Journal of Electrical Engineering, Electronics, Control and Computer Science – JEEECCS, Volume 10, Issue 37, pages 1-6, 2024

New Review of a Polymorph Duty Cycle Modulation Technique in Industrial Electronics Engineering

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***Abstract* – This paper presents the state of the art of relevant research works, on the theory and application areas of the polymorph DCM (duty cycle modulation) technique. A brief summary of the first review paper about is provided. Then, additional potential research works published until today are outlined. Furthermore, a set of unexplored application areas are illustrated, in order to show unexplored application areas, to be considered in future research works, on polymorph electronic devices for duty cycle modulation, in industrial electronics Engineering.**

Keywords- State of the art; Duty cyle modulation; theory and applications; Polymorph electronic devices; unexplored aplication areas; industrial electronics engineering

I. INTRODUCTION

The PDCM (Polymorph Duty Cycle Modulation) circuit considered in this paper is the dynamic core of electronic modulation devices, initiated since 2005 in pioneering works ([1], [2]). Figure 1 shows its electronic scheme in which x(t) is a modulating input and Em(x(t)) = ±E being a switching modulated output. The relevance of the PDCM policy is to overcome a few technical weaknesses, of most switching modulation techniques used in industrial electronics, e.g. Sigma Delta, Pulse Width, etc.

From 2005 to 2018, significant research works have been published in most leading international scientific Journals, on both theory and relevant applications of the PDCM policy.

As a significant outcome, a first review paper about the achievements of the PDCM technique and technology, has been published in [3].

Figure 2 shows Matlab Pie plot of published works from 2005 to 2018 about the PDCM technique and its most relevant applications, in industrial electronics engineering. These applications consist of a total of 18 published papers, excluding however published scientific conferences and symposiums, as well as PhD thesis defended during the same time period. It is important to note here that, the Pie plot in figure 2, is a visual tool for performance comparison of 18 sample types, collected over the same time period.

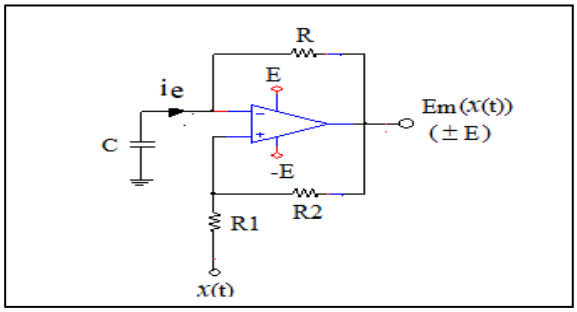

Figure 1. PDCM modulation circuit

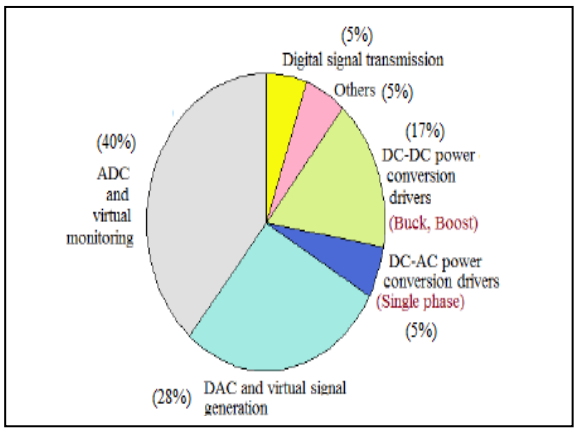

Figure 2. Matlab Pie plot of PDCM application areas from 2005 to 2018 [2].

In Section II of this paper, the overall research works published from 2005 to 2024 are presented. Then, section 3 might deal with new open research areas to be explored by the PDCM technique are pointed out, followed by the conclusion of this near review paper.

II. Research Works From 2019 To 2024 About Polymorph DCM Tehnique

From 2019 to 2024, additional research works of PDCM policies, have been studied in depth and published. These additional research works are summarized in Table 1.

