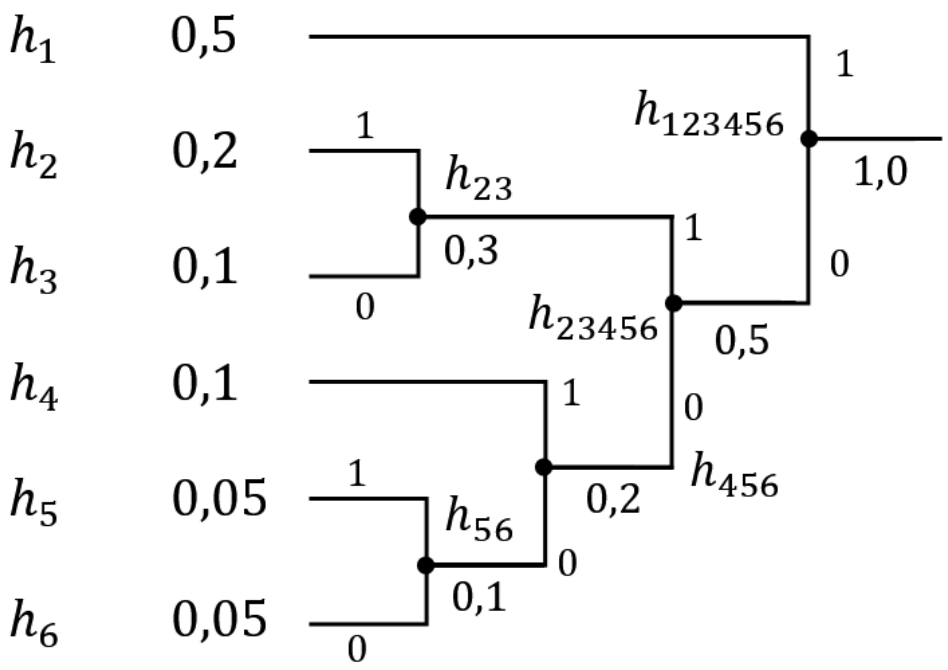
Huffman coding is lossless entropy compression algorithm;

Based on variable-length code table called Huffman tree;

Coding process can be divided in two parts:

- creation of Huffman tree;
- creation of code for each symbol in alphabet;

Universal data compression block (UDCB) is based on a particular type of Huffman coding called Canonical Huffman coding.



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Canonical Huffman coding

Canonical Huffman coding allows to describe Huffman tree;

Description table is created using one formula and simple «for» loop:

$for\ f := 5\ downto\ 1\ do\ first[f] :=$

$:= [(first[f+1] + probability[f+1]/2)]$

where $first[6] := 0$

Nr.	Huffman code	Canonical Huffman code	Nr.	Huffman code	Canonical Huffman code
1	000	011	9	10100	01000
2	001	100	10	101010	000000
3	010	101	11	101011	000001
4	011	110	12	101100	000010
5	10000	00100	13	101101	000011
6	10001	00101	14	101110	000100
7	10010	00110	15	101111	000101
8	10011	00111	16	110000	000110

Code length	1	2	3	4	5	6
Code "probability"	0	0	4	0	5	7
First number	2	4	3	5	4	0

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Development methods

Possible UDCB development methods:

- ASIC (Application-specific integrated circuit) or similar;
- Microcontrollers (Modified C or other languages);
- FPGA (VHDL, LabVIEW environment).

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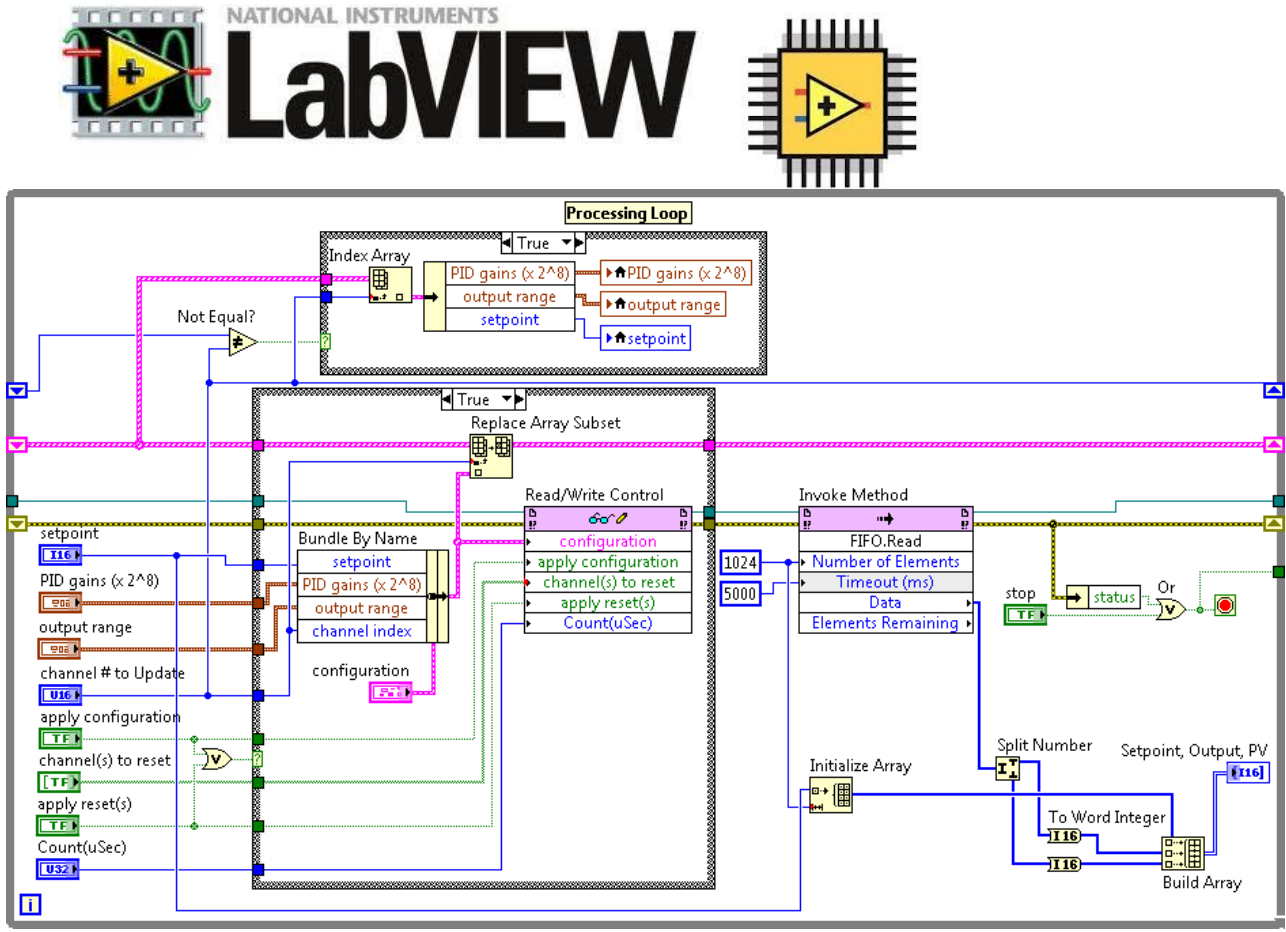
LabVIEW FPGA

