**МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РФ**

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ **«БЕЛГОРОДСКИЙ ГОСУДАРСТВЕННЫЙ ТЕХНОЛОГИЧЕСКИЙ УНИВЕРСИТЕТ ИМ. В. Г. ШУХОВА»**

Кафедра программного обеспечения вычислительной техники и автоматизированных систем

**ЛАБОРАТОРНАЯ РАБОТА №5**

**Дисциплина: Синтез и анализ многовыходных комбинационных схем**

**в базисе И-ИЛИ-НЕ**

Выполнил: ст. группы ВТ-31

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**Белгород 2019**

**Цель работы:** научиться строить эффективные по быстродействию и затратам оборудования многовыходные комбинационные схемы.

**Вариант 13**

**Ход выполнения работы**

1. Составить таблицу истинности системы булевых функций, которая состоит из трех функций f1(X), f2(X) и f3(X), где X = {x1, x2, x3, x4, x5}. Булева функция fi(X) для k-го варианта определяется как , где gj(X) — булева функция, представленная в таблице 1 в строке j.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| x1 | x2 | x3 | x4 | x5 | f1 | f2 | f3 |
| 0 | 0 | 0 | 0 | 0 | **0** | **1** | **1** |
| 0 | 0 | 0 | 0 | 1 | **0** | **1** | **0** |
| 0 | 0 | 0 | 1 | 0 | **0** | **0** | **0** |
| 0 | 0 | 0 | 1 | 1 | **0** | **0** | **0** |
| 0 | 0 | 1 | 0 | 0 | **0** | **0** | **1** |
| 0 | 0 | 1 | 0 | 1 | **0** | **0** | **1** |
| 0 | 0 | 1 | 1 | 0 | **1** | **0** | **0** |
| 0 | 0 | 1 | 1 | 1 | **0** | **0** | **0** |
| 0 | 1 | 0 | 0 | 0 | **0** | **1** | **1** |
| 0 | 1 | 0 | 0 | 1 | **0** | **1** | **1** |
| 0 | 1 | 0 | 1 | 0 | **1** | **1** | **0** |
| 0 | 1 | 0 | 1 | 1 | **1** | **1** | **0** |
| 0 | 1 | 1 | 0 | 0 | **0** | **0** | **0** |
| 0 | 1 | 1 | 0 | 1 | **1** | **0** | **1** |
| 0 | 1 | 1 | 1 | 0 | **1** | **0** | **1** |
| 0 | 1 | 1 | 1 | 1 | **0** | **0** | **0** |
| 1 | 0 | 0 | 0 | 0 | **0** | **0** | **0** |
| 1 | 0 | 0 | 0 | 1 | **0** | **0** | **0** |
| 1 | 0 | 0 | 1 | 0 | **1** | **1** | **0** |
| 1 | 0 | 0 | 1 | 1 | **1** | **1** | **0** |
| 1 | 0 | 1 | 0 | 0 | **0** | **0** | **0** |
| 1 | 0 | 1 | 0 | 1 | **0** | **0** | **0** |
| 1 | 0 | 1 | 1 | 0 | **0** | **0** | **0** |
| 1 | 0 | 1 | 1 | 1 | **1** | **0** | **0** |
| 1 | 1 | 0 | 0 | 0 | **0** | **0** | **0** |
| 1 | 1 | 0 | 0 | 1 | **0** | **0** | **0** |
| 1 | 1 | 0 | 1 | 0 | **0** | **0** | **0** |
| 1 | 1 | 0 | 1 | 1 | **0** | **0** | **0** |
| 1 | 1 | 1 | 0 | 0 | **0** | **0** | **0** |
| 1 | 1 | 1 | 0 | 1 | **0** | **0** | **0** |
| 1 | 1 | 1 | 1 | 0 | **0** | **0** | **0** |
| 1 | 1 | 1 | 1 | 1 | **0** | **0** | **0** |

1. Получить систему минимальных дизъюнктивных нормальных форм булевых функций f1(X), f2(X) и f3(X).

