15th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2011, Prague, Czech Republic, 12-18 September 2011

THE MOTION CHARACTERISTIC CODE, SCREW MOTION AND SPATIAL PRESENTATION OF FIVE COMBINATIONS OF MOTIONS FOR BASIC KINEMATICS BLOCKS AT THE MECHANISM DESIGN

Dr. Sc. Kastriot A. Buza
Faculty of Education
Address: Agim Ramadani, nn 10000 Prishtina
Kosova

Dr.Sc.Ismajl Gojani, Dr.Sc.Arbnor Pajaziti, Dr.Sc.Fevzi Radoniqi
Faculty of Mechanical Engineering
Address: Kodra e Diellit, nn 10000 Prishtina
Kosova

ABSTRACT
The concept of mechanisms design methodology includes the motion characteristics, and functional, topological and dimensional synthesis.
Functional synthesis selects the basic kinematic building blocks using the Motion Characteristic Code (MCC), while during topological synthesis the basic kinematics building blocks are assembled using dual-vector algebra.
From the data base of the basic kinematics building blocks can be determined: types of motion (Rotation – Rotation, Rotational –Translation, Translation – Translation, Helical – Rotation, Helical – Translation), relation between input-output motions (Parallel, Perpendicular, Incline) and motion characteristics (Linearity and Non-Linearity).
In the paper the representatives of five types of the motions are analysed and for each basic kinematic building block is presented: Motion Characteristic Code, Screw Motion and picture showing the spatial orientation.
Key words: Basic Kinematics Building Blocks, Motion Characteristic Code, Screw Motion, Spatial Orientation.

1. INTRODUCTION
Mechanism design can be realised using several methodologies [1,2,8,9,10].
The methodology the algorithm that presents the mechanisms design using Basic Kinematics Blocks goes through four basic phases: (a) Motion Specifics, (b) Functional Synthesis, (c) Topological Synthesis and (d) Dimensional Synthesis [1,2].In the motion specifics and functional synthesis the Motion Characteristic Code is taken into consideration, while at topological synthesis the methodology of dual-vector algebra is used [1].

2. METODOLOGY OF DUAL - VECTOR ALGEBRA
It is known that motion of any solid body in three-dimensional space can be represented through screw kinematic couples [1,4].
Screw can be represented by displacement and line. Line contains the information about position and direction of the motion. Displacement represents the transformation between rotational and translational motion. The motion transformation can be divided into a dual-number and dual-vector [1, 4, 8].

The final expression for screw motion for basic kinematics block is given as:

$$\hat{S} = (\alpha + \varepsilon a)\left[\begin{Bmatrix} l_x \\ l_y \\ l_z \end{Bmatrix} + \varepsilon \begin{Bmatrix} r_y l_z - r_z l_y \\ r_z l_x - r_x l_z \\ r_x l_y - r_y l_x \end{Bmatrix}\right] \quad (1)$$

3. METODOLOGY OF MOTION CHARACTERISTIC CODE (MCC)

Some authors, the motion in input and output of the kinematics block have used Motion Transformation Matrices of First Level (MTL[1]) and Operational Constraint Vector (OCV) [2, 3, 9, 10]. Similarly, in this paper Motion Characteristic Code (MCC) including data is used to determine the type of motion, continuity, linearity and direction of building blocks.

Motion Characteristic Code from can be described by:

$$MCC = (Motion\,Type, Continuity, Linearity, Direction) \quad (2)$$

Kinematics function for each building block is presented correctly through two Motion Characteristic Codes: the first one represents characteristics of input motion and the second one characteristics at output.

4. MOTION CHARACTERISTIC CODE (MCC), SCREW MOTION AND SPATIAL PRESENTATION OF FIVE COMBINATIONS OF MOTIONS FOR BASIC KINEMATICS BLOCKS

Analyzing screw motion for simple order kinematics couples and their synthesis, the high order kinematics couples can be realized.

Therefore, for five combinations of basic kinematics blocks are given: motion characteristic code (MCC), screw motion input and output, type of the basic kinematics block and spatial orientation [1].

