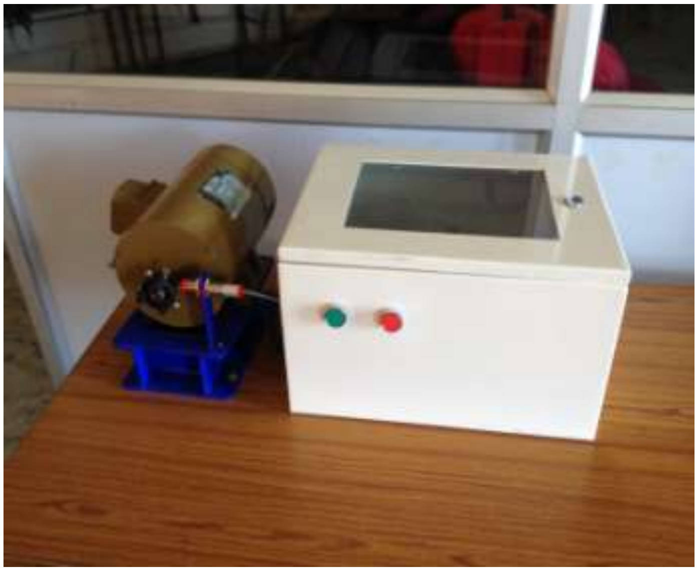
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

IV YEAR –I sem

Industrial Automation

POWER ELECTRONICS AND DRIVES LAB



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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Industrial Automation

POWER ELECTRONICS AND DRIVES

LABORATORY MANUAL /RECORD

CERTIFICATE

This is to certify that this is bonafide record of practical work done in the engineering lab……………………………….. in B.Tech…………………………year, during the academic year ……………..

Student name: ___________________________

Roll no: _________________________________

Class: ___________________________________

Branch: _________________________________

Signature of staff **signature of external examiner**

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1. FIRING ANGLE CONTROL OF THYRISTOR BASED DC DRIVE CONNECTED TO DC MOTOR

AIM: To obtain speed response of firing angle control of thyristor based DC drive connected to DC motor.

Apparatus:

i. NI LabView Software, DAQ
ii. Thyristorised DC drive
iii. DC motor
iv. Proximity Sensor

Specifications:

DC Drive	***DC motor, DC generator***
Thyristorized Bridge Rectifier: 0-220V DC	*Armature voltage:* 220V DC
Diode Bridge Rectifier : 220V DC	*Current:* 2Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Many industrial applications such as steel-rolling mills, paper mills and traction systems etc, make use of controlled DC power. DC power is obtained earlier from motor-generator sets or by thyristor rectifiers. The advent of thyristors has changed the art of ac to dc conversion. Presently phase controlled ac to dc converters employing thyristors are extensively used for changing constant ac input voltage to controlled dc output voltage. Here a thyristor is turned off as ac supply voltage reverse biased it, provided anode current has to fallen to a level below the holding current. The turning off or commutation, of a thyristor by supply voltage is called natural commutation or line commutation. Phase controlled concept is implemented by generating and triggering thyristor by firing pulse at desired firing angle. Firing angle of thyristor is measured from the instant it would start conducting if it were replaced by a diode. Firing angle may be defined as the angle measured from the instant SCR gets forward biased to the instant it is triggered. A single phase semi controlled converter is used in this experiment to vary voltage applied to DC motor. Semi converter has an advantages of freewheeling action is present inside converter itself, which improves p.f of circuit.

