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Journal of Engineering and Applied Sciences
(AJEAS)
e-ISSN: 3023-6002

Alfa Mühendislik ve Uygulamalı Bilimler Dergisi
(2025) 3/1: 1 – 14

Research Article

*DOI: 10.70988/ajeas.1583799*

*Received: 11/14/2024*

*Accepted: 03/28/2025*

*Published: 04/30/2025*

# PID Controller Design in Buck Converters: Real-Time Implementation and Performance Evaluation with TMS320F28379D

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## Abstract

Among the advancing technology, energy management systems and power electronics studies are becoming more and more significant day by day. Therefore, the application areas of buck converters in industrial and consumer electronics are increasing day by day. In this study, a simple and effective real-time controller for buck converters is designed and implemented. The study aims to performance the dynamic performance of the system and reduce energy losses by using the advantages of real-time control. One of the most important objectives is to reduce complex programming processes by using a model-based approach. With this model-based approach, easy changes of the system are provided with a fast intervention to the changes in the system. With the developed TMS320F28379D based real-time control approach, the stability and response time of the buck converter are tested. Simulations and experimental studies have shown that the proposed hardware and software architecture provides stable, fast and accurate results in the control of buck converters. As a consequence, this study aims to contribute to the field of power electronics by providing an effective, simple and accessible control mechanism that improves energy conversion processes. In addition, since the results obtained can be used as a reference in the design of similar systems, it is expected to be useful for both academic and industrial applications. When the voltage control of the buck converter is made for 2 Volts, the voltage change, and the duty cycle reach the desired steady state in $1.75*10^{-3}$ seconds. The results show that the proposed control structure provides a suitable and reliable solution for industrial applications. Future studies on energy efficiency and control systems will open the door to innovative designs in this field.

***Keywords:*** *TMS320F28379D controller, Buck converter, Closed loop controller, Real-time controller*

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# Buck Dönüştürücülerde PID Kontrolör Tasarımı: TMS320F28379D ile Gerçek Zamanlı Uygulama ve Performans Değerlendirmesi


## Özet

Gelişen teknoloji içerisinde enerji yönetim sistemleri ve güç elektroniği çalışmaları gün geçtikçe daha da önem kazanmaktadır. Bu nedenle buck dönüştürücülerin endüstriyel ve tüketici elektroniğindeki uygulama alanları her geçen gün artmaktadır. Bu çalışmada, buck dönüştürücüler için basit ve etkili bir gerçek zamanlı denetleyici tasarlanmış ve uygulanmıştır. Çalışma, gerçek zamanlı kontrolün avantajlarını kullanarak sistemin dinamik performansını artırmayı ve enerji kayıplarını azaltmayı amaçlamaktadır. En önemli amaçlardan biri model tabanlı bir yaklaşım kullanarak karmaşık programlama süreçlerini azaltmaktır. Model tabanlı bu yaklaşım ile sistemdeki değişikliklere hızlı bir şekilde müdahale edilerek sistemin kolay bir şekilde değiştirilmesi sağlanmaktadır. Geliştirilen TMS320F28379D tabanlı gerçek zamanlı kontrol yaklaşımı ile buck dönüştürücünün kararlılığı ve tepki süresi test edilmiştir. Simülasyonlar ve deneysel çalışmalar, önerilen donanım ve yazılım mimarisinin buck dönüştürücülerin kontrolünde kararlı, hızlı ve doğru sonuçlar verdiğini göstermiştir. Sonuç olarak bu çalışma, enerji dönüşüm süreçlerini iyileştiren etkili, basit ve erişilebilir bir kontrol mekanizması sağlayarak güç elektroniği alanına katkıda bulunmayı amaçlamaktadır. Ayrıca elde edilen sonuçlar benzer sistemlerin tasarımında referans olarak kullanılabileceğinden hem akademik hem de endüstriyel uygulamalar için faydalı olması beklenmektedir. Buck dönüştürücünün gerilim kontrolü 2 Volt için yapıldığı zaman, geriliminin değişimi ve doluluk oranının $1,75*10^{-3}$ saniyede istenilen kararlı hale ulaşmaktadır. Sonuçlar, önerilen kontrol yapısının endüstriyel uygulamalar için uygun ve güvenilir bir çözüm sağladığını göstermektedir. Enerji verimliliği ve kontrol sistemleri üzerine gelecekte yapılacak çalışmalar bu alanda yenilikçi tasarımlara kapı aralayacaktır.


***Anahtar kelimeler:*** *TMS320F28379D denetleyicisi, Buck dönüştürücü, Kapalı çevrim denetleyici, Gerçek zamanlı denetleyici*

Citation: G. Gorel, Y. Bektes, F. Korkmaz, H. Ozkaya, "PID Controller Design in Buck Converters: Real-Time Implementation and Performance Evaluation with TMS320F28379D", AJEAS. (2025) 3(1): 1-14. http://dx.doi.org/10.70988/ajeas.1583799

## 1. Introduction

Energy efficiency is one of the important issues of sustainable development today. Energy saving during production, transmission, distribution and consumption is important in terms of economic gain and reducing negative impacts on the environment. Especially in industrial areas, energy efficiency enables better use of resources and lower costs by optimizing business processes. In addition, increasing energy efficiency facilitates the integration of renewable energy sources and reduces fossil fuel dependency. Considering all these situations, the development and implementation of energy efficiency strategies is an important need at individual and societal levels [1]. Therefore, energy efficiency should be the most important goal for a sustainable future.