LabVIEW* is a system-design platform and development environment;

LabVIEW FPGA is an extension module for LabVIEW to target FPGAs on NI** reconfigurable I/O (RIO) hardware

Implements true parallelism for parallel data processing on FPGA chip in real-time



*Laboratory Virtual Instrument Engineering Workbench

**National Instruments

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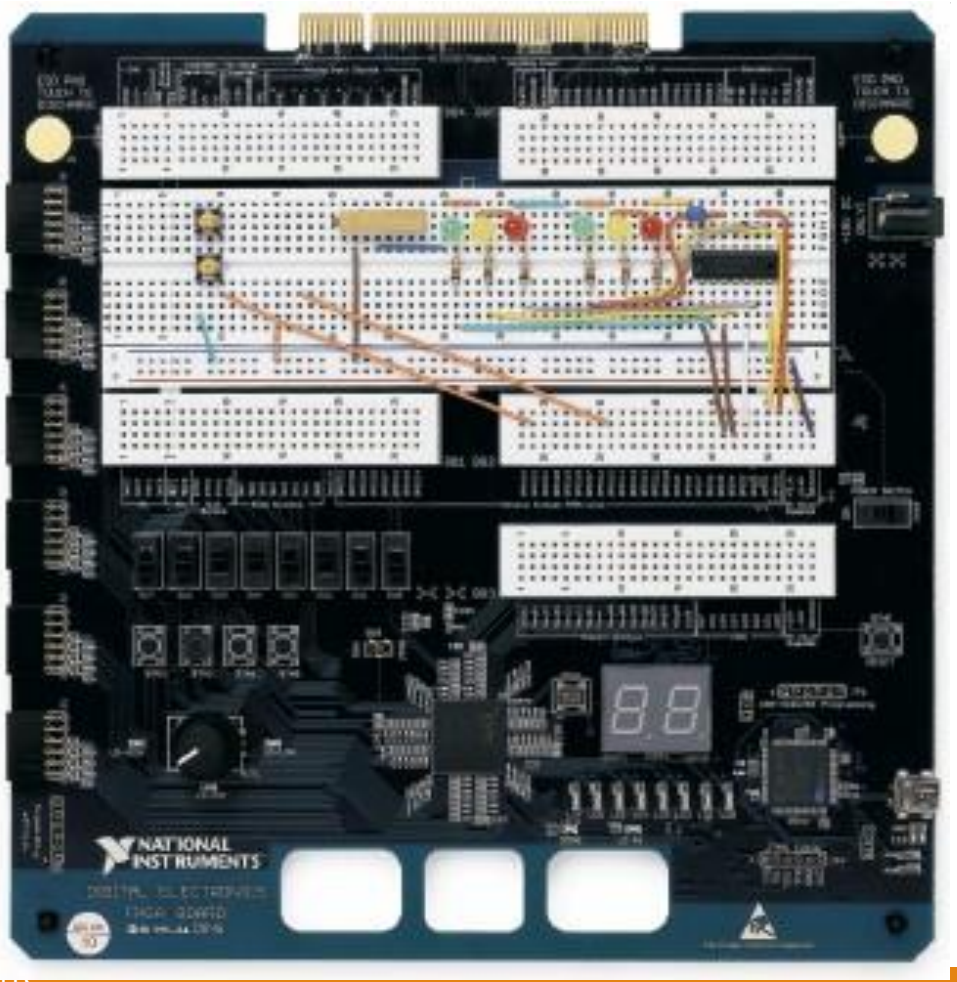
FPGA target device

Xilinx Spartan-3E FPGA Family chip:

- System gates – 500K;
- Equivalent Logic Cells – 10 476;
- Distributed RAM bits – 73K;
- Block RAM bits – 360K;
- Dedicated multipliers – 20;
- User I/O – 232;



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Development of UDCB

The goal of development is a true parallelism for high speed compression of large amount of data;

Possible to change the capacity of the buffer memory;

UDCB can compress 8 bit input data;

Despite of Huffman coding sequential nature, it is possible to do parallel data processing:

- Data reading;
- Compression of data;
- Data sending.