Type of motions: Rotation(Input) –Rotation (Output)

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	OUTPUT
0-Rotation 0-Continuous 0-Linear 0-Unidirectional	0-Rotation 0-Continuous 0-Linear 0-Unidirectional

$$\hat{S}_I = (\theta_I \quad + \quad \varepsilon \cdot 0)\left[\begin{Bmatrix} 0 \\ 0 \\ 1 \end{Bmatrix} + \varepsilon \begin{Bmatrix} 0 \\ 0 \\ 0 \end{Bmatrix}\right].$$

$$\hat{S}_O = (G(\theta_I) \quad + \quad \varepsilon \cdot 0)\left[\begin{Bmatrix} 0 \\ 0 \\ 1 \end{Bmatrix} + \varepsilon \begin{Bmatrix} 0 \\ -D \\ 0 \end{Bmatrix}\right].$$

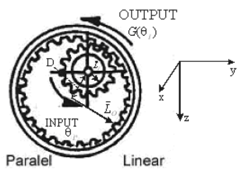

Figure 1. Internal Gear Pear Follower

Type of motions: Rotation(Input) –Translation (Output)

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	OUTPUT
0-Rotation 0-Continuous 0-Linear 0-Unidirectional	1-Translation 0-Continuous 1-Nonlinear 0-Unidirectional

$$\hat{S}_I = (\theta_I \quad + \quad \varepsilon \cdot 0)\left[\begin{Bmatrix} 0 \\ 0 \\ 1 \end{Bmatrix} + \varepsilon \begin{Bmatrix} 0 \\ 0 \\ 0 \end{Bmatrix}\right].$$

$$\hat{S}_O = (0 \quad + \quad \varepsilon \cdot D(\theta_I))\left[\begin{Bmatrix} 1 \\ 0 \\ 0 \end{Bmatrix} + \varepsilon \begin{Bmatrix} 0 \\ 0 \\ -D \end{Bmatrix}\right].$$

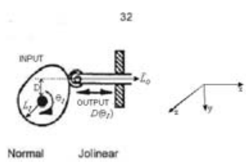

Figure 2. Cam-

<u>*Type of motions: Translation(Input) –Translation (Output)*</u>

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	**OUTPUT**
1-Translation 0-Continuous 0-Linear 0-Unidirectional	1-Translation 0-Continuous 1-Nonlinear 0-Unidirectional

$$\hat{S}_I = (0 \quad + \quad \varepsilon \cdot d_I)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\0\\0\end{Bmatrix}\right].$$

$$\hat{S}_O = (0 \quad + \quad \varepsilon \cdot F(d_I))\left[\begin{Bmatrix}0\\1\\0\end{Bmatrix} + \varepsilon\begin{Bmatrix}-D\\0\\0\end{Bmatrix}\right].$$

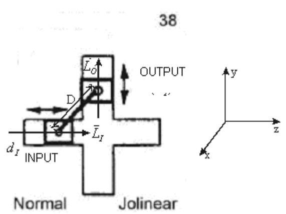

Figure 3. Double Slider

<u>*Type of motions: Helical (Input) -Rotation (Output)*</u>

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	**OUTPUT**
2-Helical 0-Continuous 0-Linear 0-Unidirectional	0-Rotation 0-Continuous 0-Linear 0-Unidirectional

$$\hat{S}_I = (\theta_I \quad + \quad \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\0\\0\end{Bmatrix}\right].$$

$$\hat{S}_O = (F(\theta_I) \quad + \quad \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}D\\0\\0\end{Bmatrix}\right].$$

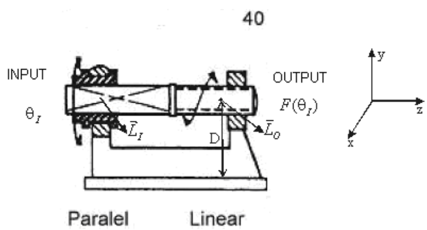

Figure 4. Screw Mechanism

<u>*Type of motions: Helical (Input) -Translation (Output)*</u>

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	**OUTPUT**
2-Helical 0-Continuous 0-Linear 0-Unidirectional	1-Translation 0-Continuous 0-Linear 0-Unidirectional

$$\hat{S}_I = (\theta_I \quad + \quad \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\0\\0\end{Bmatrix}\right].$$

$$\hat{S}_O = (0 \quad + \quad \varepsilon \cdot G(\theta_I))\left[\begin{Bmatrix}0\\1\\0\end{Bmatrix} + \varepsilon\begin{Bmatrix}D\\0\\0\end{Bmatrix}\right].$$