f1(X)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 |
|  |  | 10010 +  01010 +  00110 + | 10011 +  01110 +  01101  01011 + | 10111 + |  |
|  |  | 1001-  01-10  0-110  0101- | 10-11 |  |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 01101 + |  |  |  | + |  |  |  |  |
| 10-11 + |  |  |  |  |  |  | + | + |
| 1. + |  |  |  |  |  | + | + |  |
| 01-10 |  | + |  |  | + |  |  |  |
| 0-110 + | + |  |  |  | + |  |  |  |
| 0101- + |  | + | + |  |  |  |  |  |
|  | 00110 | 01010 | 01011 | 01101 | 01110 | 10010 | 10011 | 10111 |



f2(X)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 00000 + | 00001 +  01000 + | 01001 +  01010 +  10010 + | 01011 +  10011 + |  |  |
| 0000- +  0-000 + | 0-001 +  0100- +  101-0 + | 010-1 +  0101- +  1001- |  |  |  |
| 0-00- | 010-- |  |  |  |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1001- + |  |  |  |  |  |  | + | + |
| 0-00- + | + | + | + | + |  |  |  |  |
| 010-- + |  |  | + | + | + | + |  |  |
|  | 00000 | 00001 | 01000 | 01001 | 01010 | 01011 | 10010 | 10011 |



f3(X)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 00000 + | 00100 +  01000 + | 00101 +  01001 + | 01101 +  01110 |  |  |
| 00-00  0-000 | 0010-  0100- | 0-101  01-01 |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 01110 + |  |  |  |  |  |  | + |
| 00-00 | + | + |  |  |  |  |  |
| 0-000 + | + |  |  | + |  |  |  |
| 0010- + |  | + | + |  |  |  |  |
| 0100- |  |  |  | + | + |  |  |
| 0-101 |  |  | + |  |  | + |  |
| 01-01 + |  |  |  |  | + | + |  |
|  | 00000 | 00100 | 00101 | 01000 | 01001 | 01101 | 01110 |



1. Применить факторизационный метод синтеза многоярусной комбинационной схемы в базисе И-ИЛИ-НЕ с двухвходовыми элементами И и ИЛИ по системе минимальных дизъюнктивных нормальных форм булевых функций f1(X), f2(X) и f3(X).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | x1 | !x1 | x2 | !x2 | x3 | !x3 | x4 | !x4 | x5 | !x5 | z1 | z2 | z3 | z4 | z5 | z6 | z7 | z8 | z9 |
| u1 | 1+ |  |  | 1+ |  | 5+ | 5+ |  |  |  | + |  |  |  | + |  |  |  |  |
| u2 | 1+ |  |  | 1+ |  |  | 6+ |  | 6+ |  | + |  |  |  |  | + |  |  |  |
| u3 |  | 2+ | 3+ |  |  | 3+ | 2+ |  |  |  |  | + | + |  |  |  |  |  |  |
| u4 |  | 2+ |  |  | 4+ |  | 2+ |  |  | 4+ |  | + |  | + |  |  |  |  |  |
| u5 |  | 7+ | 7+ |  | 8+ |  |  | 8+ | A+ |  |  |  |  |  |  |  | A+ | + |  |
| u6 |  | 9+ |  |  |  | 9+ |  | 10+ |  | 10+ |  |  |  |  |  |  |  |  | + |
| u7 |  | 7+ | 7+ |  |  |  |  | 11+ | 11+ |  |  |  |  |  |  |  | + |  |  |
| u8 |  | 12+ |  | 12+ | 8+ |  |  | 8+ |  |  |  |  |  |  |  |  |  | + |  |
| u9 |  | 13+ | 13+ |  | 4+ |  | B+ |  |  | 4+ |  |  |  | B+ |  |  |  |  |  |
| u10 |  | 9+ |  |  |  | 9+ |  | + |  |  |  |  |  |  |  |  |  |  | + |
| u11 |  | + | 3+ |  |  | 3+ |  |  |  |  |  |  | + |  |  |  |  |  |  |
| z1 | **+** |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z2 |  | **+** |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |
| z3 |  |  | **+** |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z4 |  |  |  |  | **+** |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |
| z5 |  |  |  |  |  | **+** | **+** |  |  |  |  |  |  |  |  |  |  |  |  |
| z6 |  |  |  |  |  |  | **+** |  | **+** |  |  |  |  |  |  |  |  |  |  |
| z7 |  | **+** | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z8 |  |  |  |  | **+** |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |
| z9 |  | **+** |  |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z10 |  |  |  |  |  |  |  | **+** |  | **+** |  |  |  |  |  |  |  |  |  |
| z11 |  |  |  |  |  |  |  | **+** | **+** |  |  |  |  |  |  |  |  |  |  |
| z12 |  | **+** |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z13 |  | **+** | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h1 |  |  |  |  |  |  |  |  |  | **+** |  |  |  |  |  |  | **+** |  |  |
| h2 |  |  |  |  |  |  |  | **+** |  |  |  |  |  | **+** |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | u1 | u2 | u3 | u4 | u5 | u6 | u7 | u8 | u9 | u10 | u11 | v1 | v2 | v3 | v4 | v5 | g1 |
| f1 | 1+ | 1+ | 2+ | 2+ | A+ |  |  |  |  |  |  | A+ | + |  |  |  | + |
| f2 |  |  |  |  |  | 3+ | 3+ | 4+ | 4+ |  |  |  |  | + | + |  |  |
| f3 | + |  |  |  |  |  |  |  |  | 5+ | 5+ |  |  |  |  | + |  |
| v1 | + | + |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| v2 |  |  | + | + |  |  |  |  |  |  |  |  |  |  |  |  |  |
| v3 |  |  |  |  |  | + | + |  |  |  |  |  |  |  |  |  |  |
| v4 |  |  |  |  |  |  |  | + | + |  |  |  |  |  |  |  |  |
| v5 |  |  |  |  |  |  |  |  |  | + | + |  |  |  |  |  |  |
| g1 |  |  |  |  | + |  |  |  |  |  |  | + |  |  |  |  |  |