TABLE I. PDCM APPLICATIONS

Main applications from 2019 to 2024		
N	***Type***	***Ref***
1	Buck chopper	[4]
2	DC/AC converter	[5]
3	ECG signal transmission	[6]
4	PID/LQR Control driver	[7]
5	Solar DC-AC power converter	[8]
6	Harmonics reduction in electric net woks	[9]
7	Harmonics reduction in photovoltaic systems	[10]
8	Power Filter for Duty Cycle Modulation	[11]
9	DCM Structures for Industrials Applications	[12]
10	PDCM-based ECG signal transmission system	[13]
11	FPGA-Based Multi-Channel A/D Converter	[14]
12	DCM and Fuzzy Controller of a Chopper	[15]
13	PDCM and Sigma-Delta modulation schemes	[16]

At this point, it is quite clear to discover that unlike any classic DCM strategy (e.g. Sigma-delta, pulse width), with restricted application areas, our PDCM strategy and technique, appears to be a relevant scientific challenge, since it offers unlimited application areas in industrial electronics, as well as in signal processing and transmission engineering.

Figure 3 stands for a simple Matlab code to be edited for automatic drawing, of the **Pie3 plot**, given the set of ordered input data values {1 3 1 3 1 3 1 1}. Each data set being associated with corresponding labels to be displayed on the graph. As an implication, the set of ordered quantities indicates the respective weights assigned to corresponding labels. Compared to the "diagram per year" strategy, a single **Matlab Pie3** plot offers the simplest way, to compare statistical outcomes of many data sets, over the same time horizon.

```
% Pie3Dcm.m

% Matlab code for pie3 command
% Sample from 2019 to 2024
% ***************************
pie3 ([1  3   1  3  1  3  1   1 ], ...
     {  ' Signal Transmission ',   ...
        ' ADC drivers  ' ,  ...
        ' DAC drivers',       ...
        ' Harmonic Filter',   ...
        ' DC-AC Power' ,   ...
        ' Power Buck and Boost',  ...
        ' 3-Phase Power Inverters', ...
        ' Other'
     } );

% ****************************
% ****************************
```

Figure 3. Matlab code of Pi3 plot (2019- 2024)

As a result, Figure 4 shows a corresponding Matlab **Pie3 plot** of data collected from 2019 to 2024, given a total of 14 papers, selected in leading international scientific journals. Given statistical trends emerging from Matlab Pie3 plots in both Figure 2 and Figure 4, the novelty have been:

- A continuous interest about all research fields initiated before 2018.
- An increasing need from 2018, on new applications areas of the PDCM technique, including 3-phase power inverters and even harmonic filters for power electric networks.

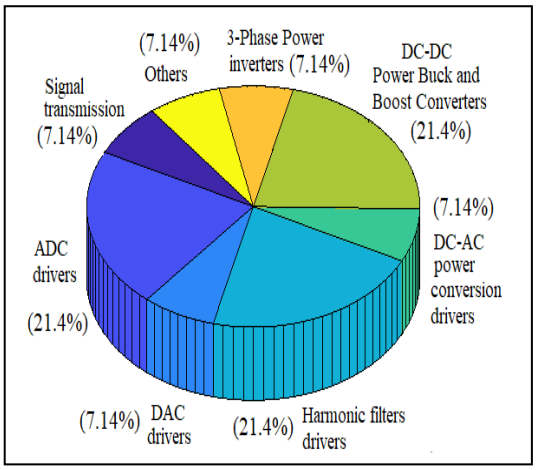

Figure 4. Matlab Pie3 plot of PDCM application areas from 2019 to 2024.

III. Overall Application Areas Of The Duty Cycle Modulation Technique From 2005 To 2024

The aim of this section is to combined both Pie3 plots (in Figure 3 for 2005-2018 and Figure 4 from 2019 to 2024 data), in order to discover the overall Pie3 plot over a target time period (i.e. 2005-2018).

Figure 5 stands for a unified Matlab code to be used for automatic plotting a single overall Pie3 graph from 2005 to 2024, of international scientific researches, in theory and relevant applications of the PDCM technique and technology.

```
1   %  Matlab code for pie3 command
2   %  January 12, 2025
3   %
4   % ****************************
5   pie3 ([2  10  6  3  2  3  1  2 ], ...
6      { ' Signal Transmission ',        ...
7        ' ADC drivers  ' ,        ...
8        ' DAC drivers',           ...
9        ' Harmonic Filter',       ...
10       ' DC-AC Power' ,          ...
11       ' Power Buck and Boost',  ...
12       ' 3-Phase Power Inverters',  ...
13       ' Other'
14     } );
```

Figure 5. Matlab code of Pi3 plot (2005 - 2024)