The improvement of energy conversion systems, frequently used in developing technology, has become an essential subject of study in electronic system design. Buck converters' role and usage area in modern power electronics are increasing daily. Buck converters work primarily based on the cycle of energy storage and release by the switching process. They generally work with inductive and capacitive elements to provide efficient current and voltage control. In addition, using advanced algorithms to control these systems helps obtain the desired output values by reducing cyclic voltage and current errors. The efficiency of the control systems of these transducers plays a vital role in energy efficiency and system performance [2]. When optimal control algorithms are implemented, the stability of the system increase, and energy losses are reduced with the ability to react quickly to dynamic load conditions.

Optimal control of buck converters is crucial for the system's efficiency, stability, and dynamic response time. Software-based control technologies, especially with integration of the digital control algorithms, improved the performance of buck converters [3]. PID control is a widely used method to reduce losses and optimize system response. In addition, improved adaptive control strategies and fuzzy logic-based methods offer effective solutions for adapting to variable load conditions. Modern microcontrollers provide high processing power and allow real-time implementation of complex control algorithms [4-5].

The selection of the optimum control method is very important to improve system performance and achieve the targeted output. Especially in buck converters, these applications significantly impact the system's stability and throughput. Among the important criteria in determining the performance of control systems, factors such as dynamic response time, control cycle speed and algorithm complexity draw attention. While the dynamic response time shows how quickly the system can respond to instantaneous changes; control cycle speed is essential for continuous monitoring and control. On one hand dynamic response time indicates the speed with which the system can react to instantaneous changes; control cycle speed is essential for continuous monitoring and control. Moreover, the control method can also influence both application integration and system load thereby being inherently related to overall reliability and performance [6]. Thus, it goes without saying that we must account for such features in a control application design as well.

In applications where efficiency is important, such as Buck converters, real-time operation of control algorithms reduces energy losses and improves system performance. Advanced control units, such as TMS320F28379D microprocessor boards, ensure that these systems operate with the desired precision. Increased reliability and efficiency lead to a smoother progression of industrial automation processes, since new features are added with real-time control. This field of engineering (real-time control system) has become an important topic in research and development [7].

This study aims to develop a new approach by offering alternatives to traditional methods of controlling buck converters. Thus, the findings obtained are hoped to contribute to academic literature and be a valuable reference for industrial applications. In addition to all these contributions, it also contributes to simple programming in universities and academic education. The main purpose of the controller to be developed is to increase the efficiency of buck converters and reduce energy losses. In this context, the design of real-time control algorithms is important to improve the system's dynamic response and ensure its stability. In addition, good use of the features offered by TMS320F28379D microprocessor card is critical to improving the overall performance of the system. The research aims to examine the integration of this controller with real-time operating systems and the challenges encountered in software development processes. As a result, the analysis of the data obtained is necessary to evaluate the performance of the developed system and, thus, to ensure its suitability for industrial applications [8]. These findings will contribute to the literature on optimizing energy efficiency and control strategies.

## 2. Buck Converters

Buck converters are effective and efficient basic electronic circuit elements used in the conversion of dc-dc voltage levels. These converters use high frequency switching to reduce the input voltage to a desired output voltage. The selection of components used in the design of the conversion system is critical; Suitable capacitors and inductors increase the stability of the system, ensuring sustainable control. The switch controls the output voltage level by turning on and off at high frequency, while the inductor stores this energy and balances the output voltage. In particular, the switching frequency directly affects the efficiency and heating status of the system. The capacitor at the output provides a smoother output voltage by preventing surge. The dynamics and stability of the parameters involved play an important role in the development of control strategies of Buck converters. Therefore, understanding these basic principles is very important for the realization of an effective control system [9].

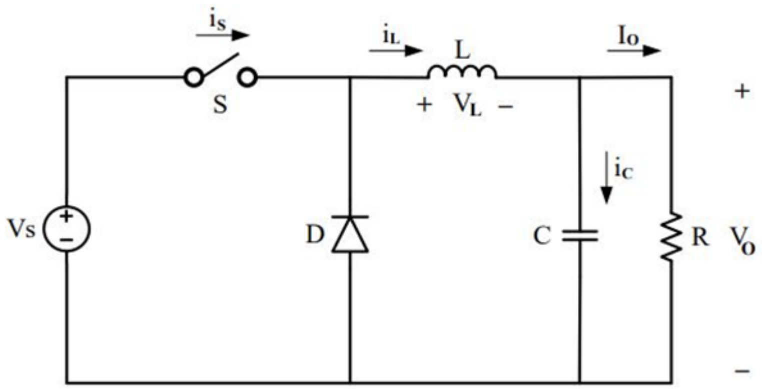


**Figure 1.** DC-DC step-down converter circuit diagram

Figure 1 shows the step-down converter circuit. A resistor (R) is attached to this arrangement, acting as a circuit load. In addition, it refers to power electronic circuit elements such as inductor (L), capacitor (C), input source (Vs), output voltage (Vo), and diode (D) in the circuit. The circuit operates in two modes. The first mode is the mode in which the S switch is off, and the other is the mode in which the S switch is on. Output current (Io), inductor current ($I_L$), capacitor current ($I_C$), switch current ($I_S$) waveforms are shown in Figure 2.

