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# PI CONTROLLER FOR SPEED CONTROL OF SEPARATELY EXCITED DC MOTOR SUPPLYING FROM DUAL BUCK CONVERTER

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***Purpose.*** *The primary objective of this revision is to adjust the speed and overall performance of a separately excited direct current motor by implementing a traditional controller route that incorporates a Proportional-Integral (PI) controller. The objective of the present scheme is to verify the precise functionality of the motor by means of the dynamic regulation of the two input currents, which are sourced from two separate direct current (DC) power supplies. The objective of the present study is to apply the PI controller to achieve stable and effective performance, especially under variable load conditions, thereby reducing oscillations in speed and enhancing the motor's response to dynamic vagaries. This tactic has been demonstrated to enhance the motor's flexibility, rendering it particularly well-suited for scenarios that demand high-precision motion control. The research demonstrates the efficacy of the PI controller in preserving optimal operational parameters, thereby enhancing energy efficiency and system dependability.*

***Methodology.*** *The design methodology of the Proportional-Integral (PI) controller is based on exact principles, with the aim of improving motor operation by defining the model controller parameters. This method guarantees the optimal system performance by means of successful adjustment of current inputs, with the objective of minimizing fluctuations and enhancing response stability. The tuning procedure involves the selection of appropriate proportional and integral gains, with a view to maintaining a balance between speed control and dynamic flexibility. The efficacy of the PI controller is enhanced by systematic parameter optimization, resulting in improved efficiency, reduced steady-state error, and enhanced transient response. Consequently, the controller is well-suited for applications that demand precise motor control.*

***Findings.*** *The PI controller design increases separately the excited dc motor stability and regulates its speed.*

***Originality.*** *This research introduces a modified control routine for a dual buck DC-DC converter, whereby one converter supplies power to the armature motor circuit, while the second provides power to the flux circuit. The originality of the work lies in the application of a devoted control system on the second converter, which has been built to adjust the flux current. It is evident that by controlling the flux current, the controller enhances the magnetic field stability.*

***Keywords: dc-dc buck converter, separately excited dc motor, speed control, dual.***

## I. INTRODUTION

Now a day's power electronics are efficient science that played a great role in various field of life, as example automation, smart grid, industrial process, renewable energy system, as well as electrics vehicle etc. In industrial process and applications, require movement that used dc motor, speed control at different load conditions considered the main challenges faced the customer's. Many researches are introduced for this purpose.

An artificial neural network are implemented to regulate the speed of dc motor it is involved with model reference adaptive controller, the complete scheme developed the overall performance of drive, where the controller regulate the duty cycle of converter thus the voltage of supplied to motor change according to the ratio of variations. This control structure improve the performance under different state of load or transient condition [1].

Another research deals with design, analysis and of dc-dc Buck converter used proportional –integral – differential controller is proposed, the control strategy for switching power device depend on storing and freeing energy at circuit that represent model operation principle.

Circuit is realized and tested for different values of resistive load to evaluate the controlled buck characteristic. [2] A fuzzy logic controller base on pulse width modulation is expressed on dc-dc buck converter to perform power device switching. Where the strategy providing smooth control for dc motor speed and accurate response for all operation condition even with disturbances presences. [3]. Additional paper discussed speed control of dc motor fed from buck converter where differential flatness control technique used. this strategy is satisfied for all dynamic conditions which faced dc motor [4].

Dc motor supplied from different scheme of power converter consist of full wave bridge rectifier connected to dc-dc buck converter. The whole system is adjusted at open loop control strategy using matlab Simulink. The


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research examine the system performance taking account altered factors total harmonics distortion, ripple, efficiency of rectifiers etc. and their effects on buck performance. Also field and load disturbances are considered in performance of bridge performance. Where all mentioned affect the control strategy is taking account for generating signal of firing angle [5].

A proportional –integral –differential control implemented on dc –dc buck converter. The suggested method make regulating the output voltage of buck independently on input voltage. It is modeled using matlab Simulink tools and constructed dependently of transfer function of system. Supporting by practical experiment system is capable to increase the accuracy and decrease overshoot response for different statuses of load variation controller [6].

## II. DC-DC BUCK CONVERTER HES

Buck converter is one of the multi- kind of converters family, these family conclude three main type buck, boost and buck boost. The main function of this converter is to reduce or step down voltage at its output. Buck converter involve transistor as switch , inductor ,diode , and capacitor as well as the load connecting at the end side ,figure 1 shown the complete buck scheme. [7], [8], [10].

