

# A Novel Technique for Designing LC Filter in Torque-Speed Control of DC Motor

Suyash Kumar Singh\*, Pankaj Aswal, Apurv Thakur, Anubhav Charan and Anjali Thapliyal

Department of Electrical and Electronics Engineering, Graphic Era University, Dehradun – 248002, Uttarakhand, India; suyashsingh7132@gmail.com

## Abstract

**Objectives:** To comprehend transient behaviour of circuit, mathematical model of DC engine is produced utilizing MATLAB/SIMULINK. Torque ( $T_e$ ) is corresponding to current. Current is high at beginning because of zero back EMF and as it spans to enduring state current decreases. Speed can be obtained from torque, and rotor position  $\theta$  from speed. **Methods:** These conditions are displayed in SIMULINK/MATLAB to model DC engine. This model was utilized to watch transient condition and LC channel control was executed. DC engine replaces regular brushed engines because of its focal points like higher proficiency utilizing channel plan. In this paper, DC drive circuit and control is re-enacted. A profoundly effective second order LC passive filter is designed and implemented. **Findings:** In this article the harmonics content of the voltage and current for a DC motor is dissected. From the simulation comes about it is obvious that the harmonic segments at the exchanging frequency and multiple of exchanging frequency are lessen by the filter. From the trial comes about, it is found that up to a decent degree the harmonics segments are lessened with filter. The present waveforms are smoothened by the filter amid the operation and the substitution frequency harmonics limited and consequently the torque swell is reduced. It is presumed that, it is conceivable to acquire exact speed control of DC motor utilizing a LC filter. Again here the utilization of a sensor is not executed for the speed control of the framework, rather than that a sensor less control method is actualized keeping in mind the end goal to get the stator and rotor position of the framework. **Conclusion:** The sensor less piece of the framework is finished by utilizing back EMF discovery strategy where the back EMF of the motor is recognized with the assistance of channels and from these signs a sine wave is gotten and they are contrasted and the triangular waveforms with the assistance of controllers. A basic strategy of recognize back EMF zero intersection for a DC motor utilizing line voltage is proposed.

**Keywords:** AC Supply, Capacitor, DC Series Motor, Filter, Inductor, Rectifier, Thyristor

## 1. Introduction

DC or direct current supply is generally not available for runtime use so to get DC supply for a runtime use we need to have devices such as AC-DC rectifier or AC-DC converter. In general the DC which will obtain as an output of Rectifier or as an output of a converter is not flawless rather it is of a very poor quality, contains lots of ripples or we can say that an impure DC supply is obtained as a result of the Rectifier.<sup>1</sup> So to remove that flaw of DC supply we need to use filter. Filter in general is a fusion of inductor and capacitor or single handed use of inductor

or capacitor can also be preferred.<sup>2,3</sup> Some general filters are pi-filter, inductive filter, and capacitive filter. The inductor as well as capacitor both have a property that they block AC component and allows DC component to pass through them. The output of a rectifier or a converter is DC with AC ripples, as these filters soak the AC components and permits only DC to flow, so in this manner we are somehow able to obtain a better DC component in comparison to previous ones.<sup>4,5</sup> DC motor or a direct current motor is defined as a motor which takes DC supply as an input and gives mechanical energy as an output. The DC motor's speed generally depends on torque of motor,

\*Author for correspondence

field current and armature current. The DC motor is classified as (DC) series motor, (DC) Shunt motor and (DC) compound motor which can be further classified as long shunt and short shunt.<sup>6-8</sup> Here in this paper we will make use of DC series motor.

Here in this paper we will study how various characteristics of Direct Current motor i.e. motor's Speed, Torque and Armature current varies on using various filters and without using any kind of filter. For displaying this effect we have designed a Matlab simulated model using Matlab software.

