Semiconductor Physics, Quantum Electronics & Optoelectronics. 2002. V. 5, N 2. P. 193-196.

PACS: 85.60.Bt, 42.79.Kr

Model of dynamic indication in the bar graph form

A.V. Bushma, N.I. Sypko
Institute of Semiconductor Physics, NAS of Ukraine, 45 prospect Nauky, 03128 Kyiv, Ukraine
Phone: +380 (44) 265-6188; fax: +380 (44) 265-5430; e-mail: bushma@isp.kiev.ua

Abstract. The main principles of formation of dynamic bar graph representation using display with a matrix electric connection of elements have been considered in this work. Applying the theory of sets we formalized a synthesis of symbols and obtained logic operators describing a formation of a visual image at the display information area. Offered and analysed is the information model for the bar graph form of information representation using the scale with scanning along the columns (elder digits) of the element matrix.

Keywords: indication in bar graph form, dynamic control, display, modeling, multielement bar graph array, array connection of elements, information area, theory of sets, logical operator.

Paper received 08.04.02; revised manuscript received 31.05.02; accepted for publication 25.06.02.

1. Introduction

The main information amount coming to a man from technical means is transferred by the sight. Indication facilities transform coming information into a visual form. These convert data into visual images in accord with a definite system of rules that are determined by an information model (IM). When developing information-measuring systems, they use IM that represent the essence of real processes and states of controlled objects in the best way using special coded images [1, 2].

Among IM widely used in measuring technique, location means and communication systems, the particular place in occupied by the bar graph display [3]. It is caused by the fact that such a way of data output provides simply recognized and effective image representation of information. Using this IM, annunciation in the indicator information area is determined both by its length and position of reading out end of an optical non-uniformity relatively to scale marks. It can be, for instance, a luminous line at the scale of an indicator based on active elements. A combination of the bar graph IM with digit methods of data processing provides high reliability of information transfer to an operator from indication means.

2. Design of imaging means with the bar graph indication form

Displays with multi-element scales enable to provide highly informative and discret indication. It determined the considerable practical interest to them in various types of measuring systems [1]. It is indicative of displays with multi-element (more than 15-20) scales that two-coordinated matrix electrical connection of elements is used. As a result, the amount of controlling buses is considerably reduced, which increases reliability of an imaging unit as a whole. However, this electrical scheme of the display causes some supplementary difficulties when realizing a control circuit, as it does not enable to simultaneously excite an arbitrary group of information area elements (IAE). Besides, there arise undesirable conditions of exciting unchosen IAE, which is caused by simultaneous supplying contacts of element groups with electric signals. This parasitic illumination worsens quality of visual symbols formed [2].

Harnessing the dynamic methods for an image synthesis at display panels enables to overcome these limitations restricting IAE integration into groups. It is obvious that in the case, the necessary group of elements is divided by sub-groups, elements of which allow simultaneous excitation. Elimination or essential reducing the parasitic illumination caused by unchosen elements is provided here by using IAE with threshold characteristics and unipolar conductivity as well as the respective algorithm of their excitation [2, 3].

The analysis of logic-time regularities characterizing the synthesis of IM for indication in the bar graph form at the multi-element scale display used in optoelectronic information-measuring systems is represented in this work.

3. Modelling the dynamic bar graph data representation

Information is transferred to an operator using S_ν symbols that in their visual form represent data upon the controlled value. The set of symbols used in determined by IM and forms its alphabet Ω_{IM}. A display unit provides a synthesis of all IM symbols in its information area. These can be determined as a set

$$\Omega_{BG} = \\ = \{ S_{1BG}, S_{2BG}, \ldots, S_{\nu BG}, \ldots, S_{(l-1)BG}, S_{lBG} \} \quad (1)$$

where Ω_{BG} is the alphabet of the bar graph IM;
$S_{\nu BG}$ is the ν-th symbol, with $\nu = \overline{1, l}$;
l is the IM alphabet length.