The operation principle of depends on using PWM technique for switching on and off of mosfet. Switching frequency generation using pwm led to emergence what is called duty cycle (d) ratio which equal to.

Duty cycle (d) = ton/(ton+toff) (1)

ton : On time period

toff : Off time period

ton+toff : Operation period

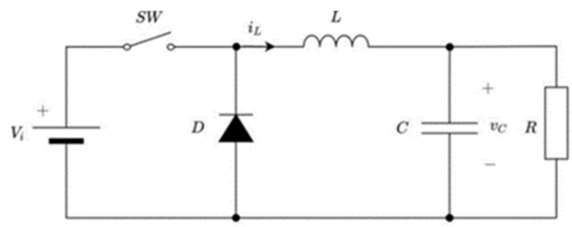


**Figure 1**. Complete buck circuit with R load

By controlling the mentioned vleue (ton) the output voltage of converter change proportionally with it, that mean increasing duty cycle. Where the output voltage according to the last equation cannot exceed the input voltage value [7], [8], [9].

The equation describe buck converter written as below

V_o=d V_in (2)

:output voltage

V_in : input voltage [13]

Figure 2 shows the output voltage.

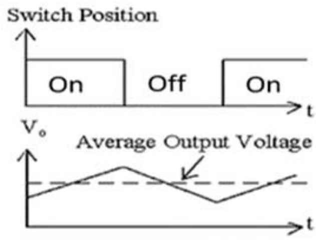


**Figure 2.** Output and average voltage

ΔVC = [Vin X d ( 1 – d)] / 8LC f2 (3)

ΔVC: ripple voltage on capacitor

ΔIL = [Vin X d (1 - d )] / f L] (4)

ΔIL: changing inductor current

IMax = I_o+ V_o toff / 2 L (5)

IMin = I_o- V_o toff / 2 L (6)

IMax, IMin: maximum, and minimum current passing through inductor [11].

## III. DC SEPARATELY EXCITED MOTOR

Dc motor can define as a device convert electrical to mechanical energy .It considered an essential drive system for many industrial application .Despite this important feature motor dc motor suffer from needing to maintenance and raising their costs. Due to various type of load many kind of motor can be classify according to how their wounded field such as series, shunt, compound and separately excited motor .The last type denote to the case study in this work, which it can represent by the figure shown below [13], [14]. Expounding the main material and results analysis.

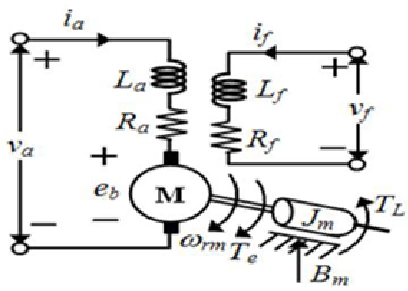


**Figure 3.** Illustrate The Total Construction Of Dc Motor With Load

$$V_f = R_f i_f + \frac{dØ_f}{dt} \quad (7)$$

$V_f$ : voltage applied on field circuit

$R_f$ : field resistance

$i_f$ : field current

$\O_f$ : Flux on field circuit

$$V_a = R_a i_a + L_a \frac{d\O_f}{dt} + K_r w_{re} i_f \quad (8)$$

$V_a$ Armaturevoltage

$R_a$ : Armature resistance

$i_a$ : Armature current

$L_a$ : Armature inductance

## IV. DC MOTOR SPEED CONTROL

Speed control for any kind of motors refers to adjusting this value until meet to desired demand, while speed regulation refers to maintain this value although load vary. There are different methods can implement to achieve speed control for the motor types such as.

*Armature control method. It executed by connecting resistor in series with armature circuit winding . This method is suitable at light load states or constant load application.

*Voltage variation. It implemented by changing input voltage (source).

*Field control method, this method employed by changing flux using field rheostat in series with field circuit or changing voltage applied on field circuit.

## V. CASE STUDY FOR MOTOR SPEED CONTROL

The case study in this work shown in figure (4) consist of an Ac voltage source feeding rectifier circuit , this rectifier supply a positive current to two identical dc-dc buck converters that supply power to dc motor.