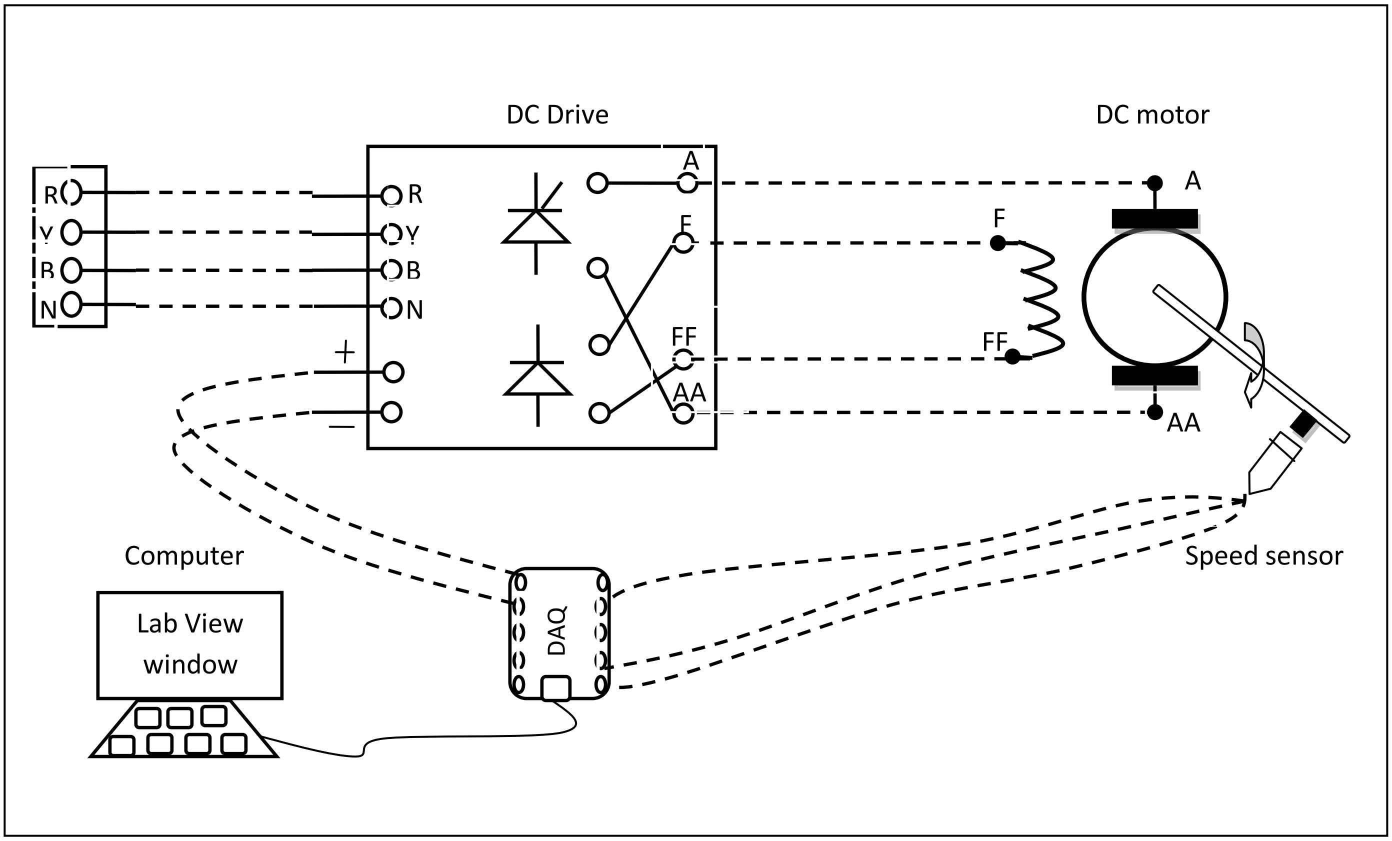


Fig.1.1 Circuit diagram for firing angle control of thyristorised DC drive

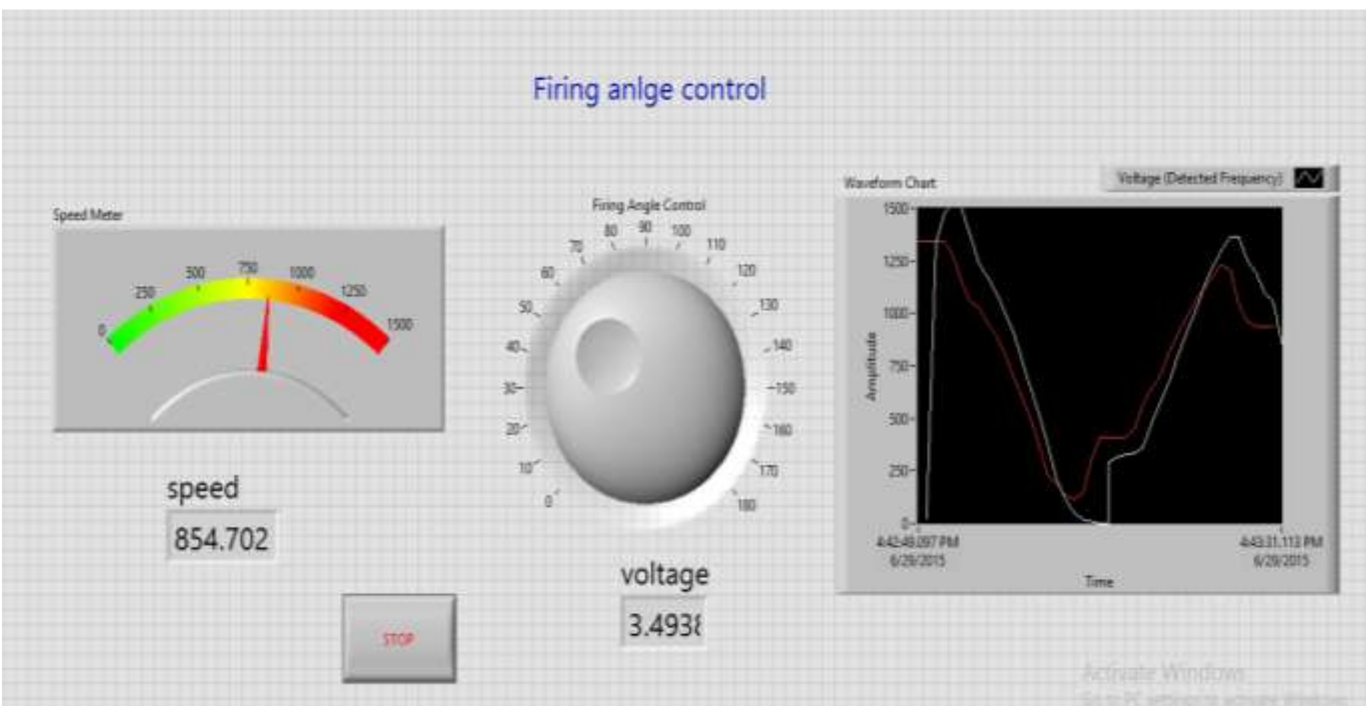
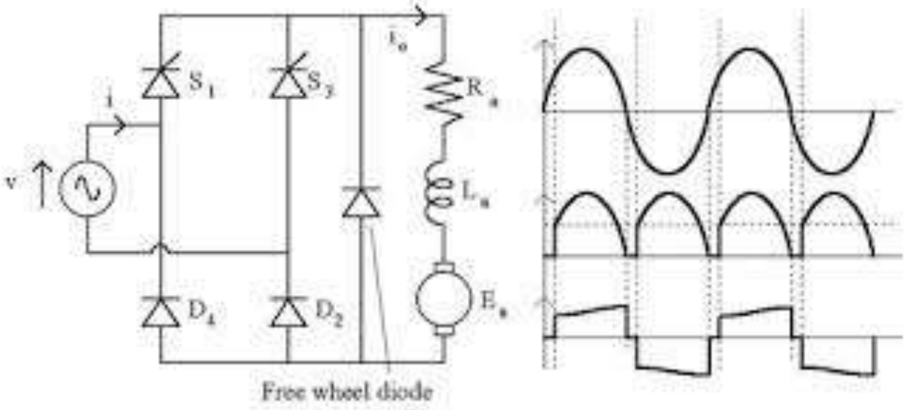


fig.1.2 LabView front panel diagram of firing angle control



The average output voltage of semi converter is given by $V_0 = \frac{V_m}{\Pi}(1+\cos\alpha)$

as the firing angle to thyristors varies from 0^0-180^0, average output voltage from semi converter 0 to V_m / Π

than speed control of dc motor can be done by firing angle control from relation

$$w_m = \frac{(V_m/\Pi)(1+\cos\alpha)}{K_m} - \frac{r_a}{K_m^2}.T_e$$

Procedure:

1. Connect circuit as per circuit diagram
   i. Connect supply to DC drive
   ii. Connect output of DC drive to armature and field supplies of DC motor
   iii. Connect speed sensor & DC drive variable point to DAQ assistant
2. Develop LabView diagram in block diagram consists of firing angle control nub and speed feedback.
3. Run the LabView diagram and vary firing angle nub around 1 mint.
4. Ensure that motor speed follows the set speed or reference speed.
5. Take the data to excel file, draw the set speed and actual speed on a single plot
6. Observe the response of speed control loop using plot