## 1.1 Background Survey

In the year 2013 a paper was issued or published in International Refreed journal of Engineering Sciences; that paper focuses on how the level of excellence of DC has been improved by using various filters. Earlier also various papers have been published regarding this issue

which emphasises on the improvement of quality of DC obtained. A well known fact exists which says that it requires large size instruments to store DC so it is beneficial for us to have real time generation which is possible only in the case of AC. That's why we generate AC and convert it to DC. It has become a topic of large interest for researchers in the past few years.<sup>9</sup> Various research papers have also been issued in the recent 2016 which also focuses on designing of a filter circuit. Every year one or two papers come out regarding this topic.

## 2. Matlab Simulation

For Matlab Simulation we made use of a full wave rectifier. A full wave rectifier converts both the half (positive or negative) of an AC supply in to positive form. Firstly we have designed a model without any kind of filter and secondly by using LC filter followed by inductive (L), and

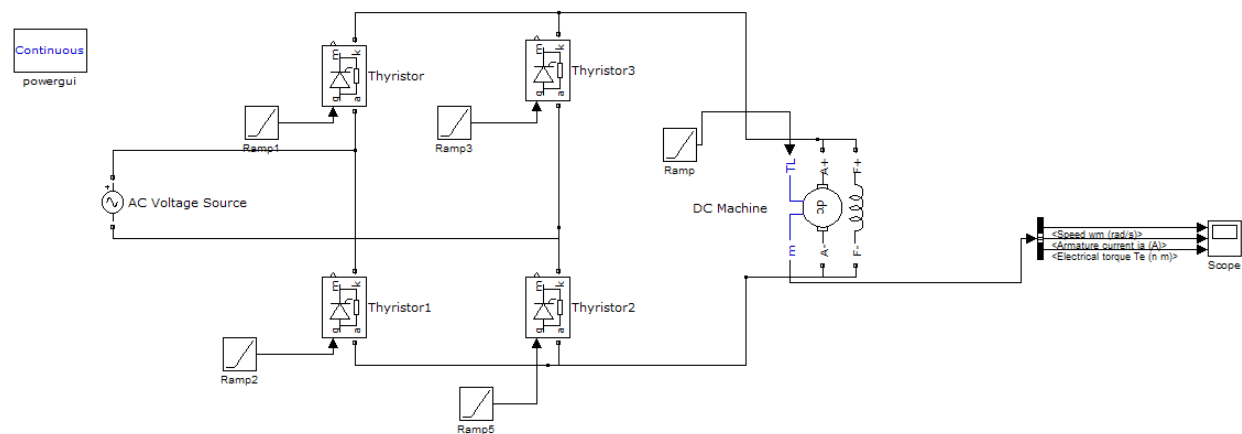


Figure 1. Without Filter.