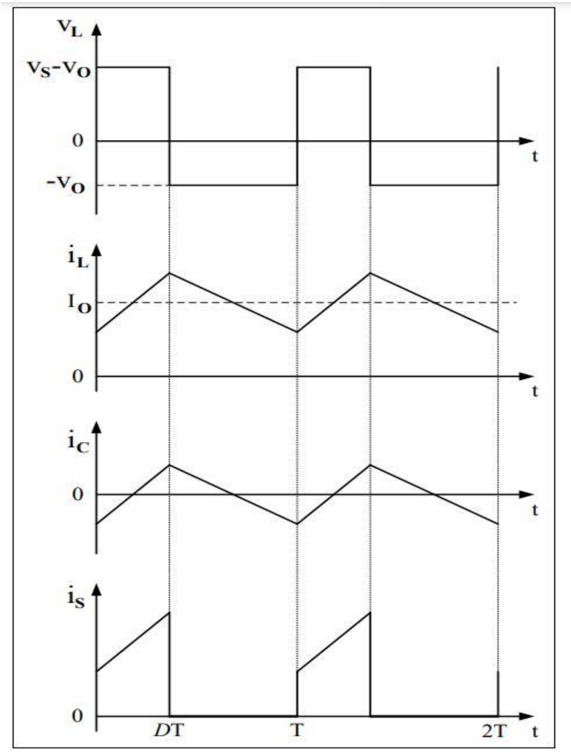


**Figure 2.** Waveforms generated on the converter elements.

## 3. PID Controllers

For systems that include a control structure, it is important to select a control circuit suitable for the system structure. PID control, which is one of the closed loop control structures, is preferred in applications due to its simple use, applicability, and high precision. PID control provides the system error by taking the difference between the voltage value obtained at the output of the system and the reference voltage value desired to be obtained at the output. This error value is recalculated with proportional (P), integral (I) and derivative (D) effects and the system output is adjusted to the lowest value and the system output is adjusted to the voltage closest to the reference voltage value. In PID control systems, and are the coefficients used to apply proportional, integral and differential effects on the system, respectively. The continuous time expression of the control system is given by Equation 1 and the transfer function is given by Equation 1. PID control controller block diagram is shown in Figure 3.

$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt} \quad (1)$$

$$G(s) = K_p + \frac{K_i}{s} + K_d s \quad (2)$$

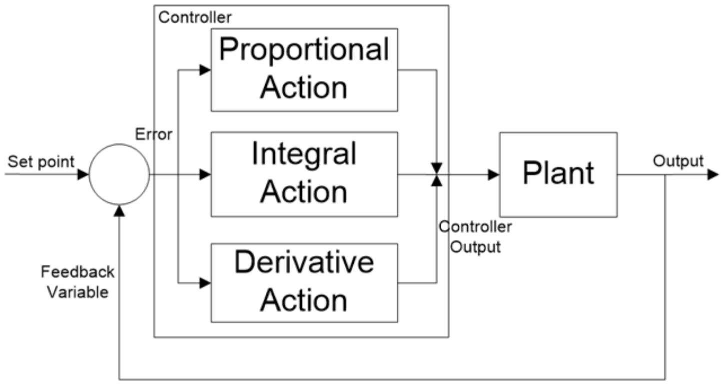


**Figure 3.** PID control controller block diagram

## 4. TMS320F28379D Microprocessor Overview

TMS320F28379D structure is a microcontroller platform that is made for advanced control systems and stands out with its fast calculation features. This microcontroller comes with a 32-bit DSP structure and offers high processing speed and multitasking capabilities. In addition, integrated advanced analog-to-digital (ADC) converter and digital signal processor (DSP) units are essential for real-time control applications. These features make it useful to use closed loop control algorithms to ensure high precision and efficiency, especially in power electronics applications such as buck converters. The expansion paths used and the many options it offers in terms of numerical control engineering increase the flexibility of the system design and ensure cost-effectiveness [10]. Overall, TMS320F28379D structure is an important tool for developing effective and efficient control solutions in both industry and academia.

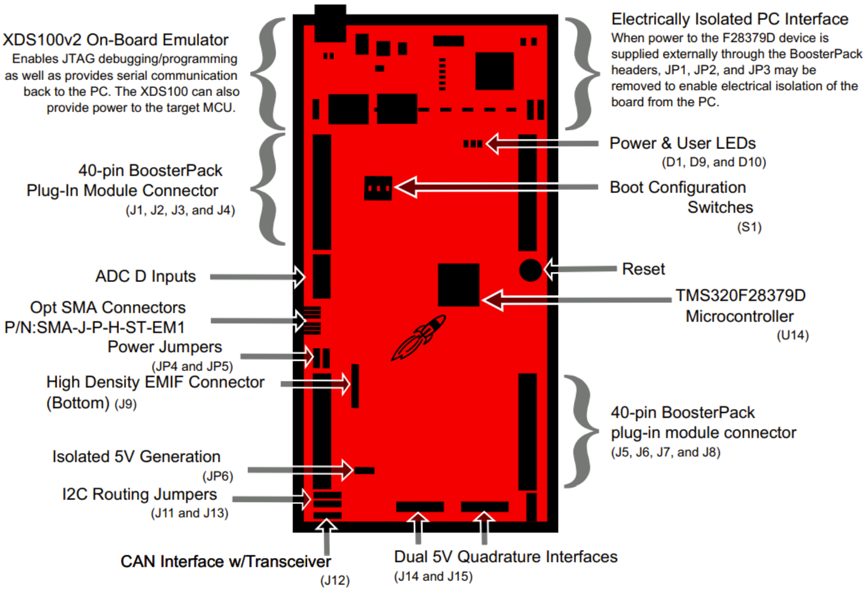


**Figure 4.** LaunchXL- F28379D Overview

Figure 4 shows the overview diagram of the Launchxl-F28379D microcontroller and includes figural information about the circuit elements on the board such as connectors and jacks.

Programming environments and tools, especially in complex systems such as the buck converter, the selection of appropriate development tools is critical to performance and efficiency. TMS320F28379D microcontroller board offers a platform suitable for such applications with its highly integrated structure and flexible programming options. At this point, the choice of software development environment is important both in terms of providing user-friendly interfaces and meeting the real-time control needs of the system. In addition, the tools used in the simulation and testing phases of the developed control algorithms have a great impact on improving performance [11]. In this study, a Matlab/Simulink-based software development infrastructure was used, and thanks to the full compatibility of the control card with the program, a simple and efficient experimental environment was created.