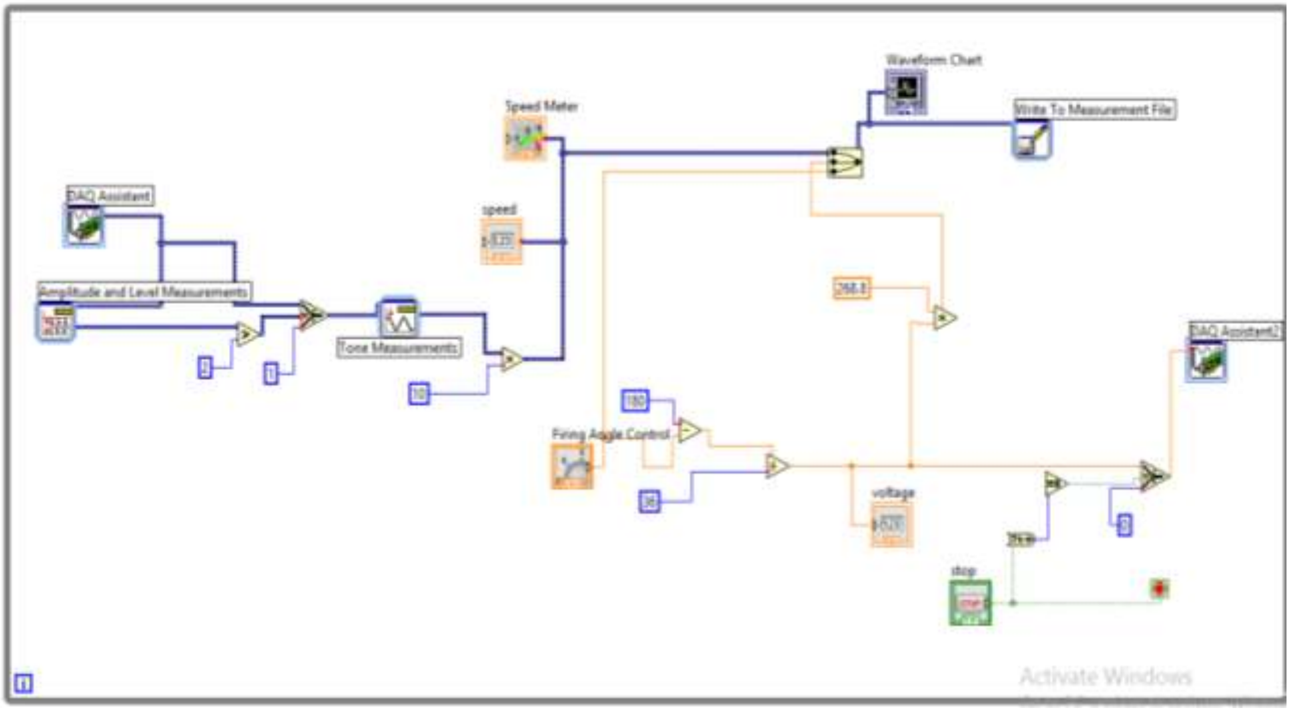


Fig.1.3 LabView block diagram of firing angle control

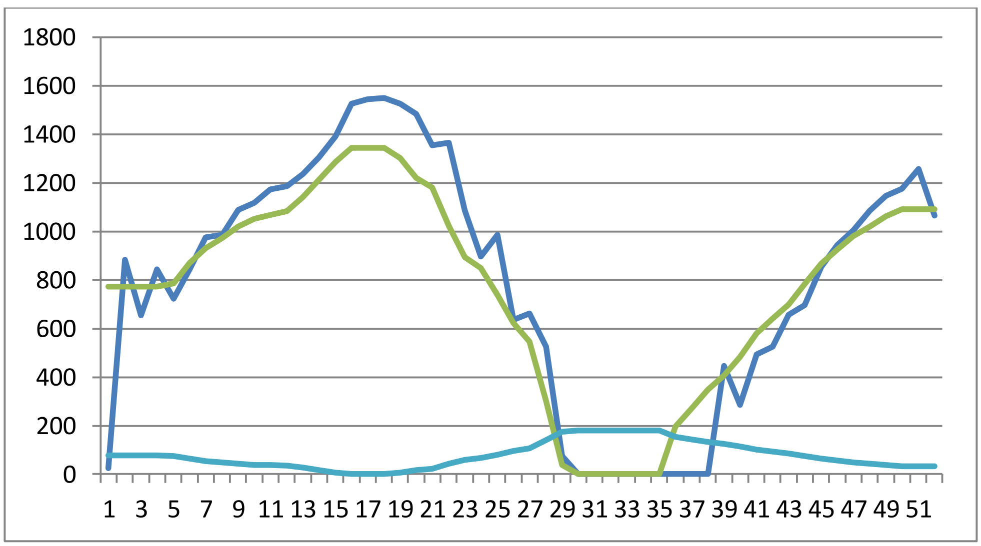


Fig.1.4 speed response plot of firing angle control of DC motor & firing angle.

RESULT: Firing angle control of thyristorised DC drive connected to DC motor is done and speed response of drawn.

2. CLOSED LOOP SPEED CONTROL OF DC MOTOR USING PI, PD AND PID CONTROLLERS

AIM: To design and tune proper PI, PD & PID controllers for speed control of DC motor drive

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. Thyristorised DC drive
iv. DC motor
v. Proximity Sensor

Specifications:

DC Drive	***DC motor***
Thyristorized Bridge Rectifier: 0-220V DC	*Armature voltage:* 220V DC
Diode Bridge Rectifier : 220V DC	*Current:* 2Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Motion control is required in large number of industrial and domestic applications like transportation systems, rolling mills, fans, pumps & robots etc. systems employed for motion control are called drives. Drives employing electric motors are called electrical drives.

