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Circuit with distributed resistance sensor based on the residue numerical system

Streszczenie. *W pracy pokazano, że wykorzystanie systemu resztkowego pozwala skutecznie określić w różny sposób zmienną skokowo rezystancję każdego z kilku połączonych szeregowo rezystorów bazując na znanej całkowitej ich rezystancji. Wybór modułów rezystancji, które dobrze spełniają warunki formy systemu resztkowego lub jego modyfikacji, znacznie upraszcza obliczenia. Podano przykłady rozwiązywania zagadnień metodą analityczną oraz tabelaryczną (**Układ z rozproszonym czujnikiem rezystancyjnym oparty na liczbowym systemie resztkowym**).*

Abstract. *It has been shown that the use of residual classes allows the known total resistance effectively determine the resistance of each of several series-connected resistors. Selection of modules that satisfy the conditions of perfect form system of residue systems, greatly simplifies the calculations. Examples of solving the problem by using analytical and tabular methods.*

Słowa kluczowe: system numeryczny resztkowy, czujniki rezystancyjne,.
Keywords: Residue numerical systems**,** resistance sensors.

Introduction

From physics course is known that the total resistance of resistors connected in series is the sum of each resistance [1]. The reverse operation with the classical approach is virtually impossible. Its solution would be an important step for the development of automated management of specialized computer systems, technological objects are characterized by specific features that preclude direct access rights. One of the main tasks is a technical diagnostic of equipment and, also, control of a distributed liquid level or pressure, and temperatures in different points and at different levels of the studied ambient medium (e.g., to control the storage and movement records - oil and gas), where for money saving a two-wire line usage is highly recommended. Such problems are particularly relevant in geophysics, petroleum, coal, metallurgy, meteorology, aerospace and other industries.

An important aspect of research in this field is to develop approaches, methods, algorithms and computer tools for building distributed sensors [2] based on the use of the residue systems (RS).

Analysis of the literature

Sensors for monitoring of distributed values [3] of temperature and pressure are usually implemented in two ways: either a parallel structure with multi-channel information, or based on positional notation systems of information transmission line [4]. The disadvantage of the first method is the large number of independent lines of sensors to microcontrollers. The basis of the second method of constructing multisensory (MS) is a serial connection resistors R_i, resistance each of which can abruptly change the value ΔR_i, which determines the accuracy of the conversion value and consistent basis of calculation. Then the total resistance of the SBS defined analytical expression

$$R_x = \sum_{i=1}^{n} R_i .$$

The disadvantage of this method of measuring conversion is a significant difference between ΔR_i, which corresponds to where the ratio $\frac{\Delta R_{i+1}}{\Delta R_i} = A$, where A base of positional number system. For example, if A = 2 and A = 10, then respectively ΔR_i each channel must be changed in the 2 and 10 times. In addition, each sensor has a following in A times the range of conversion of the measured value compared to the previous one.

The purpose of this work is to develop theoretical foundations and methods of constructing multisensory converting measured values using resistor monochannal line of remote transmission of measurement data from RS.

Theoretical foundations of residue systems, modified and improved its perfect form

The theoretical basis of RS is the Number Theory [5] – [7]. Any positive integer N decimal number system represented it as a set ($b_1, b_2, \ldots, b_n$) $p_1, p_2, \ldots, p_n$ the least positive residue of dividing this number to fixed targets positive pair wise mutually prime numbers $p_1, p_2, \ldots, p_n$ ($b_i = N \bmod p_i$), called modules (n - the number of modules) [8]. This condition should be carried $0 \le N < P-1$, where

$$P = \prod_{i=1}^{n} p_i .$$

Reverse transformation of RS in the decimal number system based on Chinese remainder theorem on and is quite difficult and cumbersome [7]:

$$N = \left(\sum_{i=1}^{n} b_i B_i \right) \bmod P , \quad (1)$$

where $B_i = M_i m_i$, $M_i = \frac{P}{p_i}$, m_i sought from the expression $(M_i m_i) \bmod p_i = 1$, and must be the condition

$$\left(\sum_{i=1}^{n} B_i \right) \bmod P = 1 .$$

It should be noted that the search for the inverse element module $m_i = M_i^{-1} \bmod p_i$ has a large computational complexity. To zoom out, for example, [9] reviewed the analytical conditions of the inverse numbers. In addition, [10] - [11] developed the theoretical basis of perfect forms (PF) and modified perfect forms (MPF) of RS in which modules are selected so performed under conditions:

$$m_i = M_i^{-1} \bmod p_i = 1 , \; m_i = M_i^{-1} \bmod p_i = \pm 1 . \quad (2)$$

This avoids cumbersome perform search operation for inverse element module and multiplication in (1) on the basic numbers m_i .