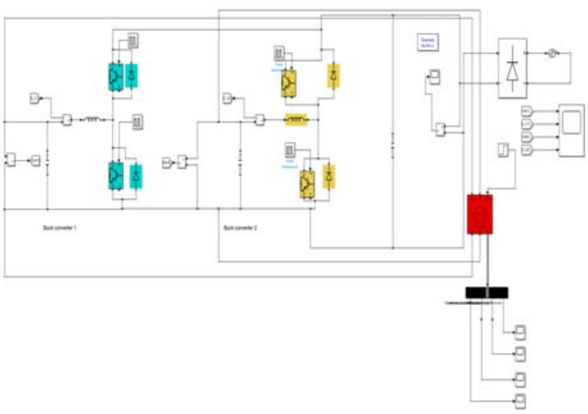

**Figure 4.** Complete system dual buck converter connected with dc motor without controller

## VI. MATLAB SIMULATION RESULTS

### 1. Simulation results without controller.

The illustrated circuit realized using matlab software describe the drive system performance without using control strategy, it shows the mechanical characteristics of motor as well as the electrical in figures 5, 6 and 7.

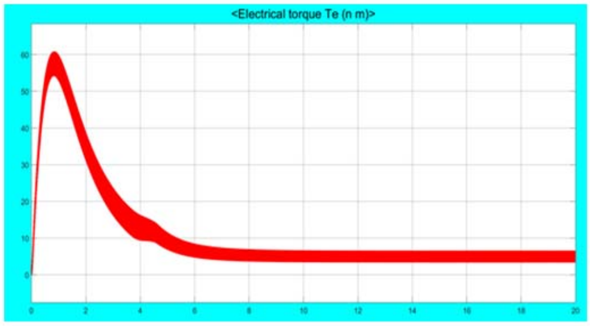


**Figure 5.** Illustrate the motor speed without using control circuit where it show the proportional increase in speed until reached the rated value of motor spee

Figure (6) shows the torque where it generated by motor at value equal to 5 N.M.

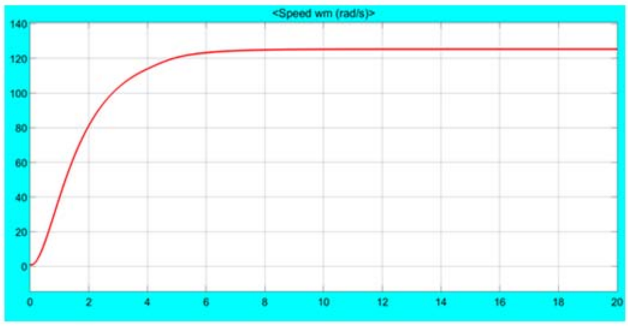


**Figure 6.** Shows the dc motor torque ( $wr$ ) without control circuit

Figure (7) refers to field current that passing in separated circuit from the armature winding.

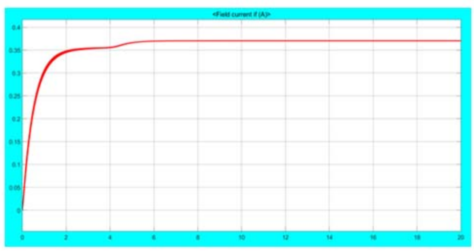

**Figure 7.** Shows the field current of dc motor without control circuit

**2. Simulation results with controller.**

During its operation dc motor faced many difficult at environmental status such as load variation, raising current, drop voltage, as well as mechanical fault etc. Load variation considered a common state that affect on motor performance especially speed. Different methods suggested and implemented to overcome speed difference similar to classical (PID) controller , modern (fuzzy logic) controller, hysteresis current controller, F28027 launch padand other [11], [12], [14].

A Proportional –integral (PI) controller is achieved in this work for controlling input voltage for motor scheme to eliminate the steady state error the increasing the reliability and stability of system. The operation principle is adjust the ton of power switch in buck converter keeping duty cycle at same value. changing ton at buck converter responsible for feeding fiel circuit of motor led to vary the operating conduction then vary the output voltage to desired target, Figure (8) illustrate the PI controller scheme connected to buck system in figure (7).

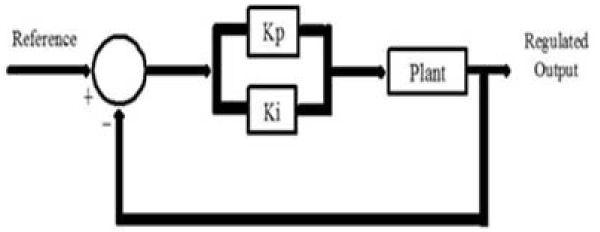


**Figure 8.** PI controller scheme connected to buck system

in above figure

Kp: Proportional gain

Ki: integration gain

nevertheless the parameter can written as transfer equation

$$c(s) = K_p + \frac{ki}{s} \quad (9)$$

The discussed system is connectd to buck as shown in figure (9).