1. Получить минимальную дизъюнктивную нормальную форму системы булевых функций f1(X), f2(X) и f3(X).



1. Применить факторизационный метод синтеза многоярусной комбинационной схемы в базисе И-ИЛИ-НЕ с двухвходовыми элементами И и ИЛИ по минимальной дизъюнктивной нормальной форме системы булевых функций f1(X), f2(X) и f3(X).

См. Приложение(1-3)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | x1 | !x1 | x2 | !x2 | x3 | !x3 | x4 | !x4 | x5 | !x5 | z1 | z2 | z3 | z4 | z5 | z6 | z7 | z8 | z9 |
| u1 |  | 1+ |  |  | 6+ |  | 1+ |  |  | 6+ | + |  |  |  |  |  |  |  |  |
| u2 |  | 1+ | 5+ |  |  | 5+ | 1+ |  |  |  | + |  |  |  | + |  |  |  |  |
| u3 |  | 2+ | 7+ |  | 2+ |  |  | 7+ | + |  |  | + |  |  |  |  | + |  |  |
| u4 | 3+ |  |  | 3+ |  | 8+ | 8+ |  |  |  |  |  | + |  |  |  |  | + |  |
| u5 | 3+ |  |  | 3+ |  |  | 9+ |  | 9+ |  |  |  | + |  |  |  |  |  | + |
| u6 |  | 1+ | 10+ |  | 6+ |  | 10+ |  |  | 6+ |  | + |  |  |  |  |  |  |  |
| u7 |  | 12+ |  | 11+ | 11+ |  |  | 12+ |  |  |  |  |  | + |  |  |  |  |  |
| u8 |  | 4+ | 5+ |  |  | 5+ |  | 4+ |  |  |  |  |  | + | + |  |  |  |  |
| u9 |  | 4+ |  |  |  | + |  | 4+ |  |  |  |  |  |  |  |  |  |  |  |
| u10 |  | 4+ |  | 13+ |  |  |  | 4+ |  | 13+ |  |  |  |  |  |  |  |  |  |
| z1 |  | **+** |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |
| z2 |  | **+** |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z3 | **+** |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z4 |  | **+** |  |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |
| z5 |  |  | **+** |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z6 |  |  |  |  | **+** |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |
| z7 |  |  | **+** |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |
| z8 |  |  |  |  |  | **+** | **+** |  |  |  |  |  |  |  |  |  |  |  |  |
| z9 |  |  |  |  |  |  | **+** |  | **+** |  |  |  |  |  |  |  |  |  |  |
| z10 |  |  | **+** |  |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |  |
| z11 |  |  |  | **+** | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| z12 |  | **+** |  |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |
| z13 |  |  |  | **+** |  |  |  |  |  | **+** |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | u1 | u2 | u3 | u4 | u5 | u6 | u7 | u8 | u9 | u10 | v1 | v2 | v3 | v4 | v5 | g1 | g2 |
| f1 | 2+ | 2+ | 1+ | 3+ | 3+ | 1+ |  |  |  |  | A+ | A+ | + |  |  | + |  |
| f2 |  |  |  | 4+ |  |  |  | 4+ | + |  |  |  |  | + |  |  |  |
| f3 |  |  | 1+ |  |  | 1+ | 5+ | 5+ |  | B+ | B+ |  |  |  | + |  | + |
| v1 |  |  | **+** |  |  | **+** |  |  |  |  |  |  |  |  |  |  |  |
| v2 | **+** | **+** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| v3 |  |  |  | **+** | **+** |  |  |  |  |  |  |  |  |  |  |  |  |
| v4 |  |  |  | **+** |  |  |  | **+** |  |  |  |  |  |  |  |  |  |
| v5 |  |  |  |  |  |  | **+** | **+** |  |  |  |  |  |  |  |  |  |
| g1 |  |  |  |  |  |  |  |  |  |  | **+** | **+** |  |  |  |  |  |
| g2 |  |  |  |  |  |  |  |  |  | **+** | **+** |  |  |  |  |  |  |