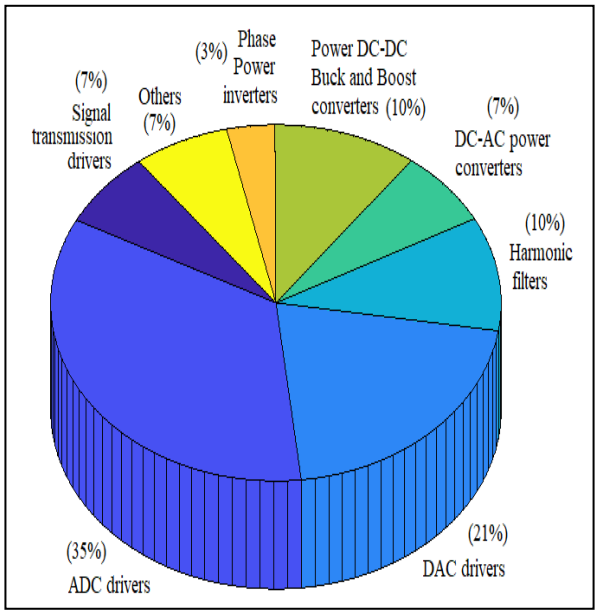

Figure 6. Matlab Pie3 plot of PDCM technique (2005- 2024)

From Section I to Section III of this new review paper, it is obvious that 100% of scientific references, cited until now about existing PDCM works, have been restricted to published scientific papers. However, it is also important to outline that, the history of the PDCM drivers and devices, has been consolidated also overtime until today, by a growing defended PhD thesis. Fortunately, the scientific content of most of cited published papers, have been extracted from the content of the related PhD research.

IV. Future Research Opportunities For PDCM Drivers And Devices

Although the PDCM technique and technology has been increasingly used from 2005 to 2024, numerous of news application fields might be further explored, as a more beneficial strategy for solving industrial electronics engineering problems, as well as signal processing and transmission devices.

A few of these new application fields to be further explored for industrial electronics and signal transmission needs, are summarized as follows:

- Buck-Boost Power converters in Figure 7.
- Three phase DC-AC converters in Figure 8.
- Multilevel power converters in Figure 9.
- Output chaotic control in Figure 10.