Structure of UDCB is divided in units which can be implemented in many ways (add new, edit existing)

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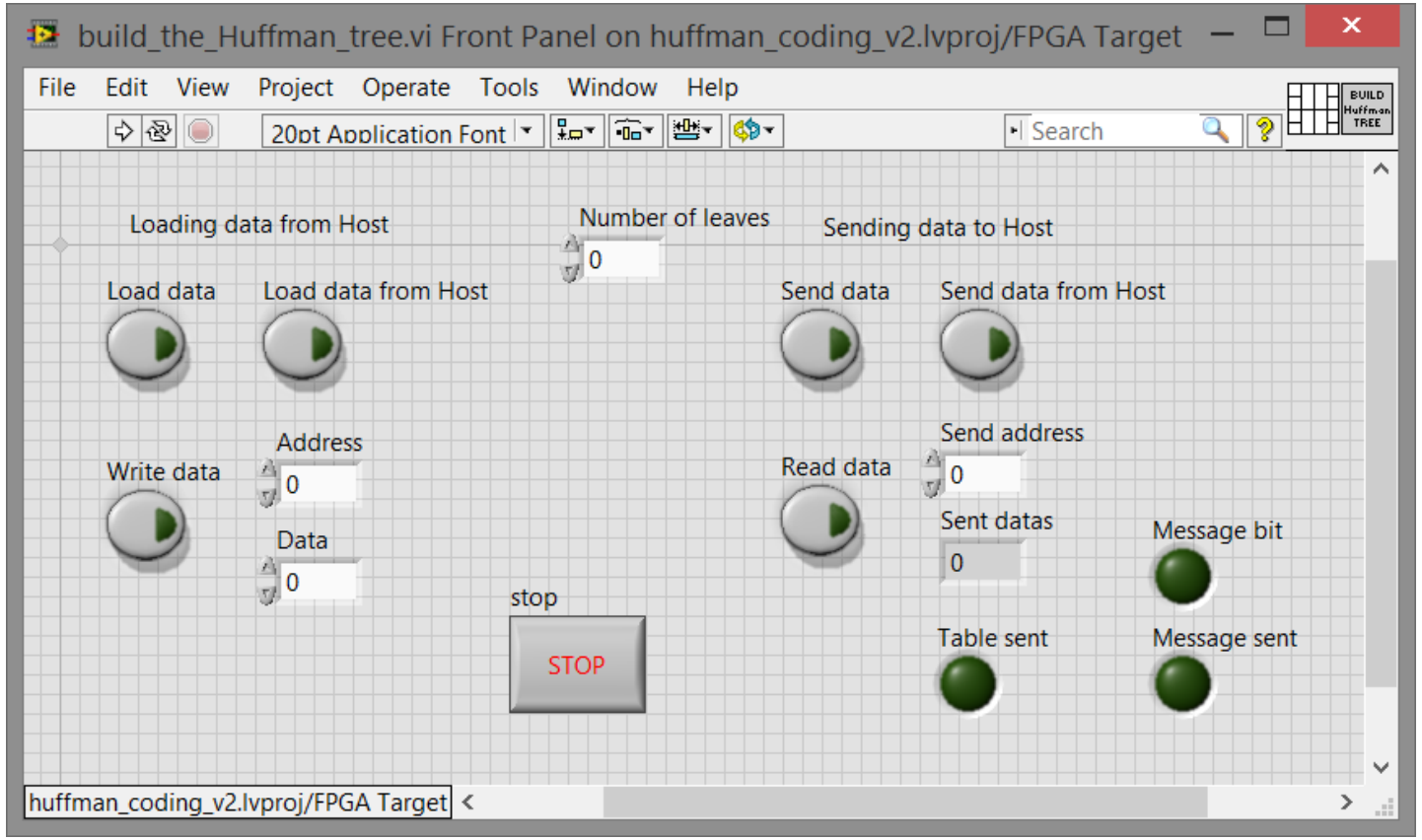