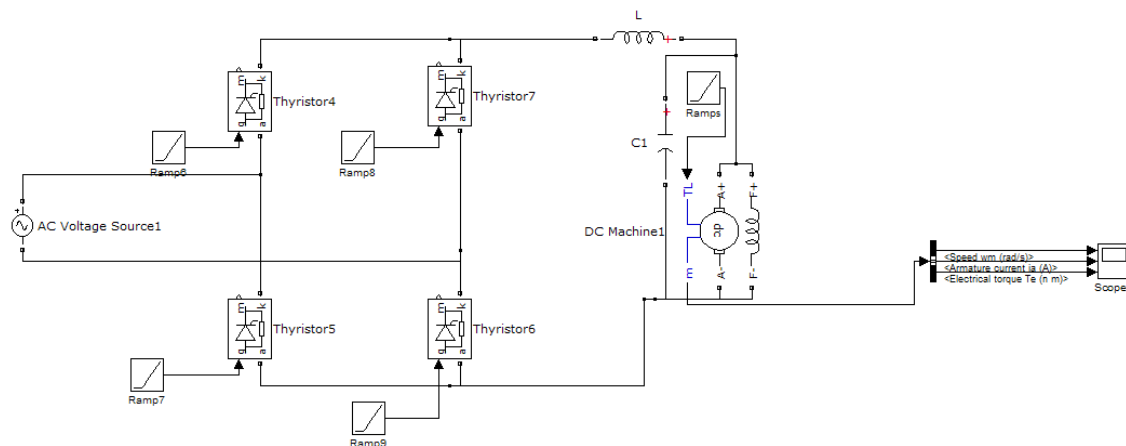
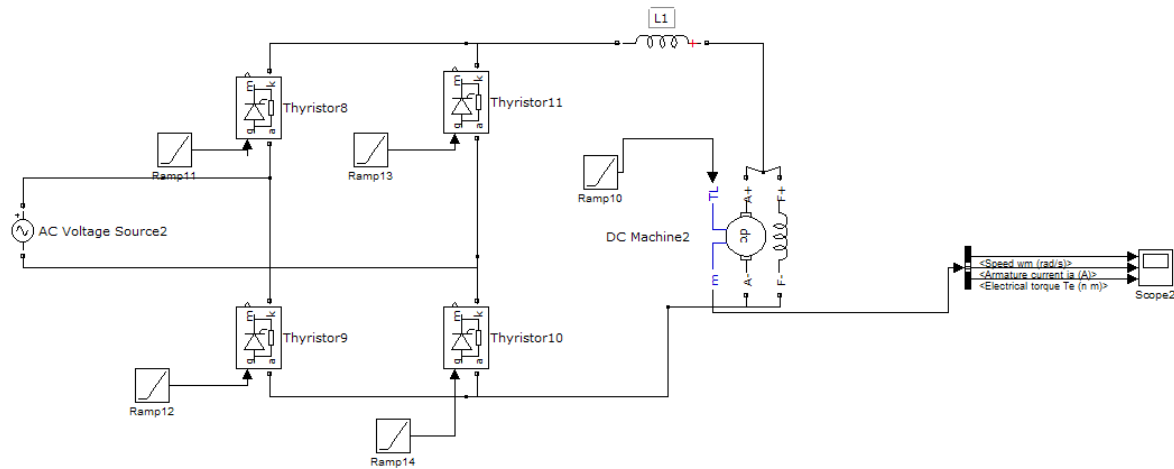
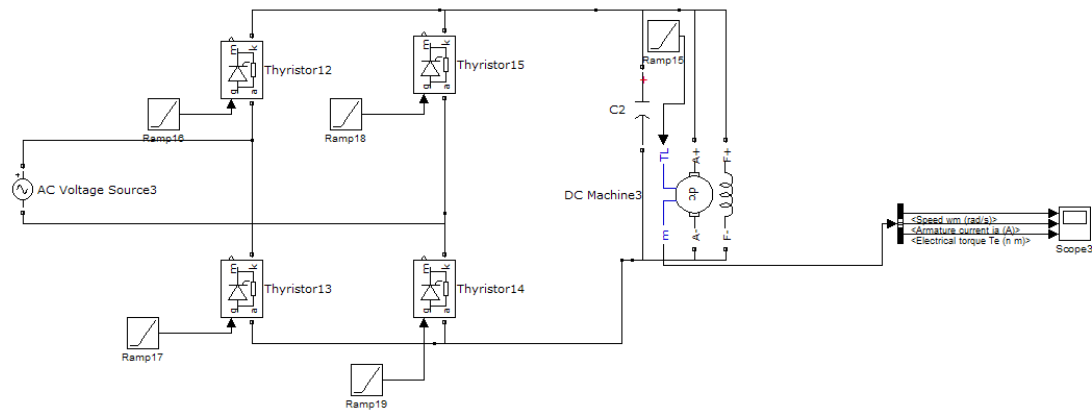


Figure 2. With LC Filter.



**Figure 3.** With L Filter.



**Figure 4.** With C Filter.

capacitive filter (C). We made use of (DC) series motor actuated by ramp signal and for the designing of rectifier we made use of Thyristors.

## 2.1 Without Filter

In this simulation we do not made any use of filters and directly supplied impure DC to the series motor as shown in Figure 1.