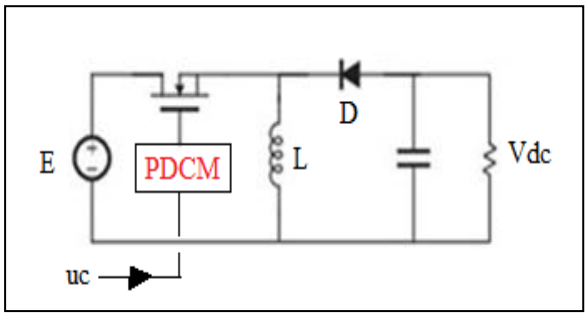

Figure 7. PDCM Buck-Boost Power converters

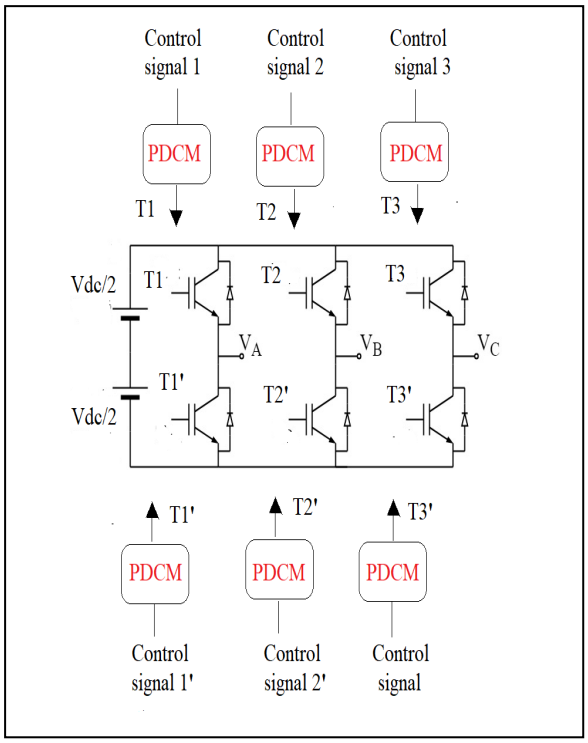

Figure 8. PDCM-based three Phase DC-AC Power converter

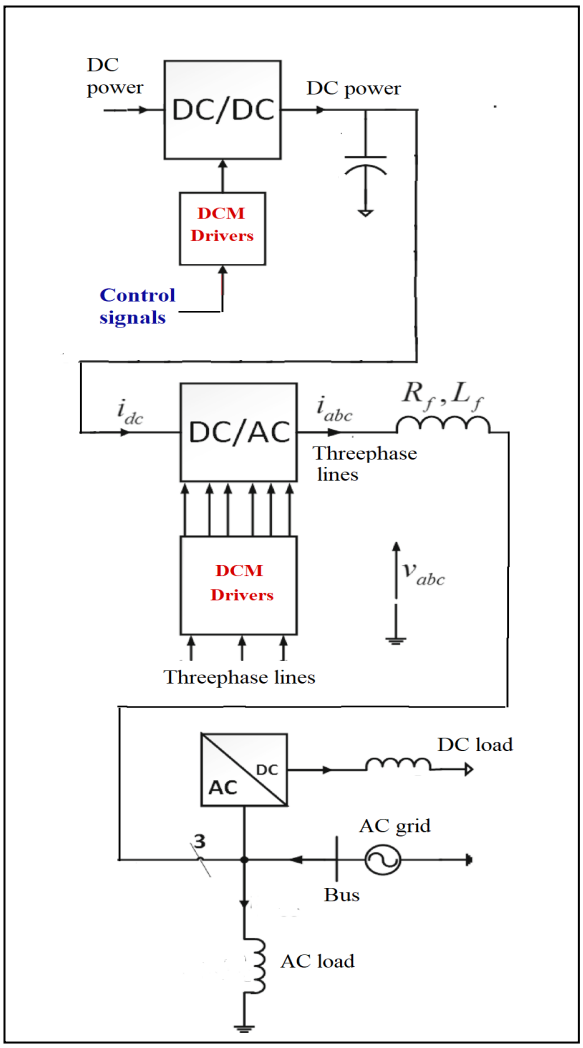

Figure 9. PDCM drivers for electronic power systems

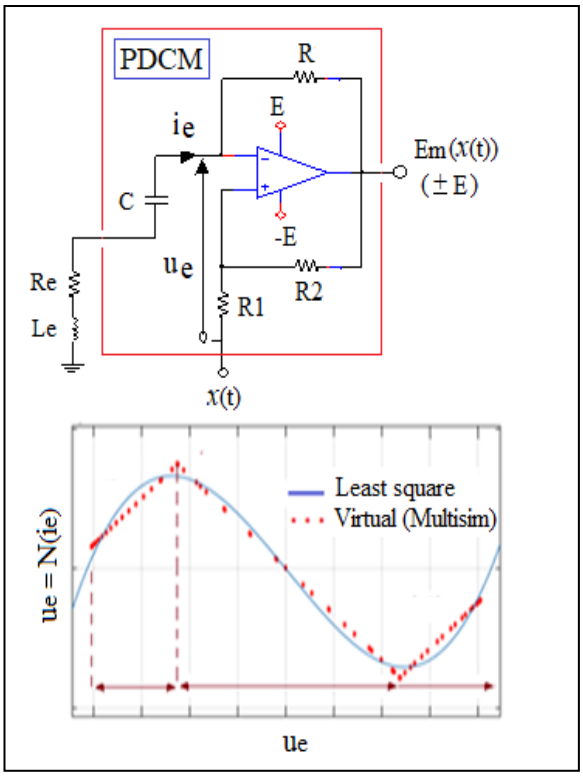

Figure 10. PDCM for chaotic oscillator [17].

The novelty in Figures 7, 8 and 9 relies on the use in industrial electronics of PDCM devices, which are more robust and efficient than PWM power converters [18]-[19].

CONCLUSION

This new review paper can be considered as an overall state of the art, about PDCM (Polymorph Duty Cycle Modulation) drivers and devices, from 2005 to 2024. Obviously, this time period has been characterized by a fast growing application areas, due to a PDCM core, involving the same types of building electronic components. However, the most contributions of this second review paper, would have been to outline a great variety of new application fields to be explored in future research works, in industrial electronics as well as in signal processing and transmission systems engineering.

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