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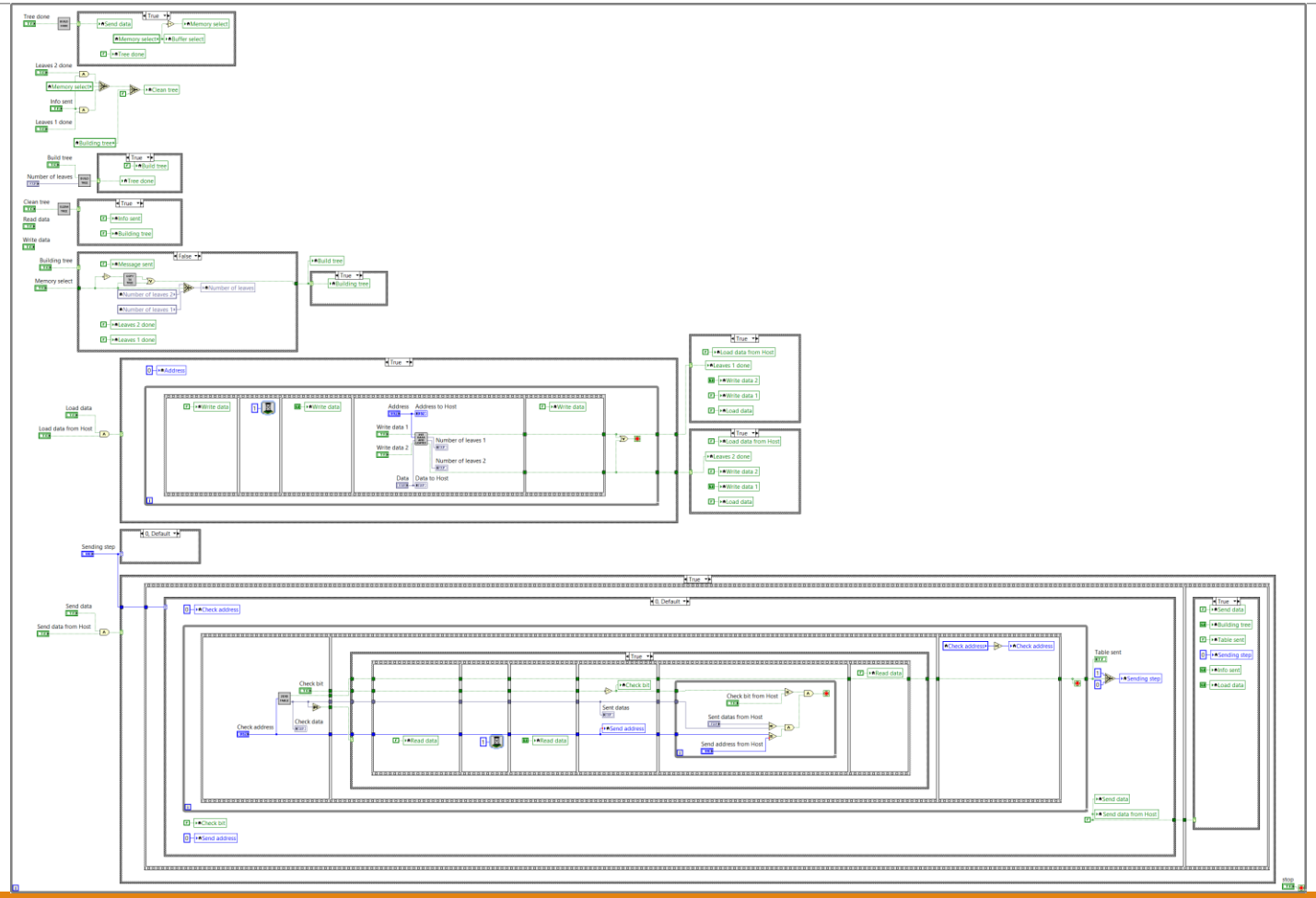

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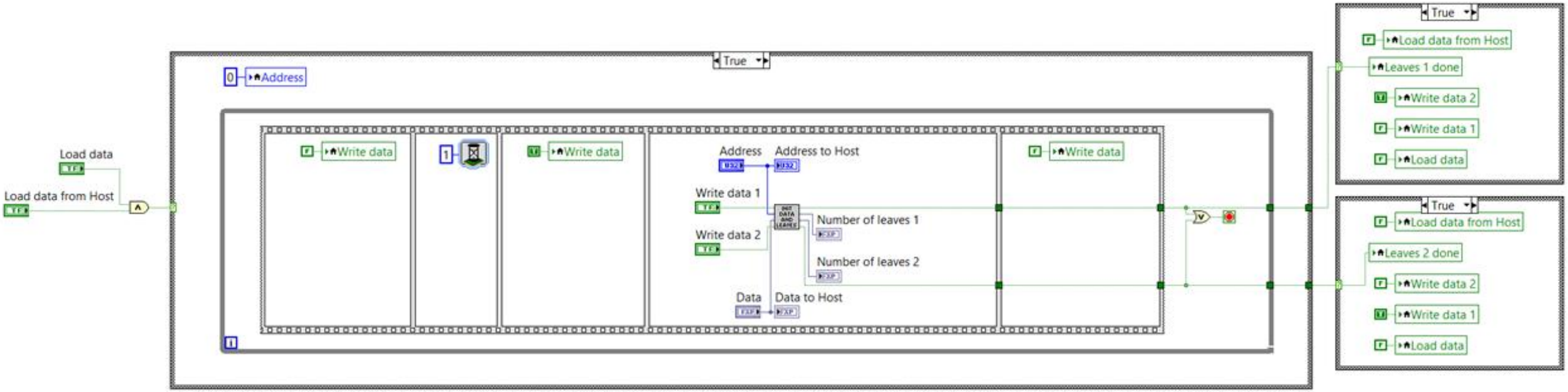

