РАЗДЕЛ VIII. ЭЛЕКТРОТЕХНИКА

Hovhannisyan A.T., Margaryan M.K., Harutyunyan L.G., Sargsyan S.Y., Avetisyan H.A.

The impact of reed montage characteristics on the magnetic moving force of control winding

*National Polytechnic University of Armenia
(Armenia, Yerevan)*

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Abstract

The amount of impact of shortening or bending the contact-cores of reed switch on reed relay's calculated magnetic moving force in the technological processes is investigated. The influence of bending the contact-cores by 90° is presented. Expressions by the type of reed switches are given as well, to evaluate the impact of shortening contact-cores with corresponding lengths.

Keywords: reed switch, relays, control winding, contact-core, magnetic moving force, shortening, bending.

Аннотация

Исследовано влияние укорочения или изгиба контакт-сердечников герконов в технологических процессах на расчетное значение магнитной движущей силы обмотки управления при проектировании герконового реле. Приведено значение влияния изгиба контакт-сердечников при угле 90°. Даны выражения по типу герконов, с помощью которых можно оценить значение влияния при укорочении контакт-сердечников по длине.

Ключевые слова: геркон, реле, обмотка управления, контакт-сердечник, магнитная движущая сила, укорочение, изгиб.

Introduction

Reed switches are magnetically controlled hermetic contacts used in automation, control and security systems, counting and measuring mechanisms, toys, and elsewhere in the fields of electrical engineering, energetics, everyday life. Different apparatus and systems, various relays, linear and angular movement converters, logical devices, electric buttons, sensors, etc are made with reed switches, where a control winding (CW) with constant or variable flux or the permanent magnet are the sources of the magnetic field [3, 6, 7].

While in factory, reed switches are tested in, such called, standard winding (SW) as a single-contact relay and depending on the results a technical document of a reed switch of that type is formed. In the document, the main parameters are the value of the working magnetic moving force (MMF) (given in a range), the working resource, time parameters, etc [1÷3].

Problem settings and method justification

Because of the variety of the range of reed switch usage, there might be a need to bend or shorten the edges of the contact-cores (CC) depending on the need to montage the reed relay and its measurements [3].

The features of the technological process of bending or shortening the edges of CCs are given in fig. 1 and fig. 2, retrieved from the available literature.

Fig. 1. The technology of bending reed switch CC

Fig. 2. The technology of shortening reed switch CC

In the case of shortening reed switch CCs, the ℓ_{r0} length of factory-produced reed switch is reduced into ℓ_r (fig. 3).

Fig. 3. Shortening by cutting reed CCs

While estimating and designing a reed relay, the calculated F_c value of CW's MMF is an important measurement, that depends on the presence or absence of relay's external magnetic wire (EM) (depending on the structure), and, in case of a multi-contact relay, on the interaction between the reed switches. These should be evaluated by corresponding coefficients, which condition the parameters of the CW [4, 5, 8, 9].

The calculated F_c MMF of reed relay's CW is determined by the following expression:

a) for single-contact

$$F_c = K_t K_r K_{EM} F_{w0}, \quad (1)$$

b) for multi-contact

$$F_c = K_t K_r K_{in} F_{w0}, \quad (2)$$

where F_{w0} is the maximum original value of reed's working MMF given in the reference books, K_r is the reserve coefficient according to the working MMF $K_r = 1, 1.2, 5$, K_t is the technological coefficient conditioned by bending or shortening CCs of reed switches, K_{in} is the coefficient evaluating the interaction between N sequential reeds in a multi-contact relay (interaction coefficient).

In case of a single-contact reed relay without EW:

$$K_{EM} = 1.$$

In case of a single-contact reed relay with EW the influence of the EW on the induction value of the magnetic field according to the K_w window coefficient of the CW is evaluated [10]:

$$K_{EM} = 1 / (0,137 \cdot 10^{-4} \cdot K_w^4 - 0,992 \cdot 10^{-3} \cdot K_w^3 + 2,515 \cdot 10^{-2} \cdot K_w^2 - 0,261 \cdot K_w + 2,264), \quad (3)$$

where $K_w = \ell_w / h_w$, ℓ_w is the length of the CW, h_w is the highth of the CW.