To find the modules in PF RS write the first equation expression (2) in the form of:

$$(3)\qquad \begin{cases} M_1 \bmod p_1 = 1 \\ \ldots \\ M_n \bmod p_n = 1. \end{cases}$$

Multiplying each equation (3) on the module, we get:

$$(4)\qquad \begin{cases} P \bmod p_1^2 = p_1 \\ \ldots \\ P \bmod p_n^2 = p_n. \end{cases}$$

Solving (4) by standard methods of number theory according to the Chinese remainder theorem, have:

$$(5)\qquad P = \left(\sum_{i=1}^{n} p_i M_i^2 m_i^2 \right) \bmod M ,$$

where $M = \prod_{i=1}^{n} p_i^2 = P^2$.

Taking into account that PF RS m_i=1, and reducing module left and right part (5) in their common divisor $P=\prod_{i=1}^{n} p_i$, we write (5) as follows:

$$(6)\qquad \left(\sum_{i=1}^{n} M_i \right) \bmod P = 1 .$$

Equation (6) is equivalent equality:

$$(7)\qquad \sum_{i=1}^{n} M_i = kP + 1 ,$$

where k=1, 2, 3, ...

Dividing the left and right parts (7) on R, we obtain an expression for the search module set in PF RS:

$$(8)\qquad \sum_{i=1}^{n} \frac{1}{p_i} = k + \frac{1}{\prod_{i=1}^{n} p_i} .$$

Research of the equation for a large number of modules, whereas the sum of a number of divergent $\sum_{i=1}^{n} \frac{1}{p_i}$, i.e. k can be arbitrarily large, is very cumbersome task.

We confine ourselves to the simplest case for which k=1. It corresponds to the range calculations for a given number of modules. Expression (8) takes the following form:

$$(9)\qquad \frac{1}{p_1} + \frac{1}{p_2} + \frac{1}{p_3} + \ldots + \frac{1}{p_{n-1}} + \frac{1}{p_n} = 1 + \frac{1}{p_1 p_2 p_3 \cdots p_{n-1} p_n} .$$

Let unknowns are the last two modules p_{n-1} and p_n. Then (9) represented as follows:

$$(10)\qquad \begin{aligned} & p_{n-1} p_n (p_2 p_3 \cdots p_{n-2} + p_1 p_3 \cdots p_{n-2} + \ldots + p_1 p_2 \cdots p_{n-3} - \\ & - p_1 p_2 p_3 \cdots p_{n-2}) + p_1 p_2 \cdots p_{n-2} (p_{n-1} + p_{n-2}) = 1 \end{aligned} .$$

We introduce the notation:

$$(11)\qquad p_{n-1,n} = \frac{a,b - p_1 p_2 \cdots p_{n-2}}{p_2 p_3 \cdots p_{n-2} + \ldots + p_1 p_2 \cdots p_{n-3} - p_1 p_2 \cdots p_{n-2}} .$$

Substituting (11) in (10), after appropriate mathematical transformations will have a condition that must be performed to determine a set of modules for PF RS:

$$(12)\qquad \begin{aligned} & (p_2 p_3 \cdots p_{n-2} + p_1 p_3 \cdots p_{n-2} + \ldots + p_1 p_2 \cdots p_{n-3} - p_1 p_2 \cdots p_{n-2}) + \\ & + (p_1 p_2 \cdots p_{n-2})^2 = ab \end{aligned} .$$

This means that the left side (12) to be factorized, based on what defined parameters *a* and *b*. In addition, it follows from (11), the module p_n and p_{n-1} be integers, i.e.,

$$(13)\qquad \begin{aligned} & (a,b - p_1 p_2 \ldots p_{n-2}) \bmod (p_2 p_3 \ldots p_{n-2} + p_1 p_3 \ldots p_{n-2} + \ldots + \\ & + p_1 p_2 \ldots p_{n-3} - p_1 p_2 \ldots p_{n-2}) = 0. \end{aligned}$$

Thus, expressions (12) and (13) determine the conditions of the resistance from any number of modules RS PF, two of which are unknown. Elementary substitution can see that the only possible system of three modules PF RS is 2, 3, 5, since any increase in the groove. Left side (9) is less than 1. For four modules, there are two cases: 2, 3, 7, 41, 2, 3, 11, 13. Table 1 given all possible sets of six modules that form PF RS.