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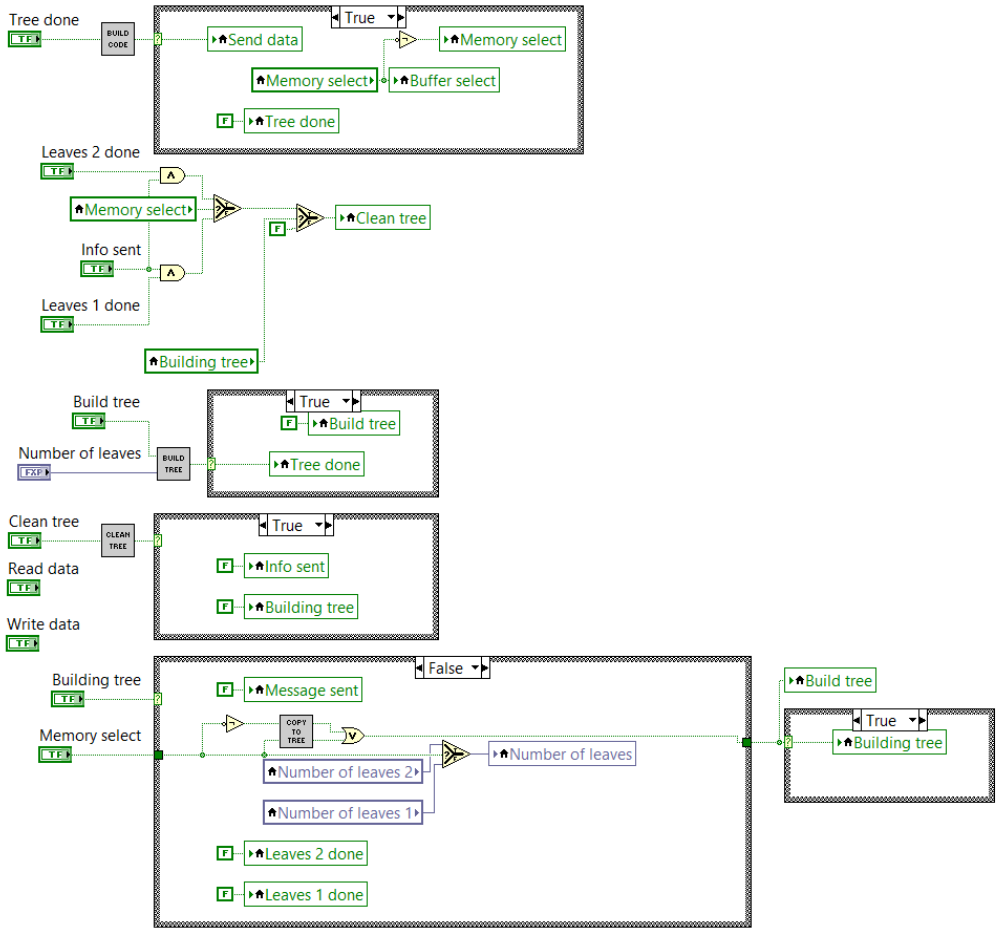

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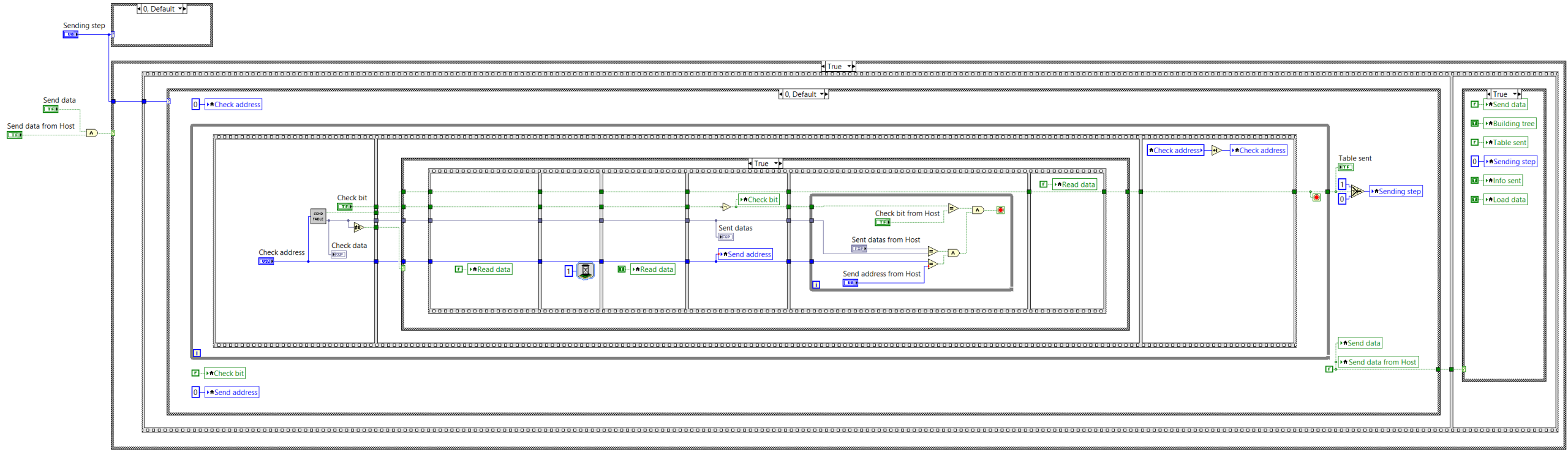

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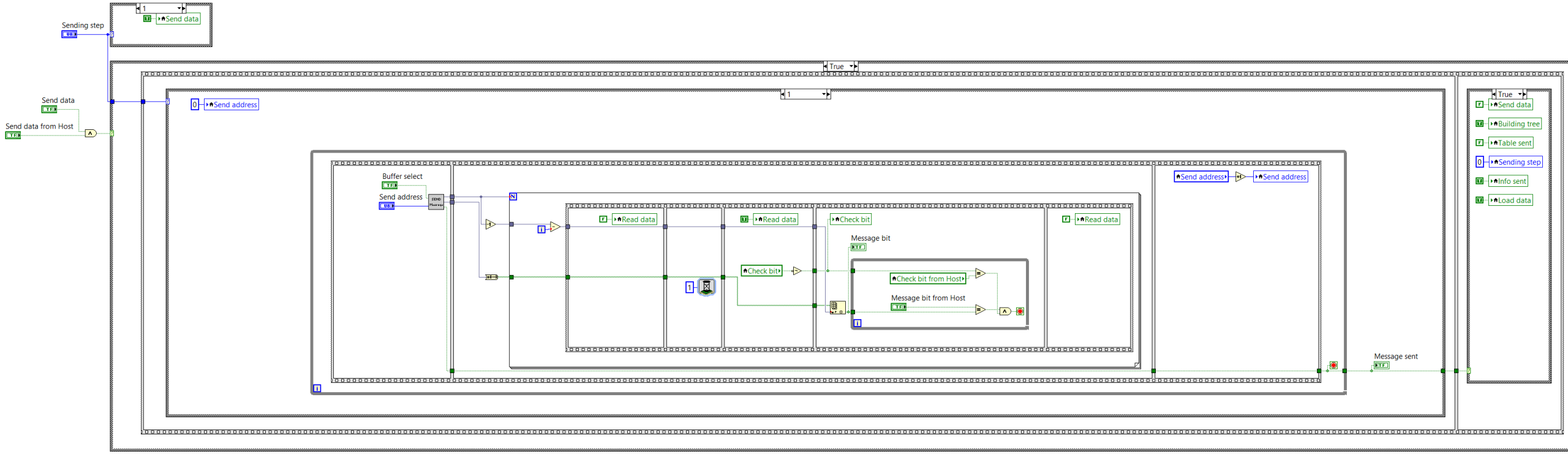