The value of K_{in} coefficient, evaluating the interaction of reeds in a multi-contact relay, can be determined as follows [4, 5]:

a) for a multi-contact reed relay without an EM

$$K_{in} = 1.36 \cdot 10^{-4} N^4 - 3.94 \cdot 10^{-3} N^3 + 3.03 \cdot 10^{-2} N^2 + 1.89 \cdot 10^{-1} N^1 + 1, \quad (4)$$

b) for a multi-contact reed relay with an EM

$$K_{in} = 0.37 \cdot 10^{-4} N^4 - 1.54 \cdot 10^{-3} N^3 + 1.37 \cdot 10^{-2} N^2 + 1.63 \cdot 10^{-1} N^1 + 1. \quad (5)$$

In order to determine the technological K_t coefficient of the reed switches, some research is done in SW with the following types of reeds: a symmetric normal КЭМ-1 with open CCs and $\ell_{r0} = 80mm$, a КЭМ-2 with $\ell_{r0} = 45,6mm$, and an asymmetric inter insulating КЭМ-3 with $\ell_{r0} = 54mm$.

In case of 90° bending of the reed, the F_w working and F_{off} switching off MMFs were measured and compared to the values of F_{w0} and F_{off0} before bending. According to the results, the values of F_w have increased by 3,4% in КЭМ-1, by 3,0% in КЭМ-2, and by 7,6% in КЭМ-3. The values of F_{off} have decreased by 0,8%, 3,1% and 1,4% correspondingly.

The value of K_t is determined by the following expression:

$$K_t = F_w / F_{w0}. \quad (6)$$

Depending on the type of the reed switch the value of K_t according to F_w has been 1,034, 1,03 and 1,076.

Based on the production characteristics and convenience of calculations, it's highly advised to take $K_t = 1,05 \div 1,1$ in calculations of the expressions (1) and (2) for CC's 90° bending.

The results of the research on the case of shortening the CCs of the reed switches are given in the tables 1÷3, where $K_t = \frac{\ell_r}{\ell_{r0}}$, and K_t indicates the results of the trial research, calculated using the expression (5).

Table 1

The results of the research on КЭМ-1 type reed switch

КЭМ -1	$K_{\ell 1}$	0,95	0,89	0,83	0,77
	K_{t1}	1,08	1,14	1,18	1,26
	K_{t1}	1,08	1,14	1,18	1,26
	$\delta, \%$	0	0	0	0

Table 2

The results of the research on КЭМ-2 type reed switch

КЭМ -2	$K_{\ell 2}$	0,93	0,86	0,77	0,71	0,63
	K_{t2}	1,09	1,16	1,23	1,26	1,38
	K_{t2}	1,07	1,13	1,20	1,24	1,36
	$\delta, \%$	1,8	2,6	2,4	1,6	1,4

Table 3

The results of the research on КЭМ-3 type reed switch

КЭМ -3	$K_{\ell 3}$	0,93	0,86	0,80	0,72	0,65
	K_{t3}	1,06	1,12	1,14	1,17	1,21
	K_{t3}	1,08	1,14	1,16	1,18	1,22
	$\delta, \%$	1,9	1,8	1,7	0,8	0,8

The results of the scientific experiment were analyzed and interpreted using Lagrange interpolating formula, using which the exponential of $K_t = f(K_{\ell})$ dependence is given in the expressions (7÷9) by K'_t depending on the reed type.