Table 1. Possible sets of six modules that form PF RS

№	p_1, p_2	p_3	p_4	p_5	p_6
1	2, 3	7	43	1807	3263441
2				1811	654133
3				1819	252701
4				1825	173471
5				1871	51985
6				1901	36139
7				1945	25271
8				2053	15011
9				2167	10841
10				2501	6499
11				3041	4447
12				3611	3613
13			47	395	779729
14				481	2203
15			53	271	799
16			71	103	61429
17		11	23	31	47057

As seen from the results, the first two modules regardless of their number must take values 2 and 3.

Unlike PF RS, the MPF of RS (8) can choose k=0. Then this expression becomes:

$$(14)\qquad \sum_{i=1}^{n} \frac{1}{p_i} = \pm \frac{1}{\prod_{i=1}^{n} p_i} .$$

By analogy to preliminary calculations we obtain conditions for sets of modules that form MPF RS:

$$(15)\qquad \begin{aligned} & \pm(p_2 p_3 \cdots p_{n-2} + p_1 p_3 \cdots p_{n-2} + \ldots + p_1 p_2 \cdots p_{n-3}) + \\ & + (p_1 p_2 \cdots p_{n-2})^2 = ab \end{aligned}$$

$$(16)\qquad \begin{aligned} & (a,b - p_1 p_2 \ldots p_{n-2}) \bmod (p_2 p_3 \ldots p_{n-2} + p_1 p_3 \ldots p_{n-2} + \ldots + \\ & + p_1 p_2 \ldots p_{n-3}) = 0. \end{aligned}$$

Its advantage is that the first model may take any values, and the next not so much increase as compared to PF because they can be negative. Especially important are the sets in which the modules have the same order as in table 2 for an example of the options are four modules in the MPF RS p_1=8, p_2=-9 obtained using (15), (16).

Method of constructing multisensory in RS

Let n have identical series-connected thermal or piezoresistors R_0 (Fig. 1), which can vary the resistance abruptly increments $\Delta R_i = \frac{R_0}{p_i}$, where p_i–mutually prime numbers or extensions that determine the accuracy of measuring conversion. The maximum value converted for each resistor $D_i = R_0\left(1-\frac{1}{p_i}\right)$, and, respectively, the maximum resistance values which can fix the system:

(17) $$D = \sum_{i=1}^{n} D_i = R_0 \cdot \sum_{i=1}^{n}\left(1-\frac{1}{p_i}\right).$$

Table 2. Variants of four modules for MPF RS at p_1=8, p_2=-9

№	p_1, p_2	p_3	p_4
1		-73	-5257
2		-71	5113
3		-77	-1109
4		-67	965
5		-89	-377
6		-55	233
7	8, -9	-133	-157
8		-11	13
9		-73	-5255
10		-71	5111
11		-143	-145
12		-1	1

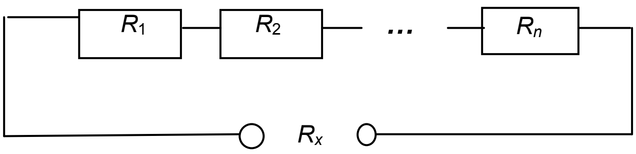

Fig. 1. Scheme of measuring conversion

The total resistance $R_x=\sum_{i=1}^{n} R_i$, which is determined by direct measurement, for the system shown in Fig. 1, you represented as the sum of the unknown resistance R_i. According to (1) find the number of possible combinations $P=\prod_{i=1}^{n} p_i$ and the basic number m_i. Then performed a sequence of actions:

(18) $X=R_x mod R_0$, $Y=\frac{XP}{R_0}$, $c_i=(m_i \cdot Y) mod\ p_i$.

Support each resistor is determined by the expression $R_i=c_i \cdot \Delta R_i$.