1. Написать программы, моделирующие работу схем, полученных в пунктах 3 и 5, на всех входных наборах и строящие таблицу истинности каждой схемы. Сравнить полученные таблицы истинности с таблицей истинности исходной системы булевых функций.

См. Приложение (программное)

1. Сравнить полученные в пунктах 3 и 5 схемы по Квайну и по быстродействию.

Модель, построенная по системе минимальных булевых функций

Быстродействие: 64

Сложность: 5

Модель, построенная по минимальной системе булевых функций

Быстродействие: 60

Сложность: 5

*Приложение (программное)*

#include <iostream>

#include <vector>

#include "math.h"

using namespace std;

#define M 14

#define N 5

bool NextSet(int\* a, int n, int m) {

int j = m - 1;

while (j >= 0 && a[j] == n) j--;

if (j < 0) return false;

if (a[j] >= n)

j--;

a[j]++;

if (j == m - 1) return true;

for (int k = j + 1; k < m; k++)

a[k] = 0;

return true;

}

void Print(int\* a, int n) {

static int num = 1;

cout.width(3);

for (int i = 0; i < n; i++)

cout << a[i] << " ";

}

void PrintMatr(int a[M][N]) {

for (int i = 0; i < M; i++) {

for (int j = 0; j < N; j++)

printf("%i", a[i][j]);

printf("\n");

}

}

void gun(int\* a, int n) {

Print(a, n);

bool x1 = a[0], x2 = a[1], x3 = a[2], x4 = a[3], x5 = a[4];

bool z1, z2, z3, z4, z5, z6, z7, z8, z9, z10, z11, z12, z13, h1, h2, u1, u2, u3, u4, u5, u6, u7, u8, u9, u10, u11, v1, v2, v3, v4, v5, g1, f1, f2, f3;

// система минимальных функций

f1 = (!x1 \* !x2 \* x3 \* x4 \* !x5) + (!x1 \* x2 \* !x3 \* x4 \* !x5) + (!x1 \* x2 \* !x3 \* x4 \* x5) + (!x1 \* x2 \* x3 \* !x4 \* x5) + (!x1 \* x2 \* x3 \* x4 \* !x5) + (x1 \* !x2 \* !x3 \* x4 \* !x5) + (x1 \* !x2 \* !x3 \* x4 \* x5) + (x1 \* !x2 \* x3 \* x4 \* x5);

printf(f1 ? " 1 " : " 0 ");