The alphbet length equal to the amount of different symbols in IM is determined by the finite set of allowable states in the display information area. A symbol image is formed from excited discrete display elements by the control circuit in accord with IM. The set A of display elements a_i is described as

$$A = \{ a_1, a_2, \ldots, a_i, \ldots, a_{p-1}, a_p \}, \quad (2)$$

where p is a total amount of elements comprised by the display information area; $i = \overline{1, p}$.

In an electrical representation, the display elements a_i are usually two-terminals. In multi-element displays, these, as a rule, are connected by a two-coordinated matrix, while their spatial location is determined by topology of IM used. The bar graph form of information representation assumes presence of a weight function $\varpi_i = \varpi(a_i)$ intrinsic to each IAE a_i. Obviously, its value is related to the element position in the display information area and is in proportion to the i number in the scale. Therefore, we assume that the set A is absolutely ordered [4]. In this set, the weight function is determined and the inequality $\varpi(a_j) < \varpi(a_{j+1})$ is valid for all $j = \overline{1, (p-1)}$. Information read-out is performed in accordance with the weight function value relatively to scale marks that serve as a multi-channel measure [1].

Symbols $S_{\nu BG}$ are synthesized from a_i elements incorporated into the A set determined by expression (2). Therefore, each visual symbol from the set Ω_{BG}, described by (1), can be supplied with one-to-one correspondence of a definite IM subset of a_i elements from the set A. IM of the bar graph form data representation is characterized by formation of a continuous visual image consisting of excited elements. The synthesized line of IAE begins from the element possessing the lowest value of the weight function. The end of the line is determined by IAE with the weight function corresponding to the imaged meaning of information. Let us assume that the symbol corresponding to the zeroth value of an input signal has the positional number $\nu = 1$. Then, using the unification operator one can write

$$S_{\nu BG} \Leftrightarrow A_{\nu BG} = \bigcup_{i=1}^{\nu} a_i = \\ = \{ a_1, a_2, \ldots, a_i, \ldots, a_{\nu-1}, a_\nu \}, \quad (3)$$

where $A_{\nu BG}$ is a subset of the set A, which forms the visual $S_{\nu BG}$ symbol image in the display information area.

In accord with the operator (3), the synthesis of symbols in the display information area is possible only at series connection of two-terminal elements or when using one common electrode. The display matrix electrical scheme does not allow to simultaneously excite all IAE that belong to the set $A_{\nu BG}$, corresponding to the symbol $S_{\nu BG}$. Therefore, used is the dynamic formation of the visual image $S_{\nu BG}$ for the number of series time intervals (cycles). Their amount is determined by IM and corresponds to conventional principles of scanning the display elements. In doing so, each of l IAE sets $A_{\nu BG}$, corresponding to l symbols of the alphabet Ω_{BG}, is divided by the number of uncrossed subsets excited within different cycles of $S_{\nu BG}$ symbol formation

$$A_{\nu BG} = A^{D}_{\nu BG} = \\ = \{ A^{1}_{\nu BG}, A^{2}_{\nu BG}, \ldots, A^{q}_{\nu BG}, \ldots, A^{r-1}_{\nu BG}, A^{r}_{\nu BG} \}, \quad (4)$$

where $A^{D}_{\nu BG}$ is the set identical to $A_{\nu BG}$ and is its dynamic equivalent;
$A^{q}_{\nu BG}$ is a subset of the set $A^{D}_{\nu BG}$ consisting of elements a_i, which corresponds to the q-th cycle of formation of the dynamic visual $S_{\nu BG}$ symbol representation, with,
$\bigcap_{q=1}^{r} A^{1}_{\nu BG} = \varnothing$ and $q = \overline{1, r}$;
r is an amount of cycles necessary to synthesize the visual symbol image.

An obligatory condition to create a stable observable image of any visual symbol is to exceed a critical flicker frequency of $f_S = 1/T_S$ by a frequency of image regeneration [3]. In this case, each group of a_i elements, incorporated into the set $A^{q}_{\nu BG}$ is excited during every symbol recovering period within the time range $\tau_g = T_S / r$.