## 2.2 With Inductor-Capacitor (LC) Filter

In this simulation we have made use of L i.e. inductive filter and C i.e. capacitive filter and then apply the DC to the series motor we have used two values of inductor & capacitor to obtain result of scope firstly  $L = 5\text{mH}$ ,  $C = 2.5\mu\text{F}$ , secondly  $L = 10\text{mH}$ ,

$C = 5\mu\text{F}$ , and thirdly  $L = 7.5\text{mH}$ ,  $C = 3.9\mu\text{F}$ . As shown in Figure 2.

## 2.3 With Inductive (L) Filter

In this simulation we made use of L i.e. inductive filter and then apply the DC to the series motor we have used to values of inductor to obtain result of scope firstly  $L = 5\text{mH}$ , secondly  $L = 10\text{mH}$ , and thirdly  $L = 7.9\text{mH}$ . As shown in Figure 3.

## 2.4 With Capacitive (C) Filter

In this simulation we made use of C i.e. capacitive filter and then apply the DC to the series motor we have used to values of capacitor to obtain result of scope firstly  $C = 2.5\mu\text{F}$ , secondly  $C = 5\mu\text{F}$  and Thirdly  $C = 3.9\mu\text{F}$ . As shown in Figure 4.

These 4 models we have simulated in the MATLAB and we have used these models for future references.

### 3. Result of Simulation

After simulating the various simulation models we obtained the following results. And we have compared the 3 filters used in order to determine the best filter for controlling the characteristics of a given DC series motor.

#### 3.1 Without Filter

The graph response is shown in Figure 5.

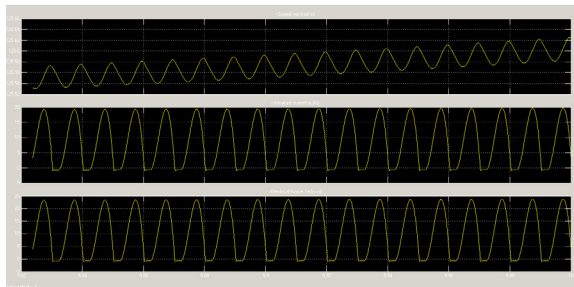


Figure 5. Without Filter.

#### 3.2 With LC Filter

##### 3.2.1 At $L=5\text{mH}$ & $C=2.5\mu\text{F}$ (Low Value)

The response obtained is shown in Figure 6.

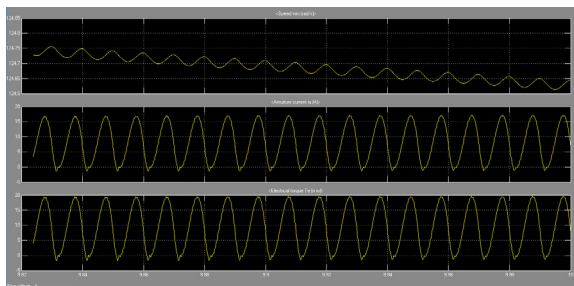


Figure 6. With LC Filter (Low Value).

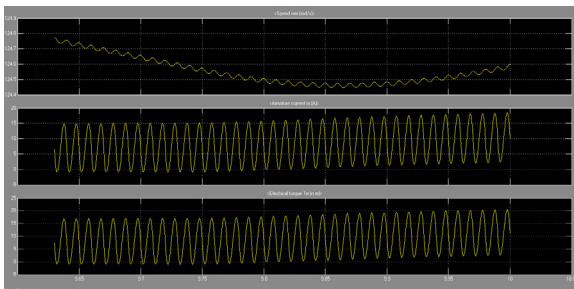


Figure 7. With LC Filter (Medium Value).

##### 3.2.2 At $L=7.5\text{mH}$ & $C=3.9\mu\text{F}$ (Medium Value)

The response obtained is shown in Figure 7.