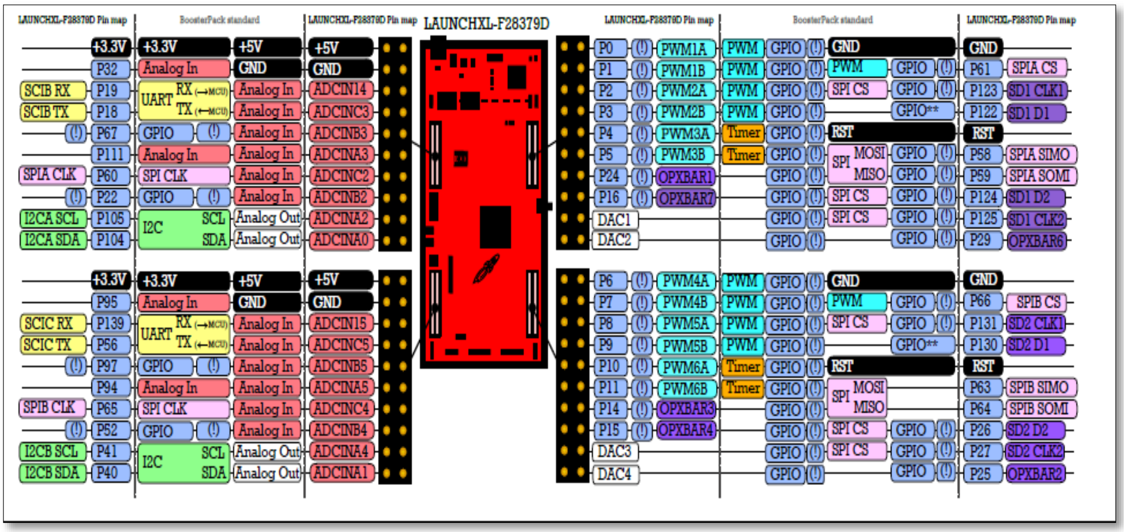


**Figure 5.** TMS320F28379D microcontroller pins

The TMS320F28379xD has four different analog digital converters (ADCs) on the microcontroller. Many analog signals can be controlled with 16-bit and 12-bit resolution. The F28379xD can be easily connected and communicated with the host computer. Figure 5 shows pinout diagram of the Launchxl-F28379D microcontroller.

## 5. System Modeling and Simulation

Systems modeling and simulation play a key role in understanding and enhancing complex systems. This approach represents the physical world through mathematical and logical expressions enabling us to examine various scenarios. Modeling dynamic behavior proves crucial to develop real-time control strategies in energy conversion systems like the buck converter. The modeling stage involves a detailed description of the system's core components and interactions, while the simulation tests this model's performance under different conditions. These techniques help to design and put into action more effective control algorithms, which leads to increased energy efficiency and better overall system performance. System modeling and simulation have a significant impact on engineering applications paving the way for groundbreaking solutions and long-lasting system designs.

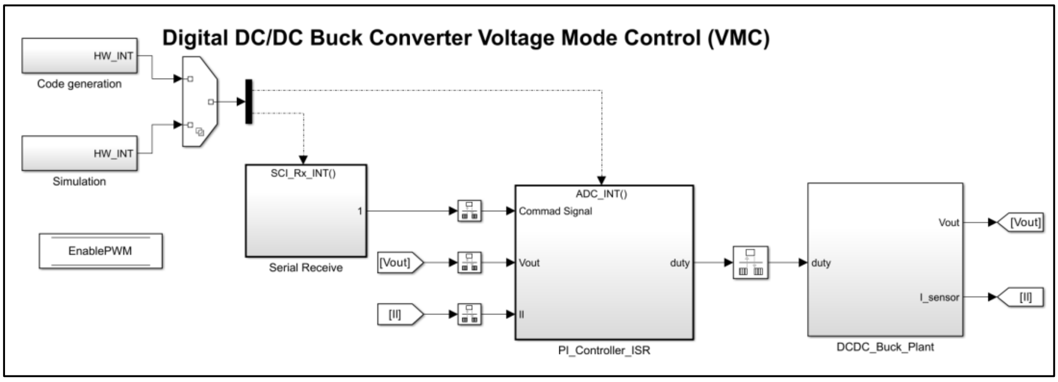


**Figure 6.** Main simulation circuit

In line with the main simulation circuit in Figure 6, the Simulink file was first run as a simulation for 0.01 seconds. Since it was operated using the simulation option in the simulink environment, the DC-DC step-down circuit was operated in the simulation environment using the Simelectronics circuit elements in Figure 7 and Figure 8.