For example, take three resistors R0=10 Ohms, p_1=3, p_2=4, p_3=5. Тоді P=60; ΔR_1=3,33 Ом; ΔR_2=2,5 Ohms; ΔR_3=2 Ohms; m_1=2, m_2=3, m_3=3. According to (17), the measuring range conversion is in the range from 0 to 22.17 ohms.

Let the unit recorded value R_x=12,83 Ohms. As a result we get X=12,83mod10=2,83; $Y=\frac{2{,}83\cdot 60}{10}\approx 17$; c_1=(2·17)mod 3=1; c_2=(3·17)mod 4=3; c_3=(3·17)mod 5=1. Then the desired value R_1 =1·3,33 Ohms =3,33 Ohms; R_2 =3·2,5 Ohms =7,5 Ohms; R_3 =1·2 Ohms =2 Ohms.

The method of construction of MS using tables

Desired resistance R_i you can search by using tables. This speeds up the results, but requires the use of more memory for the computer system. According to the previous example table 3 was built.

Table 3. Construction tabular method for MS p_1=3, p_2=4, p_3=5

X	Y	c_1	R_1	c_2	R_2	c_3	R_3	R_x
0	0	0	0	0	0	0	0	0
0,17	1	2	6,67	3	7,5	3	6	20,17
0,33	2	1	3,33	2	5	1	2	10,33
0,5	3	0	0	1	2,5	4	8	10,5
0,67	4	2	6,67	0	0	2	4	10,67
0,83	5	1	3,33	3	7,5	0	0	10,83
1	6	0	0	2	5	3	6	11
1,17	7	2	6,67	1	2,5	1	2	11,17
1,33	8	1	3,33	0	0	4	8	11,33
1,5	9	0	0	3	7,5	2	4	11,5
1,67	10	2	6,67	2	5	0	0	11,67
1,83	11	1	3,33	1	2,5	3	6	11,83
2	12	0	0	0	0	1	2	2
2,17	13	2	6,67	3	7,5	4	8	22,17
2,33	14	1	3,33	2	5	2	4	12,33
2,5	15	0	0	1	2,5	0	0	2,5
2,67	16	2	6,67	0	0	3	6	12,67
2,83	17	1	3,33	3	7,5	1	2	12,83
3	18	0	0	2	5	4	8	13
3,17	19	2	6,67	1	2,5	2	4	13,17
3,33	20	1	3,33	0	0	0	0	13,33
3,5	21	0	0	3	7,5	3	6	13,5
3,67	22	2	6,67	2	5	1	2	13,67
3,83	23	1	3,33	1	2,5	4	8	13,83
4	24	0	0	0	0	2	4	4
4,17	25	2	6,67	3	7,5	0	0	14,17
4,33	26	1	3,33	2	5	3	6	14,33
4,5	27	0	0	1	2,5	1	2	4,5
4,67	28	2	6,67	0	0	4	8	14,67
4,83	29	1	3,33	3	7,5	2	4	14,83
5	30	0	0	2	5	0	0	5
5,17	31	2	6,67	1	2,5	3	6	15,17
5,33	32	1	3,33	0	0	1	2	5,33
5,5	33	0	0	3	7,5	4	8	15,5
5,67	34	2	6,67	2	5	2	4	15,67
5,83	35	1	3,33	1	2,5	0	0	5,83
6	36	0	0	0	0	3	6	6
6,17	37	2	6,67	3	7,5	1	2	16,17
6,33	38	1	3,33	2	5	4	8	16,33
6,5	39	0	0	1	2,5	2	4	6,5
6,67	40	2	6,67	0	0	0	0	6,67
6,83	41	1	3,33	3	7,5	3	6	16,83
7	42	0	0	2	5	1	2	7
7,17	43	2	6,67	1	2,5	4	8	17,17
7,33	44	1	3,33	0	0	2	4	7,33
7,5	45	0	0	3	7,5	0	0	7,5
7,67	46	2	6,67	2	5	3	6	17,67
7,83	47	1	3,33	1	2,5	1	2	7,83
8	48	0	0	0	0	4	8	8
8,17	49	2	6,67	3	7,5	2	4	18,17
8,33	50	1	3,33	2	5	0	0	8,33
8,5	51	0	0	1	2,5	3	6	8,5
8,67	52	2	6,67	0	0	1	2	8,67
8,83	53	1	3,33	3	7,5	4	8	18,83
9	54	0	0	2	5	2	4	9
9,17	55	2	6,67	1	2,5	0	0	9,17
9,33	56	1	3,33	0	0	3	6	9,33
9,5	57	0	0	3	7,5	1	2	9,5
9,67	58	2	6,67	2	5	4	8	19,67
9,83	59	1	3,33	1	2,5	2	4	9,83