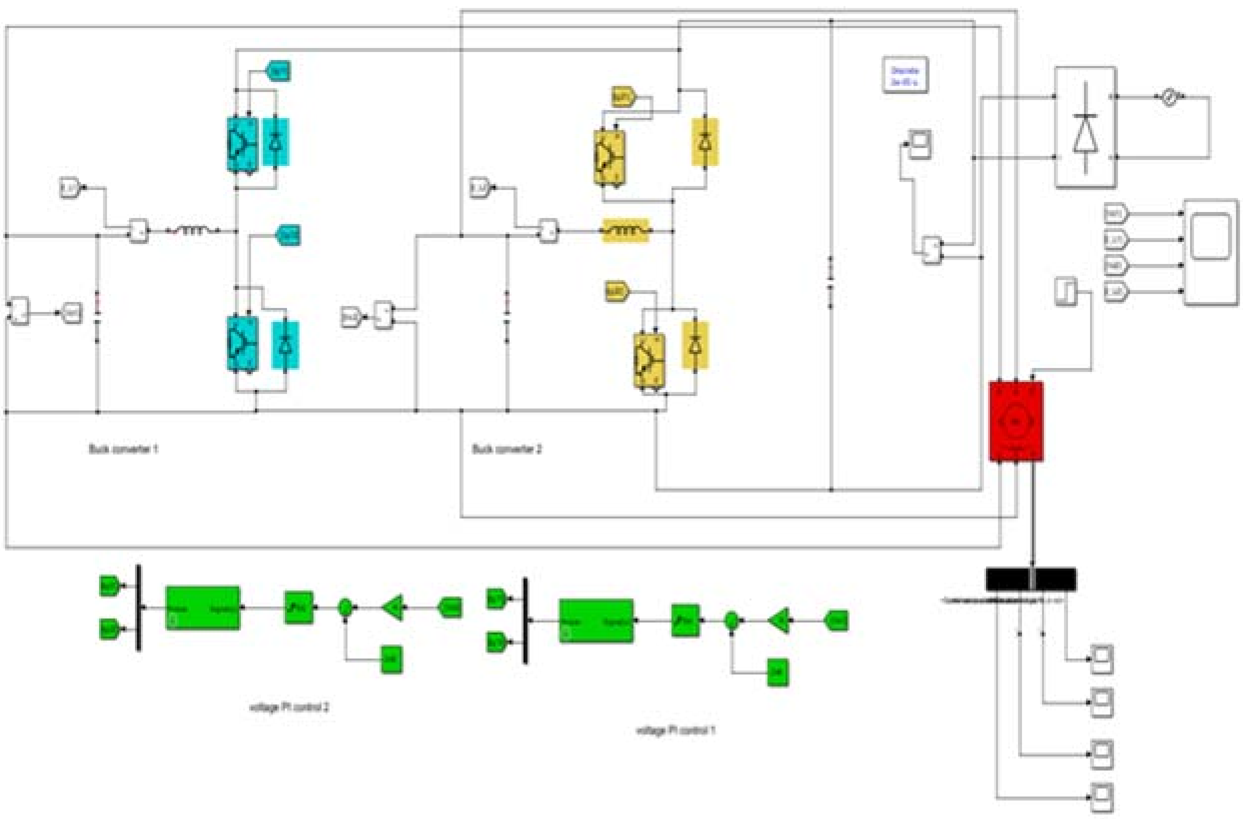

**Figure 9**.Complete system dual buck converter connected with dc motor with PI controller

When PI controller connected to the drive a sudden change in torque applied, the results describe system performance obtained are shown in the following figures.

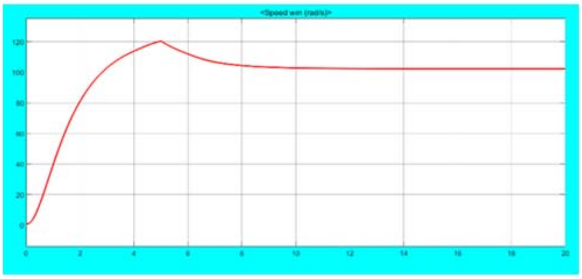

**Figure 10.** Shows the dc motor speed ( $wr$ ) with control circuit

In figure 10 a sudden change in load raising its value to 15 N.M was happened at 5 msec, the speed decreased until reached 110 rps, where the PIcontroller tried to absorbed this change by regulating the field circuit to maintain the speed of value at acceptance limits.