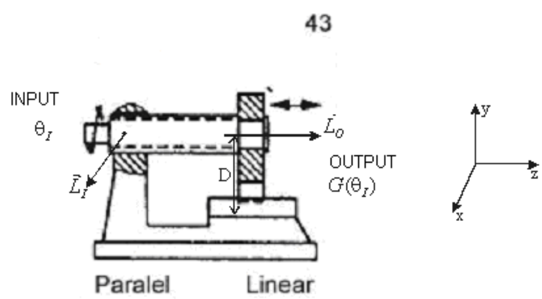

Figure 5. Screw Mechansim

5. CONCLUSIONS

Based on in-depth analyses of 43 basic kinematic blocks, representation of motion characteristic code, input-output of the screw motion and spatial presentation, it can be concluded that by:

- Kinematic couple Rotation-Rotation 26 combinations can be realized

- Kinematic couple Rotation-Translation 7 combinations can be realized
- Kinematic couple Translation-Rotation 6 combinations can be realized
- Kinematic couple Helical-Rotation 3 combinations can be realized
- Kinematic couple Helical-Translation 1 combination can be realized
- The methodology of dual-vector algebra enables realization of a high number of alternate solutions on mechanisms design.

6. REFERENCES

[1] Buza K.: Kontribut sintezës së mekanizmave duke shfrytëzuar algjebrën e vektorit-dual, Disertacioni i doktoraturës (Doctorate thesis), Prishtina, 2006.

[2] Buza K.: Disajnimi automatik i mekanizmave me ndihmen e programeve aplikative, Punim magjistrature (Master work), Prishtina, 2003.

[3] Buza K., Pirraj B., Gojani I., Pajaziti A., Anxhaku A.: General Matrix Model at the Second Level of Automatic Synthesis Procedre of the Mechanisms, Proceedings of the 10th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology", TMT 2006, Barcelona –Lloret de Mar, Spain, 11-15 September, 2006, pp. 785-788.

[4] Buza K., Gojani I., Pajaziti A., Anxhaku A.: Screw Motion of Some Basic Kinematic Blocks Through Dual-Vector Algebra, Proceedings of the 11th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology", TMT 2007, Hammamet, Tunisia, 5-9 September, 2007, pp. 891-894.

[5] Buza K., Gojani I., Pajaziti A., Anxhaku A.: Motion Characteristic Code at the Screw Motion for Some Basic Kinematics Blocks Using Dual-Vector Algebra, Proceedings of the 12th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology", TMT 2008, Istambul, Turkey, 26-30 August, 2008, pp. 1005-1008.

[6] Buza K., Gojani I., Pajaziti A., Buza Sh., Anxhaku A.: Comparison of First Level Motion Transformation Matrix and Operational Constraint Vector with Motion Characteristic Code at the Mechanisms Design, Proceedings of the 13th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology", TMT 2009, Hammamet, Tunisia, 16-21 October, 2009, pp. 601-604.

[7] Buza K., Buza Sh., Gojani I., Pajaziti A., Radoniqi F.: Design of Lathe-Blade Mechanism with Basic Kinematics Blocks Using Methodology of Dual-Vector Algebra, Proceedings of the 14th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology", TMT 2010, Mediterranean Cruise, 10-19 September, 2010, pp. 449-452.

[8] Moon Y.-M., Kota S.: Automated synthesis of mechanisms using dual-vector algebra, Mechanism and Machine Theory 37, pp.143-166, Ann Arbor, 2002

[9] Y.-M.Moon, *Reconfigurable Machine Tool Design: Theory and Application*, Ph.D. Dissertation, The University of Michigan, Ann Arbor, Michigan, 2000.

[10] Waldron K. J., Kinzel G. L.: Kinematics, Dynamics and Design of Machinery, Second Edition, John Wiley and Sons, USA, 2004.