Block diagram of electric drive is shown in figure 2.1

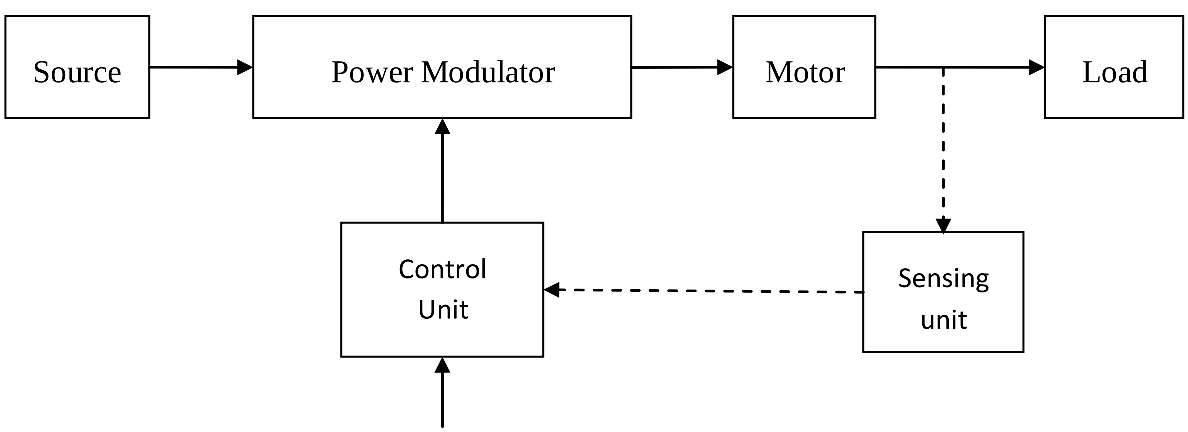


Fig.2.1 Block diagram of electric drive

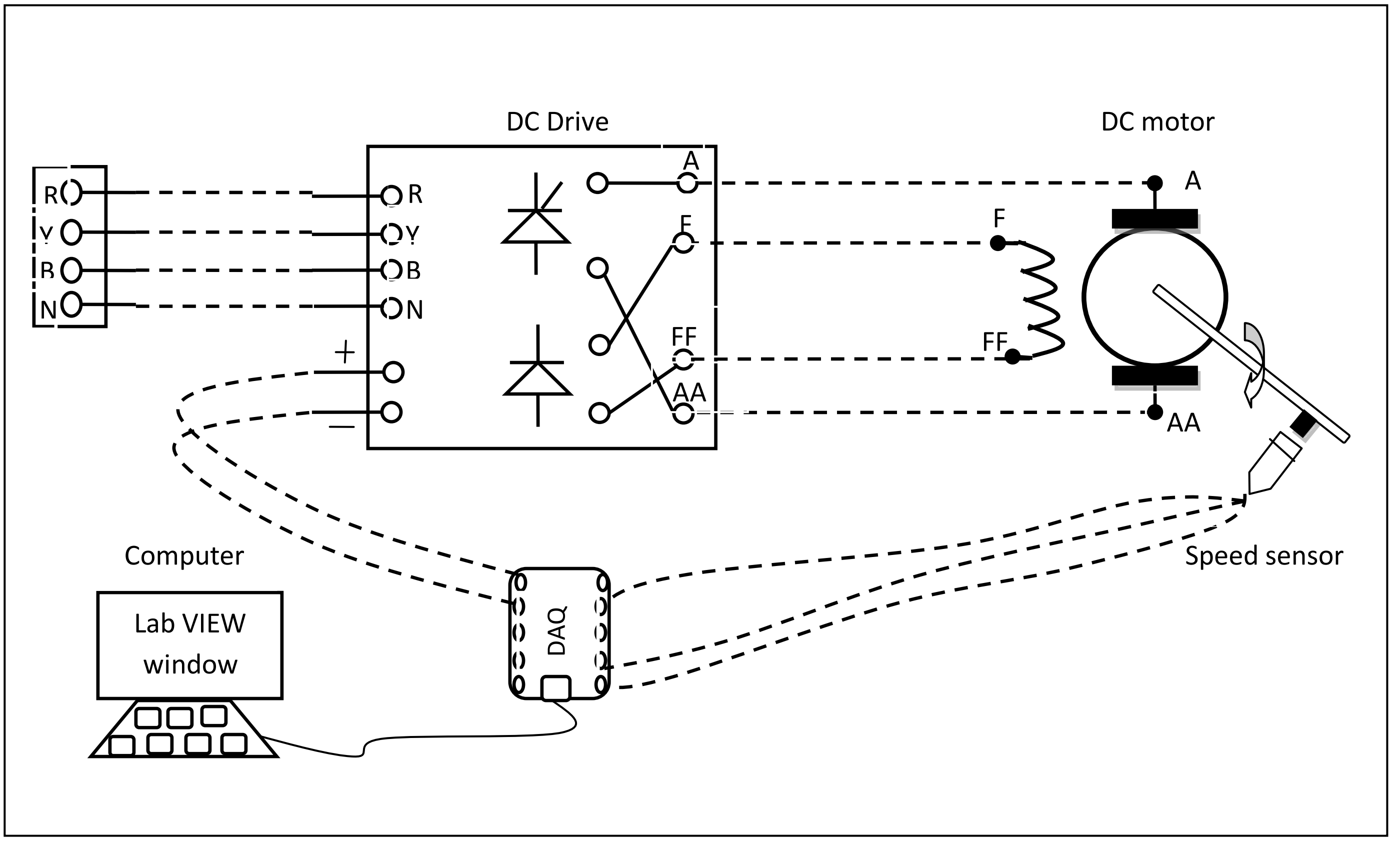


Fig.2.1 Circuit diagram for closed loop speed control of DC motor

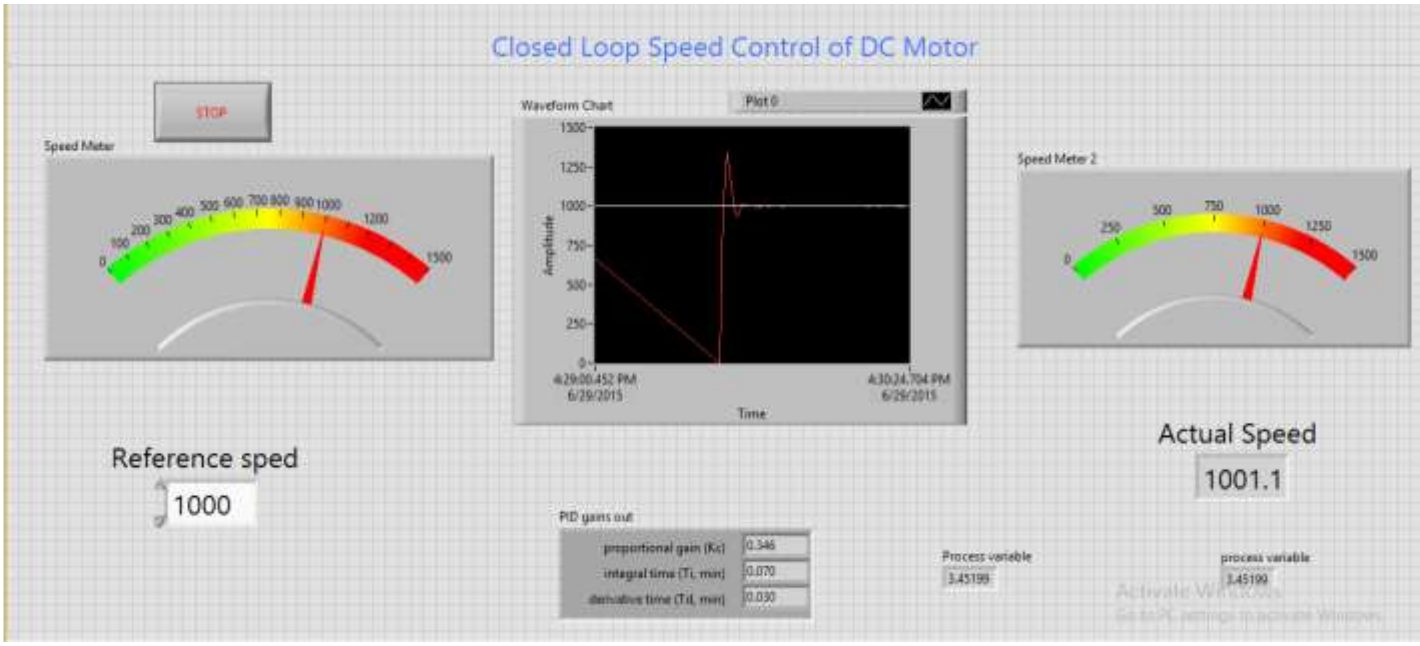


Fig.2.2 LabView front panel diagram of closed loop speed control of DC motor

Load is usually machinery designed to accomplish a given task. Usually load requirements can be specified in terms of speed control and torque demands. A motor having speed-torque characteristics and capabilities compatible with load demands. Power modulator modulates flow of power from the source to the motor in such a manner that motor is imparted speed-torque characteristics required by load. Controls for power modulator built in control unit which usually operates at much lower voltage and power levels.

Closed loop speed control of DC motor is shown in fig2.2 it consists of same elements present in block diagram 2.1, control unit is a computer in which control concept is implemented using LabView where auto tuning of PID control is done to get the motor speed to reference speed or set speed. Thyristor drive gives the required DC voltage to drive motor at desired speed according to output voltage variable from PID controller. PID controller adjusts the output voltage variable till the motor speed reaches desired speed.