In the first column there are all possible values of X, placed in ascending order. The value of Y in the second column, obtained by (18) indicates the serial number of the relevant parameter *X*. In the latter, the ninth column indicated the possible values of the impedance that can lock the device.

If the device recorded R_x=12,83 Ohms, then X=12,83 mod 10 = 2,83. Find the value given in Table 3 correspond to it c_1=1, c_2=3, c_3=1. Thus, the desired values R_1 =3,33 Ohms; R_2 =7,5 Ohms; R_3 =2 Ohms.

Fig. 2 shows a graph of the change in the total resistance R_x on the parameter *Y*, which varies in increments of 0.1667 at p_1=3, p_2=4, p_3=5.

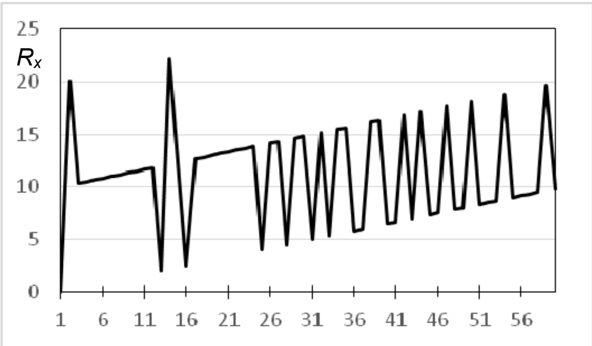

Fig. 2. Graph of the change in the total resistance R_x when the parameter X are p_1=3, p_2=4, p_3=5

From Fig. 2 shows that the timetable for R_x is spasmodic, with highs (except the two values) and minimums vary linearly.

Recommendations by the module sets in terms of number theory

In order to achieve approximately equal precision conversion resistance of each resistor selected relatively simple modules should not differ very much. An example would be a set of three consecutive numbers, including p_1=99, p_2=100, p_3=101 for R_0=100 Ohms. With the increasing number of modules they can be chosen as follows: p_1=101, p_2=102, p_3=103, p_4=107, p_5=109, … .

In terms of number theory to significantly reduce the number of computing modules desirable to choose so that they formed a PF of RS for which m_i=1. This avoids the performance is quite cumbersome operation of inverse element modulo $m_i = M_i^{-1}\ mod\ p_i$ multiplication and *Y* on the basic numbers m_i, as

(19) $c_i = Y\ mod\ p_i$.

Table 4 shows the possible values of the parameters at p_1=2, p_2=3, p_3=5, R_0=10 Ohms. It ΔR_1=5 Ohms; ΔR_2=3,33 Ohm; ΔR_3=2 Ohms. Accordingly, the maximum value of converting D = 19,67 Ohms. Let the unit recorded R_x=13,67 Ohms. Then *X*=13,67*mod*10=3,67; $Y = \frac{3,67 \cdot 30}{10} = 11$; c_1=11*mod* 2=1; c_2=11*mod* 3=2; c_3=11*mod* 5=1. Desired value R_1 =1·5 Ohms =5 Ohms; R_2=2·3,33 Ohms =6,67 Ohms; R_3 =1·2 Ohms =2 Ohms. The same value can be obtained using Table 4.

The disadvantage of this method is that the PF modules of RS rapidly growing and therefore substantially different conversion accuracy at various points.

Figure 3 show the relationship between changes in the overall resistance R_x on the parameter *Y*, which varies in increments of 0.33 at p_1=2, p_2=3, p_3=5.

From Fig. 3 shows that the timetable for R_x is too abrupt, yet, unlike all previous highs and lows vary linearly. In addition, the schedule is inversely symmetrical relative to the mid-range of the horizontal axis. For small values of X there are broader highs at large (more inside) - wider lows.