Then from (3), taking (4) into account, one can obtain the generalized IM for the dynamic bar graph form data representation

$$S_{\nu\,\mathrm{BG}} \Leftrightarrow A^{\mathrm{D}}_{\nu\mathrm{BG}} = \bigcup_{i=1}^{\nu} a_i \Bigg|_{T_S} = \bigcup_{q=1}^{r} A^{q}_{\nu\mathrm{BG}} \Bigg|_{t=t+(q-1)\tau_g}^{t=t+q\tau_g}, \tag{5}$$

where T_s is the peroid of $S_{\nu\,\mathrm{BG}}$ symbol formation in the display information area.

4. The information model for the bar graph form data representation based on scanning along matrix element columns

An information area of a multi-element bar graph display consisting of p elements corresponding to (2), from an electrical viewpoint, can be built, as a rule, in the form of two-coordinate matrix comprising n groups with m elements in each one where ($m{\cdot}n$=p). As a result, this unit is some multi-terminal with (m+n) outputs. Every common bus for a group of elements that are located near each other in the information area is the output terminal of one of n elder digits. The respective value of the weight function is determined by the position of this group relatively to the scale marks. Every common output terminal for elements with the same number in all groups serves as a bus for one of m younger digits. The relative value of the weight function for these buses is determined by positions of group elements connected with them. It follows thereof that the element $a_i = a_{xy}$ possesses the number y in the group number x with $x = \overline{1, n}$, $y = \overline{1, m}$. In such a case, its positional number in the scale is determined by the expression $i = m \cdot x + y$. Then for ν-th IAE one can write that in the matrix it occupies $y_\nu = \nu - m \cdot \mathrm{E}(\nu/m)$ position in the group with the number $x_\nu = \mathrm{E}(\nu/m) + 1$, where E is Entire. As a consequence, the operator (3) for matrix connection of display elements can be written in the following form

$$S_{\nu\,\mathrm{BG}} \Leftrightarrow A_{\nu\,\mathrm{BG}} = \bigcup_{i=1}^{\nu} a_{xy} \Bigg|_{\substack{x=\mathrm{E}(i/m)+1 \\ y=i-m\cdot\mathrm{E}(i/m)}} =$$

$$= \{ a_1,\ a_2,\ \ldots,\ a_{xy},\ \ldots,\ a_{\nu-1},\ a_\nu \}\ . \tag{6}$$

The algorithm for scanning the IAE matrix determines the specific appearance of $A^{q}_{\nu\mathrm{BG}}$ groups of a_i elements represented by (4). One of the typical variants to form the image when using two-coordinate matrix scheme of electrical connections of display elements is scanning along the columns (groups) [2]. In this case, the amount of $A^{q}_{\nu\mathrm{BG}}$ elements incorporated into the $A^{\mathrm{D}}_{\nu\mathrm{BG}}$ set described in (4), and the amount of formation cycles for the model (5) is equal to r=n. It is obvious that within any cycle, the arbitrary amount of elements related to one switched-on column of the matrix elder digits can be excited. This a_i element set can be described as

$$A^{x}_{\mathrm{BG}} = \bigcup_{y=1}^{u} a_{xy} =$$

$$= \{ a_{x1},\ a_{x2},\ \ldots,\ a_{xy},\ \ldots,\ a_{x(u-1)},\ a_{xu} \}, \tag{7}$$

where $A^{x}_{\nu\mathrm{BG}}$ is the set of excited elements related to the column number x when representing information in the bar graph form and scanning the IAE along matrix columns;

u is an amount of excited elements in the column with, in general case, $u = \overline{0,\ m}$.

Our analysis of expressions (5), (6) and (7) shows that the synthesis of all elements of the alphabet Ω_{BG} results in formation of n sets $A^{x}_{\nu\mathrm{BG}}$, that is for scanning the matrix of IAE along columns in the model (5) we used $q = x$. There are three possible variants to create $A^{x}_{\nu\mathrm{BG}}$ with different analytical description, namely: when the number of excited elements in the column $u = 0$, $u = m$ and $0 < u < m$.