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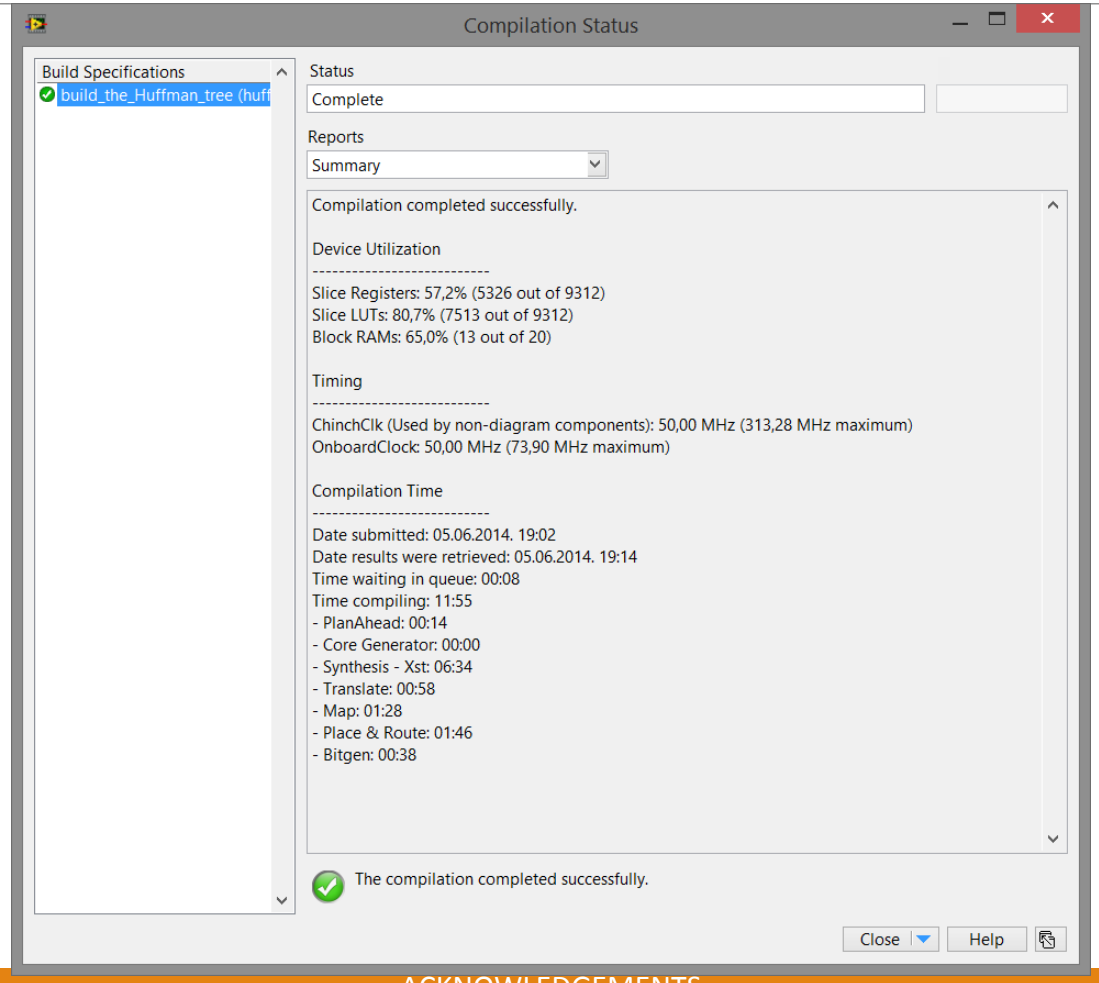