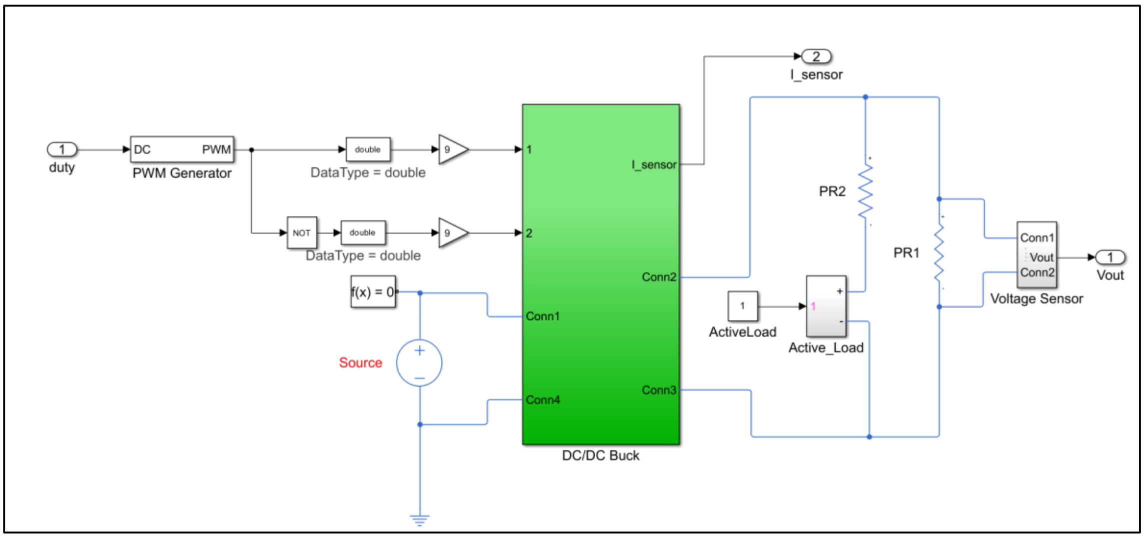

**Figure 7.** Simulink® circuit of the DA-DA converter

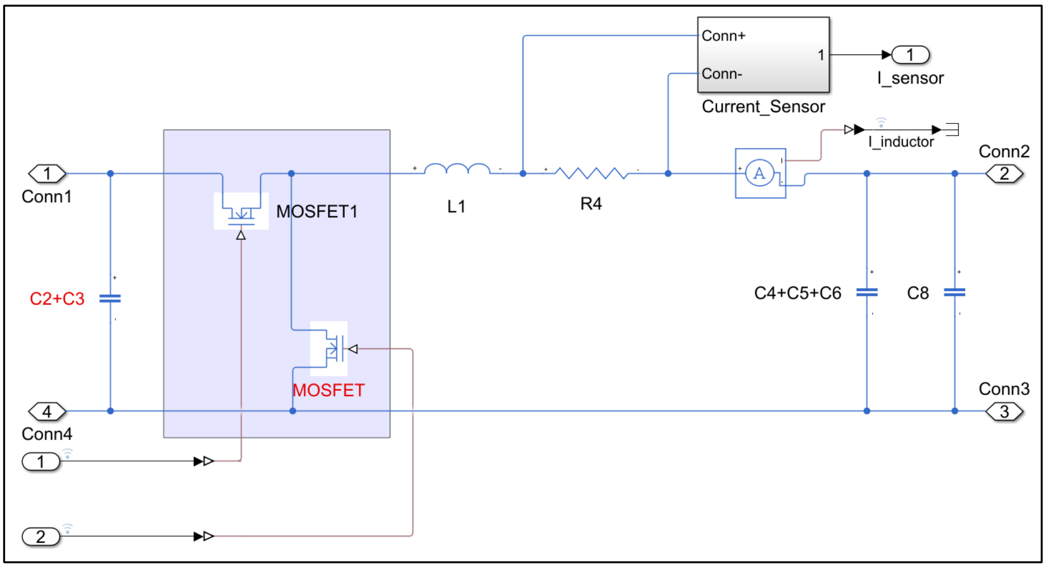

**Figure 8.** Detailed Simulink® circuit of the DA-DA converter

In order to run the simulation circuit, the P parameter was first determined as 0.1 and the I parameter as 0.008. The Vout output voltage is determined as 2V. The reference results of the DC-DC converter operated according to the Vout voltage are shown in Figure 9.

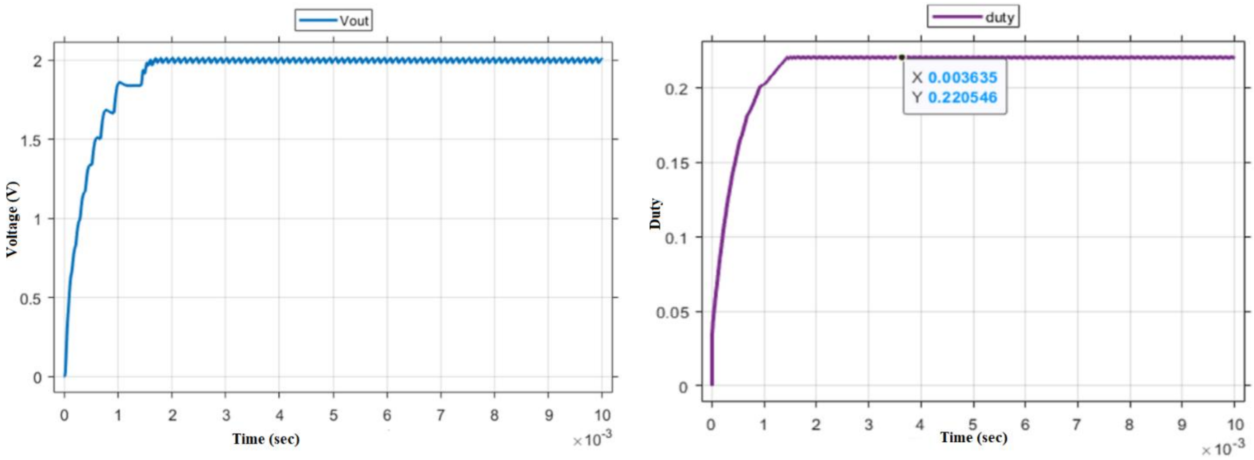


**Figure 9.** Change of Vout output voltage and fill rate

For the case where the output voltage of the step-down converter is determined as 2 Volts, the change of the Vout voltage and the time-dependent change of the duty cycle are shown in Figure 9. As shown in Figure 9, it reaches the desired voltage value in 1.75*$10^{-3}$ seconds.