##### 3.2.3 At $L=10\text{mH}$ & $C=5\mu\text{F}$ (High Value)

The response obtained is shown in Figure 8.

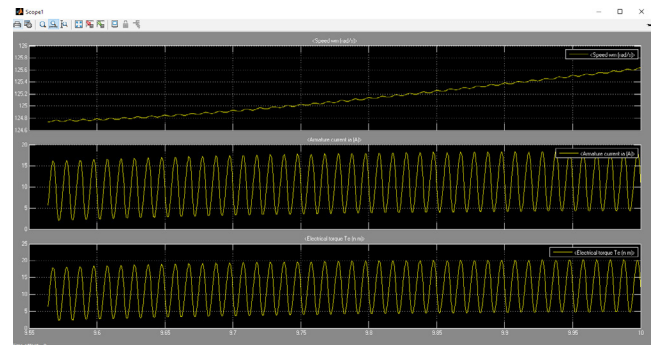


Figure 8. With LC Filter (High Value).

#### 3.3 With L Filter

##### 3.3.1 At $L=5\text{mH}$ (Low Value)

The response obtained is shown in Figure 9.

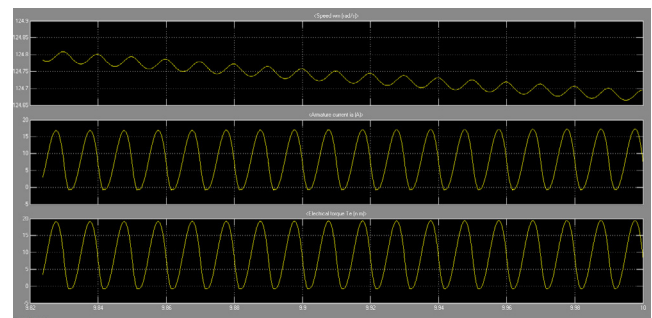


Figure 9. With L Filter (Low Value).

##### 3.3.2 At $L=7.5\text{mH}$ (Medium Value)

The response obtained is shown in Figure 10.

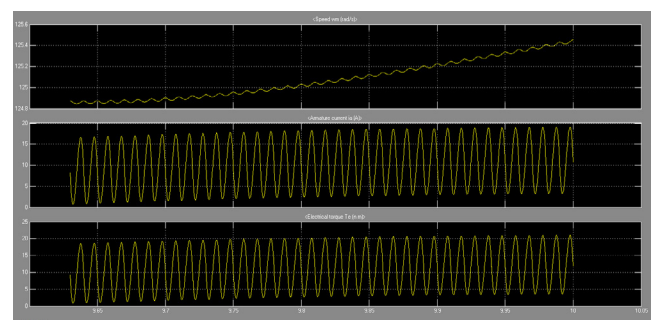


Figure 10. With L Filter (Medium Value).

### 3.3.3 At $L=10\text{mH}$ (High Value)

The response obtained is shown in Figure 11.

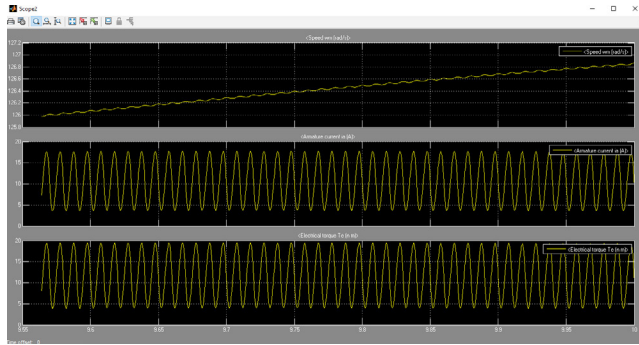


Figure 11. With L Filter (High Value).

## 3.4 With C Filter

### 3.4.1 At $C=2.5\mu\text{F}$ (Low Value)

The response obtained is shown in Figure 12.