f2 = (!x1 \* !x2 \* !x3 \* !x4 \* !x5) + (!x1 \* !x2 \* !x3 \* !x4 \* x5) + (!x1 \* x2 \* !x3 \* !x4 \* !x5) + (!x1 \* x2 \* !x3 \* !x4 \* x5) + (!x1 \* x2 \* !x3 \* x4 \* !x5) + (!x1 \* x2 \* !x3 \* x4 \* x5) + (x1 \* !x2 \* !x3 \* x4 \* !x5) + (x1 \* !x2 \* !x3 \* x4 \* x5);

printf(f2 ? " 1 " : " 0 ");

f3 = (!x1 \* !x2 \* !x3 \* !x4 \* !x5) + (!x1 \* !x2 \* x3 \* !x4 \* !x5) + (!x1 \* !x2 \* x3 \* !x4 \* x5) + (!x1 \* x2 \* !x3 \* !x4 \* !x5) + (!x1 \* x2 \* !x3 \* !x4 \* x5) + (!x1 \* x2 \* x3 \* !x4 \* x5) + (!x1 \* x2 \* x3 \* x4 \* !x5);

printf(f3 ? " 1 " : " 0 ");

// модель

z1 = x1 and !x2;

z2 = !x1 and x4;

z3 = x2 and !x3;

z4 = x3 and !x5;

z5 = !x3 and x4;

z6 = x4 and x5;

z7 = !x1 and x2;

z8 = x3 and !x4;

z9 = !x1 and !x3;

z10 = !x4 and !x5;

z11 = !x4 and x5;

z12 = !x1 and !x2;

z13 = !x1 and x2;

h1 = !x5 and z7;

h2 = !x4 and z4;

u1 = z1 and z5;

u2 = z1 and z6;

u3 = z2 and z3;

u4 = z2 and z4;

u5 = h1 and z8;

u6 = z9 and z10;

u7 = z7 and z11;

u8 = z8 and z12;

u9 = h2 and z13;

u10 = z9 and !x4;

u11 = !x1 and z3;

v1 = u1 or u2;

v2 = u3 or u4;

v3 = u6 or u7;

v4 = u8 or u9;

v5 = u10 or u11;

g1 = u5 or v1;

f1 = v2 or g1;

f2 = v3 or v4;

f3 = u1 or v5;

printf(" ");

printf(f1 ? " 1 " : " 0 ");

printf(f2 ? " 1 " : " 0 ");

printf(f3 ? " 1 " : " 0 ");

// минимальная сисема

f1 = (!x1 && x3 && x4 && !x5) || (!x1 && x2 && !x3 && x4) || (!x1 && x2 && x3 && !x4 && x5) || (x1 && !x2 && !x3 && x4) || (x1 && !x2 && x4 && x5);

f2 = (!x1 && x2 && !x3 && x4) || (x1 && !x2 && !x3 && x4) || (!x1 && !x3 && !x4);

f3 = (!x1 && x3 && x4 && !x5) || (!x1 && x2 && x3 && !x4 && x5) || (!x1 && !x2 && x3 && !x4) || (!x1 && !x3 && !x4);

// модель

z1 = !x1 and x4;

z2 = !x1 and x3;

z3 = x1 and !x2;

z4 = !x1 and x4;

z5 = x2 and !x3;

z6 = x3 and !x5;

z7 = x2 and !x4;

z8 = !x3 and x4;

z9 = x4 and x5;

z10 = x2 and x4;

z11 = !x2 and x3;

z12 = !x1 and !x4;

z13 = !x2 and !x5;

u1 = z1 and z4;

u2 = z2 and z5;

u3 = z3 and z2;

u4 = z2 and z5;

u5 = z6 and z8;

u6 = z10 and z9;

u7 = z9 and z12;

u8 = z8 and z11;

u9 = z7 and z13;

u10 = z9 and !x4;

v1 = u1 or u2;

v2 = u3 or u4;

v3 = u6 or u7;

v4 = u8 or u9;

v5 = u10 or u11;

f1 = v2 or g1;

f2 = v3 or v4;

f3 = u1 or v5;

printf("\n");

}

int main() {

vector<vector<int>\*>\* list = new vector<vector<int>\*>();

int\* tmp;

int n = 1, m = 5, \* a = new int[m];

for (int i = 0; i < m; i++) a[i] = 0;

int i = 0;

gun(a, m);

while (NextSet(a, n, m)) {

gun(a, m);

}

return 0;

}