Then, starting from the generalized model (5) and taking into account (6) and (7), IM for the bar graph representation of data in the display with matrix electrical connection of IAE can be represented as

$$S_{\nu\mathrm{BG}} \Leftrightarrow A^{\mathrm{D}}_{\nu\mathrm{BG}} = \bigcup_{i=1}^{\nu} a_i \Bigg|_{T_S} = \bigcup_{x=1}^{n} A^{x}_{\nu\mathrm{BG}} \Bigg|_{T_S} =$$

$$= \left\{ \bigcup_{x=1}^{\mathrm{E}\left(\frac{\nu}{m}\right)} \left[\bigcup_{y=1}^{m} a_{xy} \Bigg|_{t=t+(x-1)\tau_g}^{t=t+x\tau_g} \right] \right\} \bigcup$$

$$\bigcup \left\{ \bigcup_{x=\mathrm{E}\left(\frac{\nu}{m}\right)+1}^{\mathrm{E}\left(\frac{\nu}{m}\right)+1} \left[\bigcup_{y=1}^{\nu-m\mathrm{E}\left(\frac{\nu}{m}\right)} a_{xy} \Bigg|_{t=t+(x-1)\tau_g}^{t=t+x\tau_g} \right] \right\} \bigcup$$

$$\bigcup \left\{ \bigcup_{x=\mathrm{E}\left(\frac{\nu}{m}\right)+2}^{n} \left[A_{\varnothing} \Bigg|_{t=t+(x-1)\tau_g}^{t=t+x\tau_g} \right] \right\}, \tag{8}$$

where t is a flowing time for dynamic formation of the symbol image;

$A_{\varnothing}$ is an empty set.

It is noteworthy that IM (8) describing $S_{\nu\,\mathrm{BG}}$ symbol formation in a dynamical mode for n cycles can be characterized by three time intervals. During the first one corresponding to cycles from the first one up to

$q_1 = \mathrm{E}(\nu/m)$ all elements of the first q_1 matrix columns are excited. During the second interval equal by its duration to one cycle, elements of the column with the number $q_2 = \mathrm{E}(\nu/m) + 1$ are transfered to an excited state. Their amount can be changed from unity up to m in dependency on a reproduced symbol. In third period that is formed by cycles with numbers from $q_2 = \mathrm{E}(\nu/m) + 2$ to n, excitation of IAE is not made. It corresponds to formation of empty sets $A_{\varnothing}$ of elements in respective matrix columns.

5. Conclusions

Thus, we have considered principles of formation of the dynamic bar graph data representation in a display. Based on the theory of sets, offered is a formalized description suitable to synthesize symbols from elements of linear scale information area. Obtained are the logical operators that model the process of formation of a visual image at the bar graph display with matrix connection of elements. Offered and analysed is IM with the bar graph form of imaging information at the scale with scanning along columns (elder digits) of the two-coordinate element matrix.

Represented results creates an analytical basis to research and comprehensively optimize functional, structural and general-circuit simulations of units for information output in optoelectronic information-measuring systems. It will enable to increase efficiency of display devices as well as simplify their integration into automated means of controlling the complex objects and technological processes.

References

1. P.P. Ornatsky, *Theoretical principles of information-measuring techniques*. (in Russian), Kyiv, Vyshcha shkola, 1983, 455 p.
2. F.M. Yablonsky, Yu.V. Troitsky, *Means for imaging information* (in Russian). Moscow, Vysshaya shkola, 1985, 200 p.
3. Stan Gage, Mark Hodapp, Dave Evans, Hans Sorensen. *Optoelectronics application manual*. McGraw-Hill Book Company, New York, 1977.
4. V.P. Sigorsky, *Mathematics for engineers* (in Russian), Kyiv, Tekhnika, 1975, 768 p.