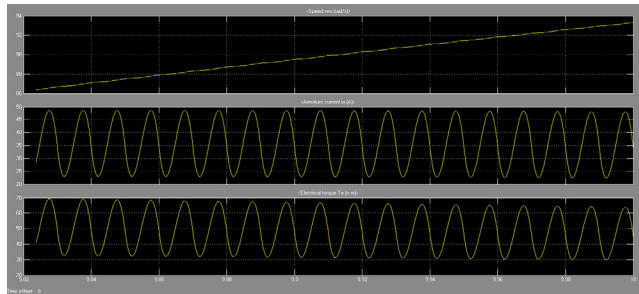


Figure 12. With C Filter (Low Value).

### 3.4.2 At $C=3.9\mu\text{F}$ (Medium Value)

The response obtained is shown in Figure 13.

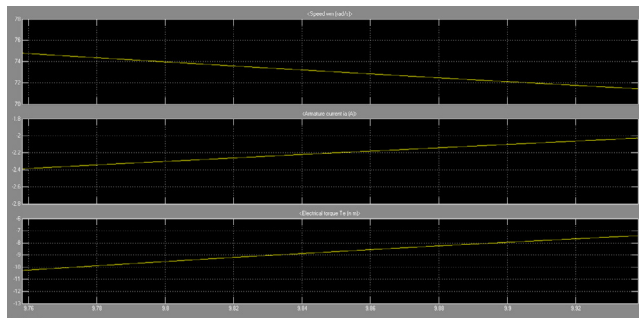


Figure 13. With C Filter (Medium Value).

### 3.4.3 At $C=5\mu\text{F}$ (High Value)

The response obtained is shown in Figure 14.

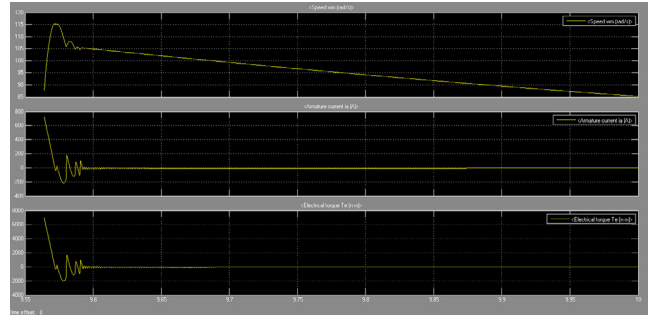


Figure 14. With C Filter (High Value).

In order to obtain the value of inductance, and capacitance we have tabulated in Table 1. And on the basis of the following table 1 we have computed the nova as shown in Figure 15, 16.

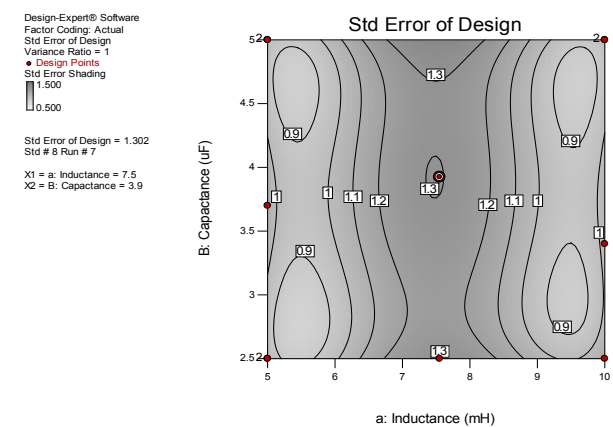


Figure 15. A NOVA FOR capacitive & inductive reactance part of Filter.