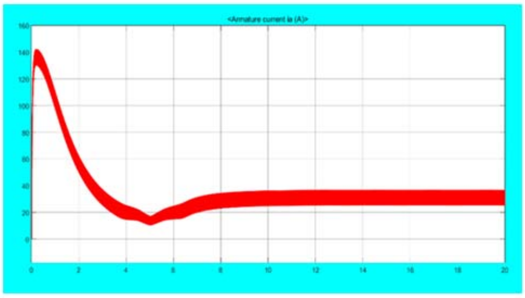

**Figure 11.** Shows the dc motor torque ( $wr$ ) with control circuit

Figure 11 illustrate the effects of PIcontroller to regulate system operation even at sudden change of load torque .at what time it happened the controller adjust the field circuit to overcome the variation in load, when at point 5 msec the load torque decelerate tehn raised to overcome the change.

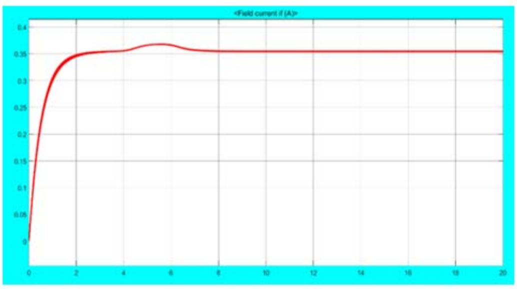

**Figure 12.** Shows the field current of dc motor with control circuit

Figure 12 denote to field circuit current where at the moment of load change the controller regulate the input voltage applied on circuit to regulate the input current which responsible for generation of torque.

## VII.CONCLUSION

In this work implementation of PI controller with dc-dc buck converter developed the system performance at any sudden vary of load torque , it is increasing the stability and reliability of motor drive. The PI effectively regulated the input current of field circuit of motor to adjust its speed .this operation achieved by changing the ducty cycle of onverter switch which connected to the field circuit .By using this technique the whole system takes the abilty to face the disturbances happened at any time with fast dynamic response.

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# ПІ-РЕГУЛЯТОР ДЛЯ КЕРУВАННЯ ШВИДКІСТЮ ДВИГУНА ПОСТІЙНОГО СТРУМУ З ОКРЕМИМ ЗБУДЖЕННЯМ, ЩО ЖИВИТЬСЯ ВІД ПОДВІЙНОГО ПОНИЖУВАЛЬНОГО ПЕРЕТВОРЮВАЧА

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***Мета роботи.*** *Метою роботи є розробка алгоритму регулювання швидкості та загальної продуктивності двигуна постійного струму з окремим збудженням, шляхом реалізації традиційного способу керування, який включає пропорційно-інтегральний (ПІ) контролер.*

***Методи дослідження.*** *Методи комьютерного моделювання з застосуванням програмного забеспечення MatLAB.*

***Отримані результати.*** *Методологія проектування пропорційно-інтегрального (ПІ) контролера побудована на точних принципах покращення роботи двигуна шляхом визначення параметрів моделі контролера. Цей метод гарантує, що система забезпечує найкращу продуктивність, успішно регулюючи струмові вхідні сигнали, мінімізуючи коливання та підвищуючи стабільність реакції. Процедура налаштування включає вибір відповідних пропорційних та інтегральних коефіцієнтів підсилення для підтримки балансу між керуванням швидкістю та динамічною гнучкістю. Завдяки систематичній оптимізації параметрів, ПІ-контролер підвищує ефективність, зменшує похибку стаціонарного режиму та покращує перехідну характеристику, що робить його придатним для застосувань, що потребують точного керування двигуном.*

***Наукова новизна.*** *Наукова новизна роботи полягає у застосуванні спеціалізованої системи керування на другому перетворювачі, спеціально розробленої для регулювання струму магнітного потоку. Керуючи струмом магнітного потоку, контролер підвищує стабільність магнітного поля.*

***Практична цінність.*** *Завдяки систематичній оптимізації параметрів, ПІ-контролер підвищує ефективність, зменшує похибку стаціонарного режиму та покращує перехідну характеристику, що робить його придатним для застосувань, що потребують точного керування двигуном..*

***Ключові слова: понижувальний перетворювач постійного струму, двигун постійного струму з окремим збу-дженням, регулювання швидкості.***