Procedure:

1. Connect circuit as per circuit diagram
    i. Connect supply to DC drive
    ii. Connect output of DC drive to armature and field supplies of DC motor
    iii. Connect speed sensor & DC drive variable point to DAQ assistant
2. Develop LabView diagram in back panel consists of reference speed, PID controller design and speed feedback.
3. Set the reference speed to some value say 1000 RPM
4. Tune the PID controller using auto-tune block till we get desired P, I , D values.
5. Ensure that motor speed follows the set speed or reference speed.
6. Take the data to excel file from LabView, draw the set speed and actual speed on a single plot
7. Observe the response of speed control loop using plot
8. Vary the P, I, D gains around the tune values and see the response.
9. Design the PI, PD controllers and repeat the step 3 to 8.

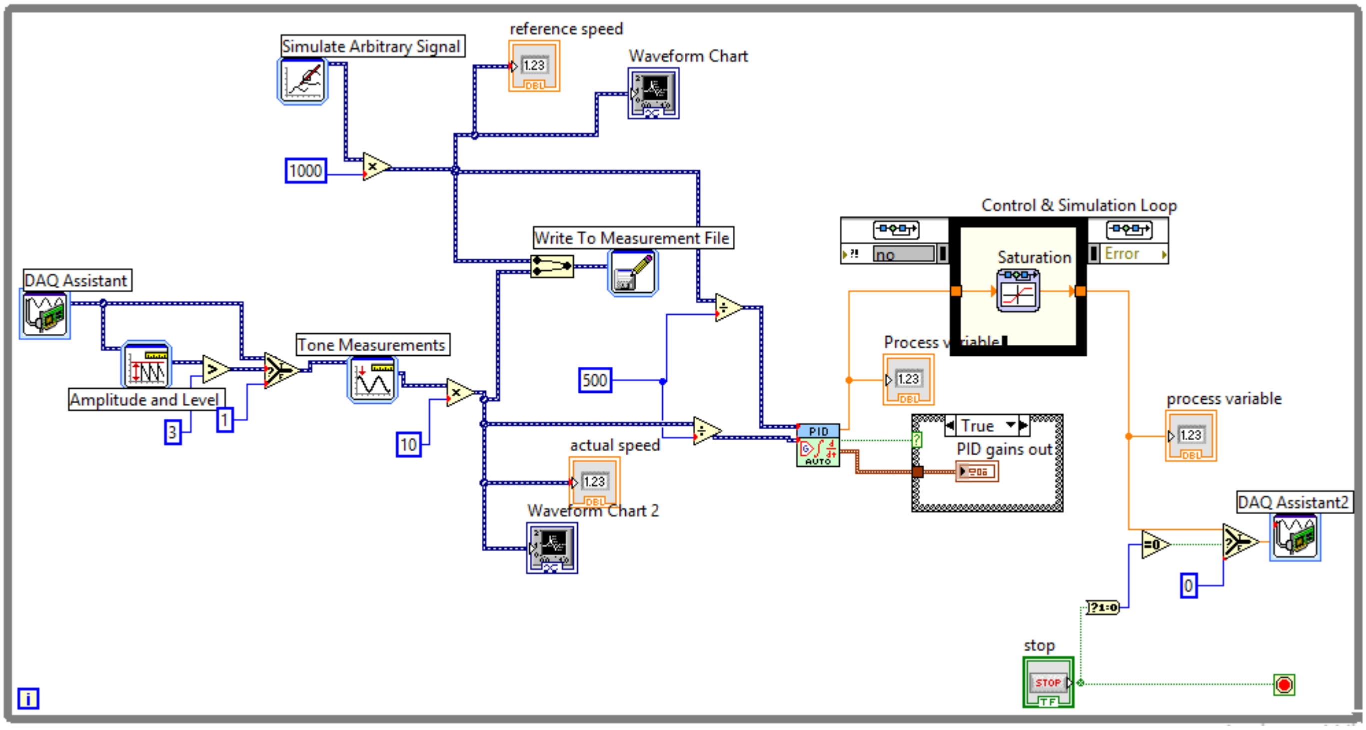


Fig.2.3 LabView Back panel diagram of closed loop speed control of DC motor

Fig.2.4 Model graph of closed loop speed control of DC motor

Table:

Reference Speed	PI gains	PD gains

Table 1: Different set speeds & P, I, D gains

Result: closed loop speed control of DC motor is done and speed response is plotted.

3. CLOSED LOOP SPEED CONTROL OF DC MOTOR-GENERATOR SET WITH LOAD USING PI, PID CONTROLLERS

AIM: To design and tune proper PI, PID controllers for speed control of DC motor-generator set with load.