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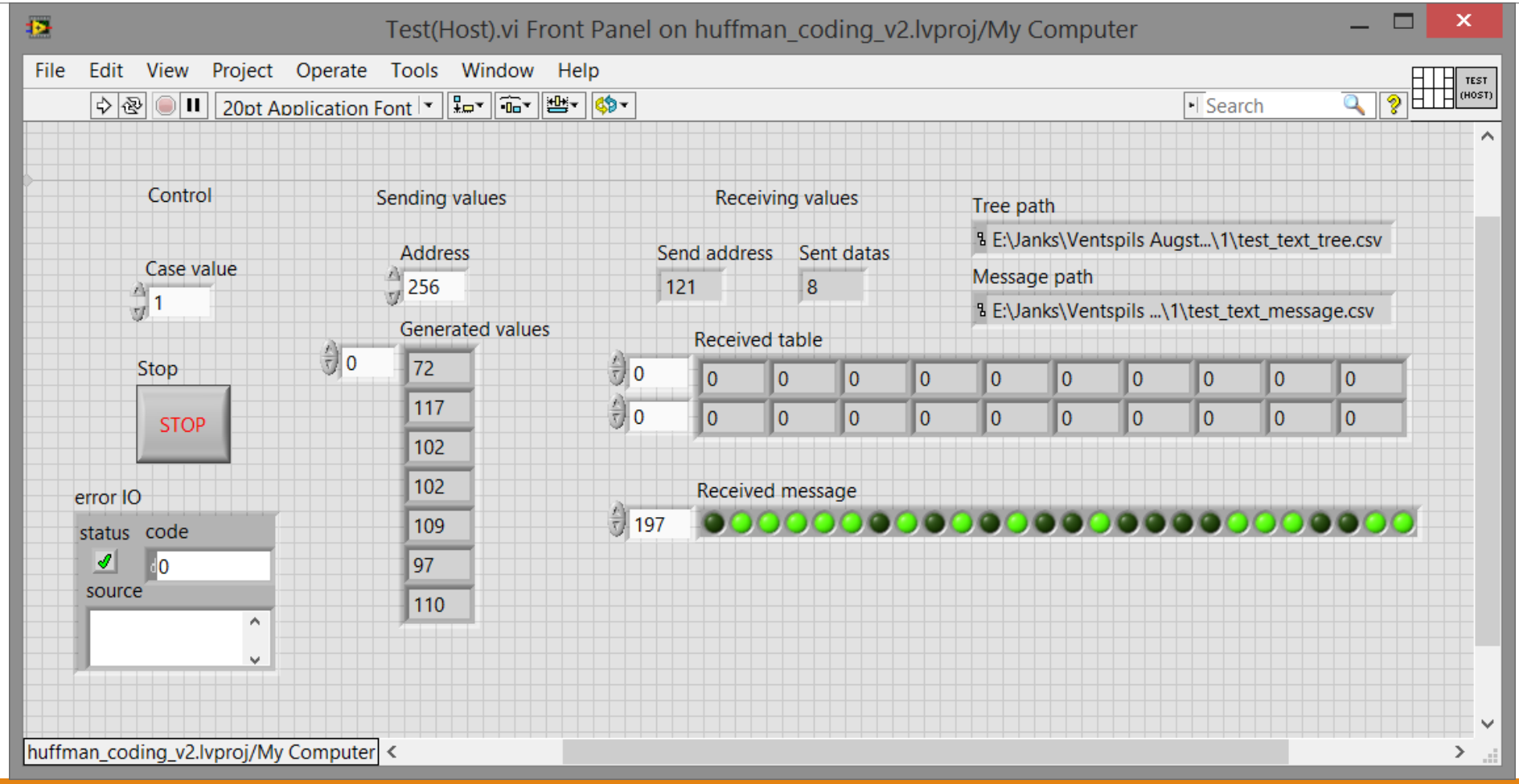
Testbench



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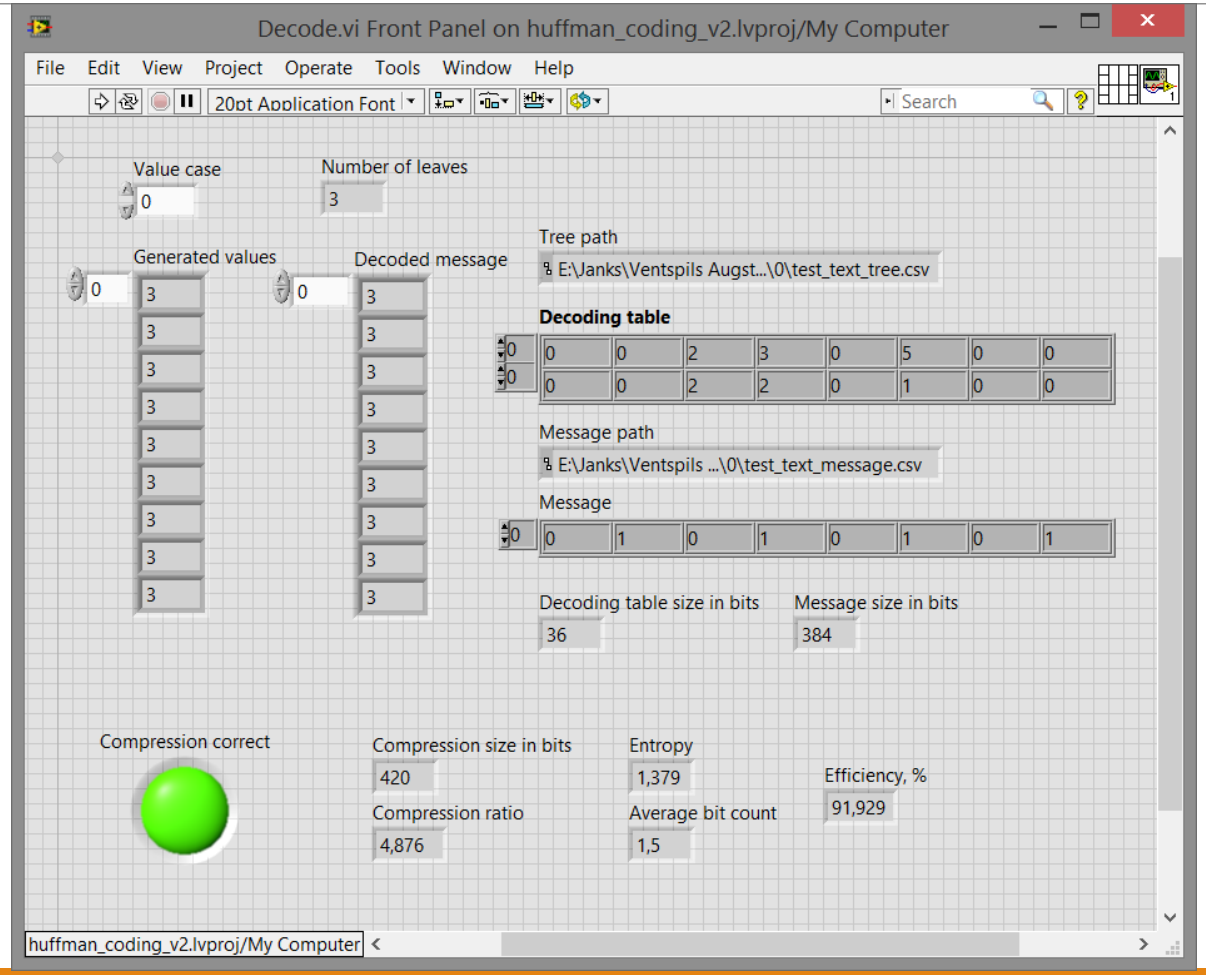
Testing results