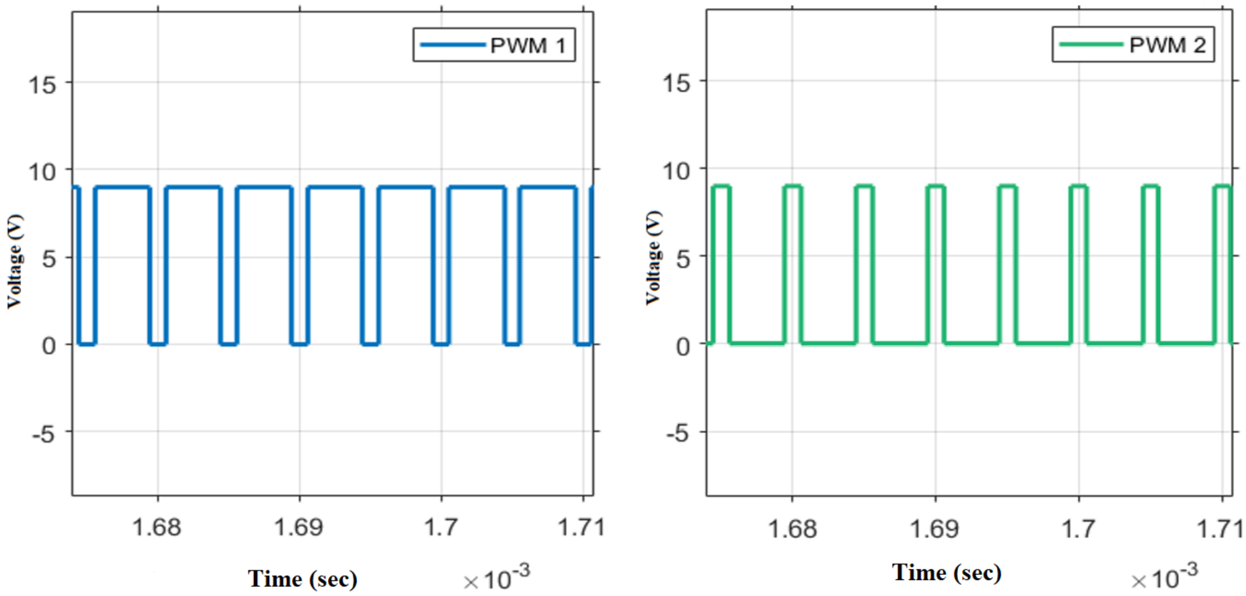


**Figure 10.** MOSFET elements PWM switching signals

PWM signals, in which the two mosfets in the DC-DC step-down converter circuit are switched at opposite times to each other, are shown in Figure 10.

According to the switching times of PWM signals, the current direction of the circuit inductor changes. This change is shown in Figure 11. It has been observed that the descending edge time and rising edge times in this figure are one-to-one compatible with PWM signals.

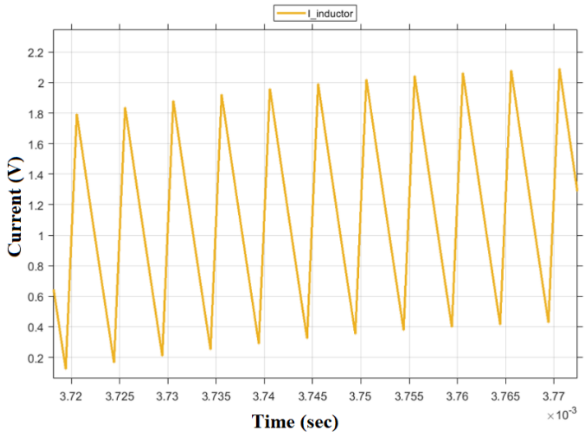


**Figure 11.** Time-dependent variation of inductor current

## 6. Experimental Studies

Hardware design is known to have a significant impact on real-time control systems. At every stage of design, the selection of hardware components is critical to improve the system's performance. TMS320F28379D In the design of the buck converter with the microcontroller, the processing capabilities of the microcontroller, as well as the speed at which the analog-to-digital converters (ADC) will operate, and the design of the power management circuits should be carefully considered. In this context, the operation of hardware components with minimal latency is very important for energy efficiency and overall system reliability, increasing the fast response time of the control system. Therefore, optimizing hardware design in the light of theoretical knowledge is a factor that directly affects the application's success.

TMS320F28379D, the application assembly is installed using the microcontroller and the Bootxl-BuckConv step-down converter, as shown in Figure 12.

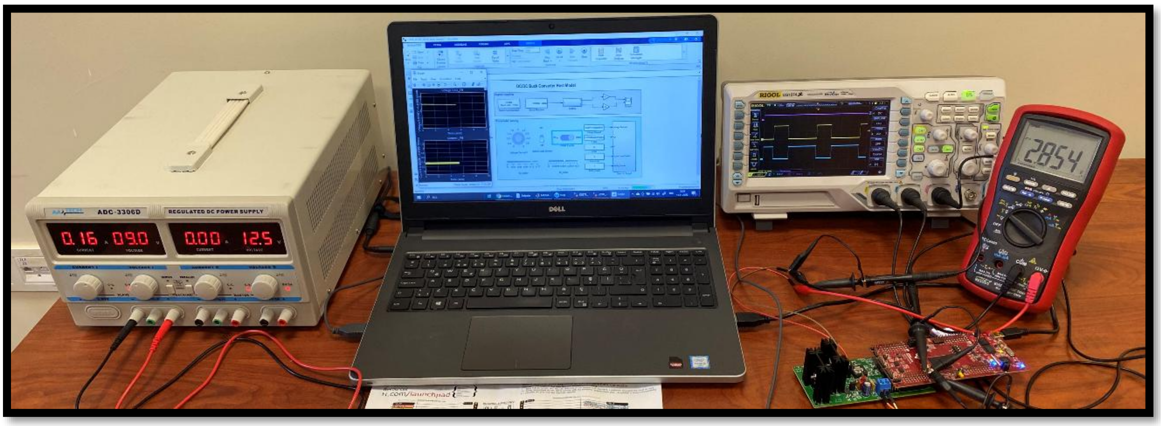

**Figure 12.** Test setup set up for experimental studies

A 9-volt DC power supply was used as the input source, an Oscilloscope was used to see the mosfet switching signals, and a multimeter was used to measure the output voltage of the DC-DC step-down converter. After the model-based circuit TMS320F28379D in the Simulink environment was programmed on the Microcontroller card.