Table 1. Response comparison of Capacitance (Actual vs Predicted)

Group	Run	Factor 1 a:Induc- tance mH	Factor 2 B:Capac- tance uF	Response 1 Actual Capac- itance uF
1	1	5	5	2.5
1	2	5	2.5	2.5
2	3	5	3.7	2.5
2	4	5	5	2.5
2	5	5	2.5	2.5
3	6	7.5	2.5	4
3	7	7.5	3.9	4

4	8	10	5	5
4	9	10	2.5	5
5	10	10	3.4	5
5	11	10	5	5

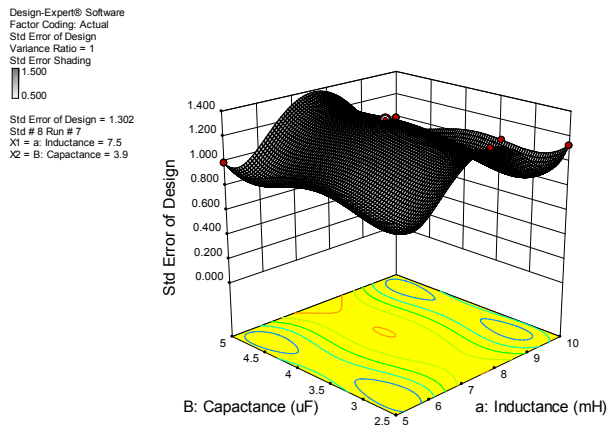


Figure 16. ANOVA for optimal results represents 5 points.

### 3.5 Final Equation in Terms of Actual Factors

R1	=
-1.80072	
+1.04022	* Inductance
+1.81024E-015	* Capacitance
+2.38769E-016	* Inductance * Capacitance
-0.036014	* Inductance <sup>2</sup>
-5.46479E-016	* Capacitance <sup>2</sup>

- The equations in terms of actual factors are used to make predictions about the response for given levels of each factor. Here, the levels must be specified in the original units for each factor. This equation should not be used to evaluate the relative influence of each factor because the coefficients are scaled to reconcile the units of each factor and the intercept is not at the centre of the design space. Diagnostic Plots clarifies the following parameters which are shown in Figure 17.
- Normal probability plot of the standardized residuals for checking normality of residuals.

- Standardized residuals versus (against) predicted values checking constant error.
- Externally Standardized Residuals to look for outliers, i.e., influential values.

Box-Cox plot for power transformations.

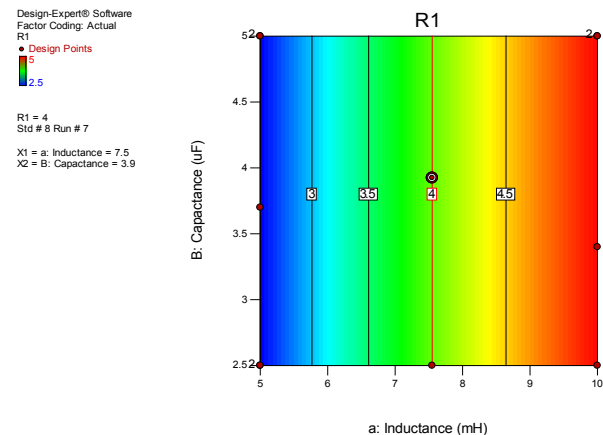


Figure 17. Diagnostic Plot.

## 4. Result

After formulating the results we have jumped into the conclusion that with  $L=7.5\text{mH}$  and  $C=3.9\mu\text{F}$  we obtained the best result with the DC Machine i.e. (DC) series motor and the best filter is LC filter. On combining both of these we obtained optimal result with variable speed and with constant torque and armature current characteristics.

## 5. Conclusion

ANOVA from the above given figure represents the optimal output for the LC –combination utilized in the filter Design. The 5 Optimal point's represents the optimal output of the range of Capacitance varies from  $2.5\mu\text{F}$  to  $5\mu\text{F}$  and Inductance  $5\text{mH}$  to  $10\text{mH}$ . The optimal value attains at the point  $L=7.5\text{mH}$  and  $C= 3.9\mu\text{F}$ . the Load Torque contains harmonic free component and itself satisfies the equation.

$$T=K\Phi I_a$$

As shown above the following values gives the constant field flux with the variable speed using the combination. The design is appropriate for the variable speed at constant armature and field, even if we do not make any variation in the mechanical Load.



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