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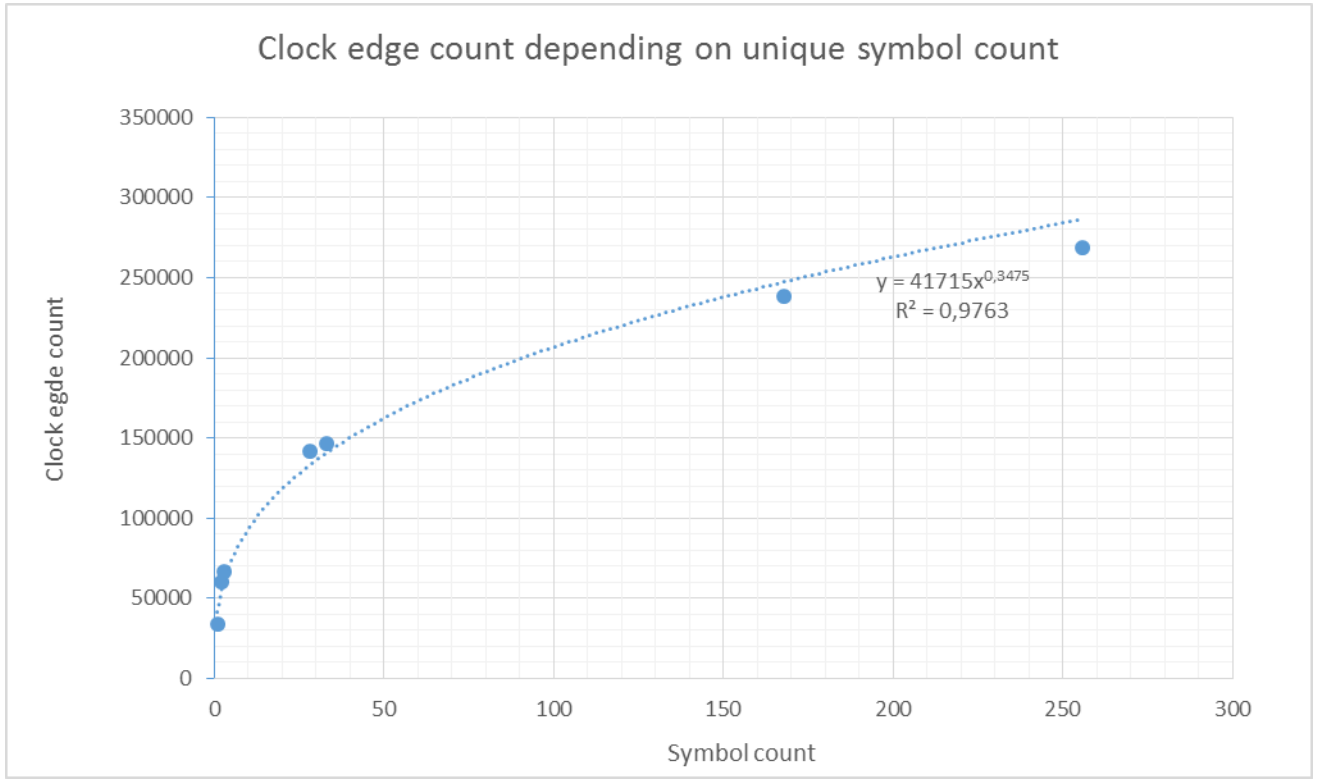
Performance results

Testing for each case – 500 runs:

Symbol count	Average clock counts	Average time, ms
3	66809	1,34
28	141479	2,83
33	146498	2,93
168	238394	4,77
2	60354	1,21
1	33422	0,67
256	268958	5,38



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Conclusions and suggestions

UDCB is developed successfully and it is compressing data correctly;

UDCB can be implemented in low power FPGA in data storing subsystem on nano-satellite CubeSAT type satellite;

Implement another Huffman coding type algorithms better performance comparing;

Implementation in other FPGA targets for more accurate and close to real-time testing;

Create adaptive table sending algorithm:

- Unique symbol count <86 then send only coded symbols and their code length;
- Unique symbol count ≥86 then send whole table but only each symbol code length;

Upgrade UDCB to compress another length data (ex. 16 or 32 bit data);

Upgrade UDCB buffer memory for larger amount of compressible data (ex. 1024 or 2048 symbols).

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"The laws of probability, so true in general, so fallacious in particular."

- Edward Gibbon

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