When measuring conversion to be executed only at two points, the set of modules conveniently choose in two consecutive large numbers, providing about the same highly accurate conversion. These modules form the MPF of RS for which the condition $m_i = M_i^{-1} \bmod p_i = \pm 1$. It also avoids searching inverse element modulo multiplication and *Y* on the basic numbers, as $m_1=p_2 mod\ p_1=(p_1+1)\ mod\ p_1=1$, $m_2=p_1\ mod\ (p_1+1)= -1\ mod\ (p_1+1)=p_1$. From here:

Table 4. Construction MS tabular method for p1=2, p2=3, p3=5

X	*Y*	c_1	R_1	c_2	R_2	c_3	R_3	R_x
0	0	0	0	0	0	0	0	0
0,33	1	1	5	1	3,33	1	2	10,33
0,67	2	0	0	2	6,67	2	4	10,67
1	3	1	5	0	0	3	6	11
1,33	4	0	0	1	3,33	4	8	11,33
1,67	5	1	5	2	6,67	0	0	11,67
2	6	0	0	0	0	1	2	2
2,33	7	1	5	1	3,33	2	4	12,33
2,67	8	0	0	2	6,67	3	6	12,67
3	9	1	5	0	0	4	8	13
3,33	10	0	0	1	3,33	0	0	3,33
3,67	11	1	5	2	6,67	1	2	13,67
4	12	0	0	0	0	2	4	4
4,33	13	1	5	1	3,33	3	6	14,33
4,67	14	0	0	2	6,67	4	8	14,67
5	15	1	5	0	0	0	0	5
5,33	16	0	0	1	3,33	1	2	5,33
5,67	17	1	5	2	6,67	2	4	15,67
6	18	0	0	0	0	3	6	6
6,33	19	1	5	1	3,33	4	8	16,33
6,67	20	0	0	2	6,67	0	0	6,67
7	21	1	5	0	0	1	2	7
7,33	22	0	0	1	3,33	2	4	7,33
7,67	23	1	5	2	6,67	3	6	17,67
8	24	0	0	0	0	4	8	8
8,33	25	1	5	1	3,33	0	0	8,33
8,67	26	0	0	2	6,67	1	2	8,67
9	27	1	5	0	0	2	4	9
9,33	28	0	0	1	3,33	3	6	9,33
9,67	29	1	5	2	6,67	4	8	19,67

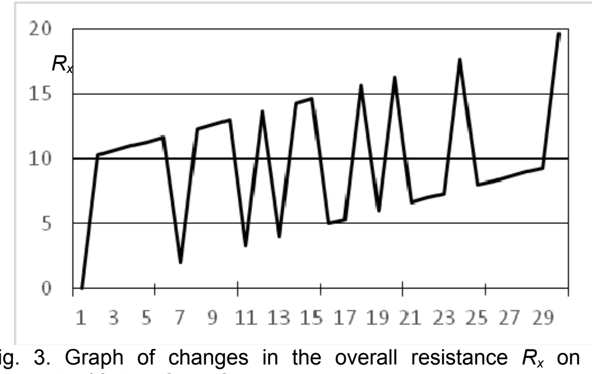

Fig. 3. Graph of changes in the overall resistance R_x on the parameter *Y* at p_1=2, p_2=3, p_3=5

(20) $C_1=Y\ mod\ p_1$, $c_2=(p_2-Y\ mod\ p_2)$.

Table 5 presents an example of the possible values of the parameters in p_1=5, p_2=6, R_0=10 Ohms, ΔR_1=2 Ohms; ΔR_2=1,67 Ohms. The maximum value you can specify device *D*=16,33 Ohms. Then m_1=1, m_2=5*mod* 6=–1 *mod* 6.

Suppose, for example, the value of the device fixed R_x=12,67 Ohms. Analytical methods will be: *X*=12,67*mod*10=2,67; $Y = \frac{2,67 \cdot 30}{10} = 8$; c_1=8*mod* 5=3; c_2=6--(8*mod* 6)=4. Desired value R_1 =3·2 Ohms =6 Ohms; R_2=4·1,67 Ohms =6,67 Ohms. the same results Using Table 5 are.