When the step-down controller is operated under the specified parameters, the desired value of 2.8 is obtained, and the result and the PWM signals produced by the control card for the mosfets to achieve this result are shown in Figure 13.

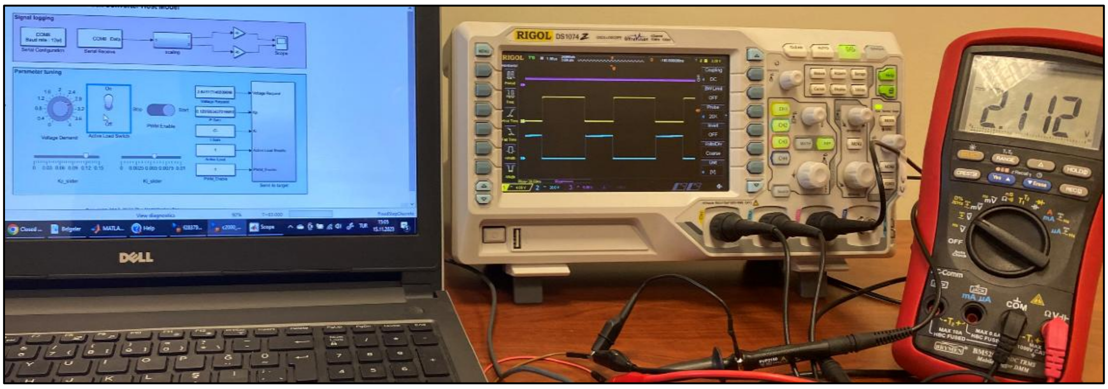


**Figure 13.** Application device installed by applying active load

In the designed circuit, the DC-DC step-down converter card has different options for static load and active load. The results obtained in the first part of the experiment were obtained with a constant resistance load of 7.5 ohms. A software-controlled active load of 2 ohms can be applied to the circuit when the load switch is changed to active load from the setting window. As in Figure 14, results with different characteristics can be obtained.

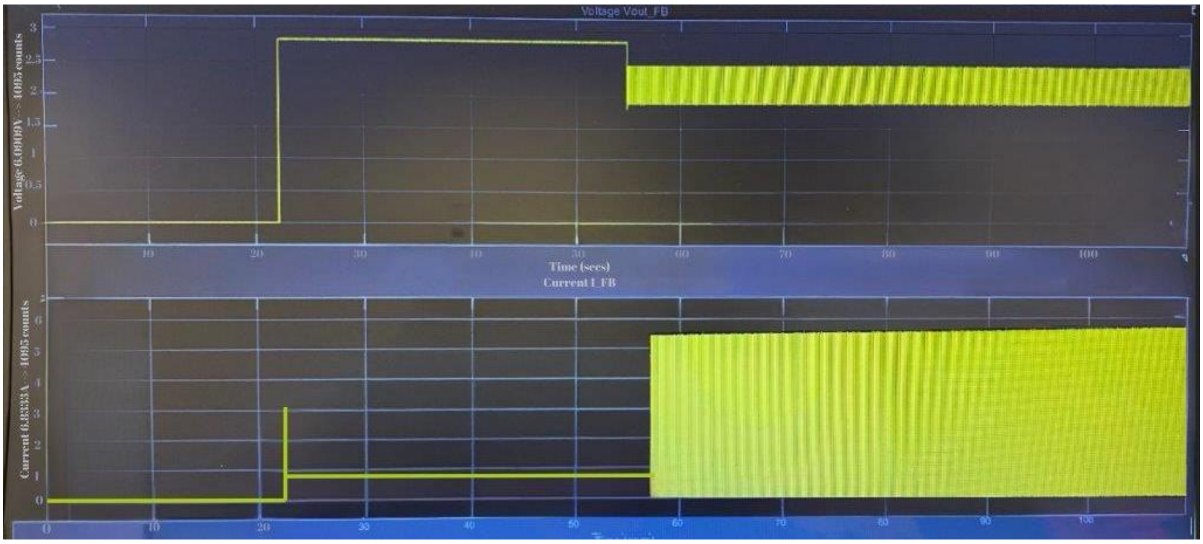


**Figure 14.** Active load switch graph

When voltage is applied to the application device, the adjustment window is suitable for replacement. To see the effect of active load on output variables, the results were observed by turning off (engaged) the active load switch at 55 seconds of the results in Figure 14.

## 7. Results and Discussion

TMS320F28379D control of the Buck converter with a microprocessor card has significantly improved performance by finding the set parameters. In this context, the effects of the applied PID control algorithm on system dynamics were examined, and the results obtained were compared with those of theoretical modeling. The results show that the proposed control structure offers a suitable and reliable solution for industrial applications. In addition, the data obtained in future research is expected to form a basis for developing more complex control strategies.

TMS320F28379D microprocessor card is a frequently chosen solution in this field and stands out with its powerful processing capacities and different integrated features. Improving the hardware-software interfaces increases the real-time performance of the algorithms, enabling the power converters to work more precisely and reliably. In addition, combining control algorithms with hardware reduces the processing load and increases the system's overall efficiency. A good integration process is an essential step in the design of power systems and paves the way for more sustainable energy solutions.