- for КЭМ-1 type reed switch:

$$K'_{t1} = -27,13K_{\ell}^4 + 47,04K_{\ell}^3 + 0,68K_{\ell}^2 - 37,13K_{\ell} + 17,51, \quad (7)$$

- for КЭМ-2 type reed switch:

$$K'_{t2} = 137,4K_{\ell}^4 - 447,1K_{\ell}^3 + 542,1K_{\ell}^2 - 291K_{\ell} + 59,68, \quad (8)$$

- for КЭМ-3 type reed switch:

$$K'_{t3} = -56,38K_{\ell}^4 + 166K_{\ell}^3 - 181,6K_{\ell}^2 + 87,04K_{\ell} - 14,15. \quad (9)$$

The values of K and relative δ deviation are given in the tables 1÷3 using the expression (10):

$$\delta = \frac{|K'_t - K_t|}{K_t} 100\%. \quad (10)$$

The resulting values of δ prove that the expressions (7÷9) reflect the $K_t = f(K_\ell)$ dependence rather good, as the value of δ is about 0% for КЭМ-1, no more than 2,6% for КЭМ-2, and 1,9% for КЭМ-3.

Using the average of calculated K_t values we get the following general expression:

$$K_{\text{tav}} = 17,96K_\ell^4 - 78,02K_\ell^3 + 120,4K_\ell^2 - 80,36K_\ell + 21,01. \quad (11)$$

The values calculated using this expression are presented in table 4.

Using the expression (11), for each type of the reed switch the values of K_{tav} and δ deviation from the results of the research (given in percents) were calculated. The results are given in tables 5÷7 according to the type of the reed switch.

Table 4

The results by reed switch type calculated using expression (7÷9, 11)

$K_{\ell 1}$	0,60	0,65	0,70	0,75	0,80	0,85	0,90	0,95
K_{t1}	2,12	1,74	1,47	1,30	1,21	1,17	1,13	1,08
K_{t2}	1,47	1,31	1,24	1,21	1,19	1,14	1,09	1,06
K_{t3}	1,25	1,22	1,19	1,17	1,16	1,14	1,11	1,05
K_{tav}	1,61	1,42	1,30	1,23	1,19	1,15	1,11	1,06

Table 5

The results of research on КЭМ-1 type reed switch using expression (11)

КЭМ -1	$K_{\ell 1}$	0,95	0,89	0,83	0,77
	K_{t1}	1,08	1,14	1,18	1,26
	K_{tav}	1,06	1,12	1,17	1,21
	$\delta, \%$	1,8	1,7	0,8	4,0

Table 6

The results of research on КЭМ-2 type reed switch using expression (11)

КЭМ -2	$K_{\ell 2}$	0,93	0,86	0,77	0,71	0,63
	K_{t2}	1,09	1,16	1,23	1,26	1,38
	K_{tav}	1,09	1,14	1,21	1,28	1,49
	$\delta, \%$	0	0,9	1,6	2,4	8,0

Table 7

The results of research on КЭМ-3 type reed switch using expression (11)

КЭМ -3	$K_{\ell 3}$	0,93	0,86	0,80	0,72	0,65
	K_{t3}	1,06	1,12	1,14	1,17	1,21
	K_{tav}	1,09	1,15	1,19	1,27	1,42
	$\delta, \%$	1,0	2,7	4,4	8,5	17,3

The resulting values of δ in the tables 5÷7 prove that the expressions (10) reflect the $K_t=f(K_\ell)$ dependence rather good. The maximum value of δ did not exceed 4% for КЭМ-1, 8% for КЭМ-2, and 18% for КЭМ-3.

We think, that the derived expression (11) can be used as a generalized one in order to determine the impact of CC shortening on the process of calculating MMF of reed switch when estimating and designing a reed relay.

Fig. 4 illustrates the graphic of the expression (11) (in graph $K_{tav}=K_t$). Its implementation can simplify the process of estimating the impact of CC shortening on the process of calculating the MMF of reed switch.

Fig. 4. Graph of $K_t=f(K_\ell)$ function

Conclusion The results of the research can assist on the process of estimating the impact of bending or shortening CCs of a reed switch on the process of calculating the MMF of reed switch when estimating and designing a reed relay.

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