Table 5. Construction of tabular method for BPS p_1=5, p_2=6

X	Y	c_1	R_1	c_2	R_2	R_x
0	0	0	0	0	0	0
0,33	1	1	2	5	8,33	10,33
0,67	2	2	4	4	6,67	10,67
1	3	3	6	3	5	1
1,33	4	4	8	2	3,33	11,33
1,67	5	0	0	1	1,67	1,67
2	6	1	2	0	0	2
2,33	7	2	4	5	8,33	12,33
2,67	8	3	6	4	6,67	12,67
3	9	4	8	3	5	13
3,33	10	0	0	2	3,33	3,33
3,67	11	1	2	1	1,67	3,67
4	12	2	4	0	0	4
4,33	13	3	6	5	8,33	14,33
4,67	14	4	8	4	6,67	14,67
5	15	0	0	3	5	5
5,33	16	1	2	2	3,33	5,33
5,67	17	2	4	1	1,67	5,67
6	18	3	6	0	0	6
6,33	19	4	8	5	8,33	16,33
6,67	20	0	0	4	6,67	6,67
7	21	1	2	3	5	7
7,33	22	2	4	2	3,33	7,33
7,67	23	3	6	1	1,67	7,67
8	24	4	8	0	0	8
8,33	25	0	0	5	8,33	8,33
8,67	26	1	2	4	6,67	8,67
9	27	2	4	3	5	9
9,33	28	3	6	2	3,33	9,33
9,67	29	4	8	1	1,67	9,67

Figure 4 shows the relationship between changes in the overall resistance R_x on the parameter X, which varies in increments of 0,33 at p_1=5, p_2=6.

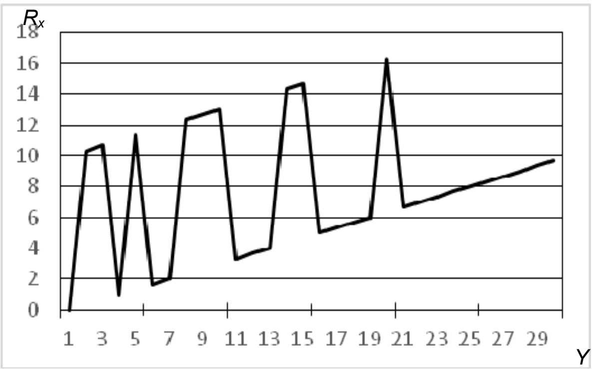

Fig. 4. Graph of changes in the overall resistance R_x on the parameter Y at p_1=5, p_2=6

From Fig. 4 shows that the number of peaks is reduced, while increasing the Y minima becomes wider.

If the measurement is necessary to convert more than two points, the modules should be selected so that they are formed of RS PF and slightly different from each other. For example, take four resistors selecting modules according to Table 2, as follows: p_1=8, p_2=9, p_3=11, p_4=13 i P=10296. It is easy to verify that m_1=7*mod* 8=–1 *mod* 8, m_2=1, m_3=1, m_4=12*mod* 13=–1 *mod* 13, selected modules that satisfy the condition of PF RS. For R_0=10 Ohms will have: ΔR_1=1,25 Ohms; ΔR_2=1,11 Ohms; ΔR_3=0,91 Ohms; ΔR_4=0,77 Ohms.

Let the device recorded value R_x=11,55 Ohms. Then, similarly to the formulas (2) - (4) can get the desired value resistors: X=11,55*mod*10=1,55;

$Y = \frac{1{,}55 \cdot 10296}{10} \approx 1596$; c_1=8-1596*mod* 8=8-4=4;

c_2 =1596*mod* 9=3; c_3=1596*mod* 11=1;

c_4 =13 -1596*mod* 13 =13-10 = 3;

R_1 = 4·1,25 Ohm = 5 Ohm; R_2 = 3·1,11 Ohm =3,33 Ohm;

R_3 =1·0,91 Ohms=0,91 Ohms;

R_4 =3·0,77 Ohms = 2,31 Ohms. These results show that the amount of found resistance is equal to that shown device.

Conclusions

Based on the foregoing, we conclude that the use of RS allows the known total resistance determine effectively the resistance of each of several series-connected thermal or piezoresistor, the analyzed option which changes abruptly. It is shown that the selection of modules satisfying PF of RS or MPF of RS can greatly simplify the calculation by avoiding bulky item search operation inverse modulo and multiplying by the basic numbers. Examples of solving the problem by using analytical and tabular methods, the choice of which is caused by the time required computing and storage capacity of computer system.

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