## 8. Conclusion

Today, the combination of control algorithms with hardware plays an important role, especially in power electronics. This process enables the control systems to offer high efficiency, fast response time, and better stability. The study covers the design and implementation of a real-time controller for a voltage reducer (buck) converter with an effective PID controller combined with simple, inexpensive hardware using the TMS320F28379D microcontroller board. The application with the Microcontroller Board was carried out to analyze the voltage regulation capability, dynamic response time, and overall efficiency of the buck converter system. In the implementation phase, firstly, the control algorithm and the transducer model were tested based on hypotheses in the simulation environment. These simulations allowed for early detection of possible errors and corrective measures to be taken. In addition, model-based design enables more flexible and improvable methods. Subsequently, an experimental setup with real-time monitoring and control was established. The performance of the system under actual test conditions was compared with the simulation results, and the effects of all variables on the system were examined. In the study, the performance of the control algorithm was tested and evaluated under different load conditions. The results are promising because the system remains stable and reacts quickly over a wide operating range. In addition, controller design have been shown to play an important role in improving system efficiency. The created control setup to improve control performance is important as it can also be used for more complex systems. As a result, the data obtained not only confirms the success of the application but also serves as the basis for further studies. In addition, the simplicity of the implemented algorithms, combined with a user-friendly interface, shows that the system offers vast application potential. Future research should investigate how the proposed control structure can be applied in more complex energy management systems, and the asynchrony of existing systems should be corrected. These findings aim to contribute to the relevant literature by allowing wider control system design applications.

## Symbols

| | |
|---|---|
| ADC | Analog digital converter |
| DC | Direct current |
| DSP | Digital sinyal processor |
| PID | Proportional Integrator Derivative |
| PWM | Pulse width modulation |

## Acknowledgments and Funding

The authors would like to thank Çankırı Karatekin University Scientific Research Project Unit for provision of funding with the Project MF240223L05. The authors thank the Electrical-Electronics Laboratory at Çankırı Karatekin University for supporting our experiments.

## Declarations and Ethical Standards

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

## Author Contributions

Goksu Gorel conceived of the presented idea. Yahya Bektes and Hakan Ozkaya developed the theory, performed the computations and carried out the experiments. Fatih Korkmaz supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

## References


[1] F. Cecati, J. K. M. Becker, S. Pugliese, Y. Zuo, M. Liserre, and M. Paolone, "LTP Modeling and Analysis of Frequency Coupling in PLL-Synchronized Converters for Harmonic Power Flow Studies", Jun. 2023, doi: 10.1109/powertech55446.2023.10202937.

[2] Wang, F., Zhang, H., Liang, C., Tian, Y., Zhao, X., & Zhang, D. (2015). Design of High Frequency Ultrasonic Transducers with Flexure Decoupling Flanges for Thermosonic Bonding. IEEE Transactions on Industrial Electronics. https://doi.org/10.1109/tie.2015.2500197

[3] K. Kanimozhi and A. Shunmugalatha, "Unified control of DC-DC buck converter using dynamic adaptive controller for battery operated devices", *Revista Facultad De Ingenieria-universidad De Antioquia*, no. 81, pp. 35–46, Dec. 2016, doi: 10.17533/UDEA.REDIN.N81A04.

[4] S. Aziz, H. Wang, Y. Liu, J. Peng, and H. Jiang, "Variable Universe Fuzzy Logic-Based Hybrid LFC Control With Real-Time Implementation", *IEEE Access*, vol. 7, pp. 25535–25546, Feb. 2019, doi: 10.1109/ACCESS.2019.2900047.

[5] B. Hekimoglu and S. Ekinci, "Optimally Designed PID Controller for a DC-DC Buck Converter via a Hybrid Whale Optimization Algorithm with Simulated Annealing", vol. 20, no. 1, pp. 19–27, Feb. 2020, doi: 10.5152/ELECTRICA.2020.19034.

[6] A. Mansouri, A. Aazami, A. Omidian, E. Mohamadian, and R. Aazami, "Evaluation of Power System Reliability Considering Direct Load Control Effects", *International Journal of Electrical and Computer Engineering*, vol. 3, no. 2, pp. 254–259, Apr. 2013, doi: 10.11591/IJECE.V3I2.2295.

[7] D. Sengeni, M. R. Mano Jemila, G. S. Krishna Priya, T. Santhana Krishnan, G. Rathinasabapathi, and S. Kannan, "Modelling of Advanced Sensor based Distributed Control System for Real- Time Prediction and Minimization of Power Loss in Industrial Automation Systems", pp. 413–419, Apr. 2024, doi: 10.1109/icoeca62351.2024.00080.

[8] J. Smołka, B. Matacz, E. Łukasik, and M. Skublewska-Paszkowska, "Performance analysis of mobile applications developed with different programming tools", vol. 252, p. 05022, Jan. 2019, doi: 10.1051/MATECCONF/201925205022.

[9] A. M. Alturas, A. O. Elbkosh, and O. Imrayed, "Stability analysis of dc-dc buck converters", vol. 4, no. 1, pp. 01–06, Feb. 2020, doi: 10.26480/AEM.01.2020.01.06.

[10] C. Weckenborg, P. Schumacher, C. Thies, and T. Spengler, “Flexibility in manufacturing system design: A review of recent approaches from Operations Research”, *European Journal of Operational Research*, Sep. 2023, doi: 10.1016/j.ejor.2023.08.050.

[11] J. Aravena *et al.*, “Design and Implementation of a Low-Cost Real-Time Control Platform for Power Electronics Applications”, *Energies*, vol. 13, no. 6, p. 1527, Mar. 2020, doi: 10.3390/EN13061527.

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