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. Thyristorised DC drive
iv. DC motor
v. Proximity Sensor

Specifications:

DC Drive	***DC motor***
Thyristorized Bridge Rectifier: 0-220V DC	*Armature voltage:* 220V DC
Diode Bridge Rectifier : 220V DC	*Current:* 2Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Closed loop speed control of DC motor generator system is shown in fig3.1 it consists of same elements present in block diagram 2.1, power modulator control power flow from source to motor. Power modulator is a DC drive consists of Thyristorised semi converter where output voltage is varied based on controlled voltage given as input to gating circuit, as input voltage varies from 0 to 5VDC drive output varies from 0-220V. Controlled voltage is generated from closed loop with PID control implemented in LabView based on reference speed set value. Actual speed is sensed using proximity speed sensor and compared with reference speed an speed error is generated, if error is positive PID controller increases controlled voltage and if error is negative it decreases the controlled voltage till the motor speed attains set reference speed. Saturation limiter is limits the output voltage always in between 0 -5V even though PID controller output varies -100 to +100. PID controller is tuned using auto tune blocks available in control design & simulation tool box.

DC generator is connected to motor, which generates DC voltage according field supply voltage to generator and motor actual speed. Loading of DC generator is done by using lamp load, as load on generator increases which indirectly loads the motor there by motor speed reduces.

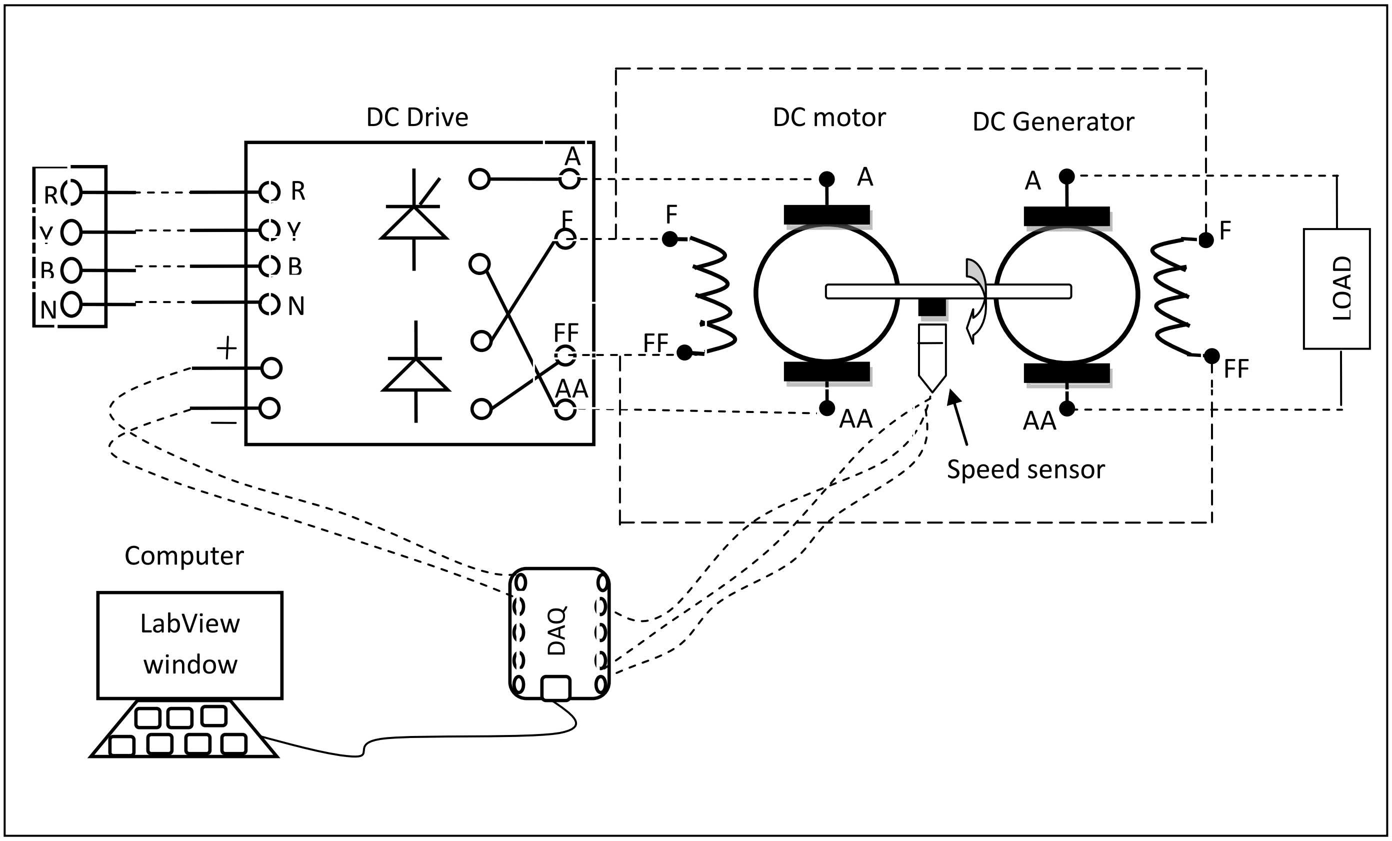


Fig.3.1 Circuit diagram for closed loop speed control of DC motor- generator set with load.

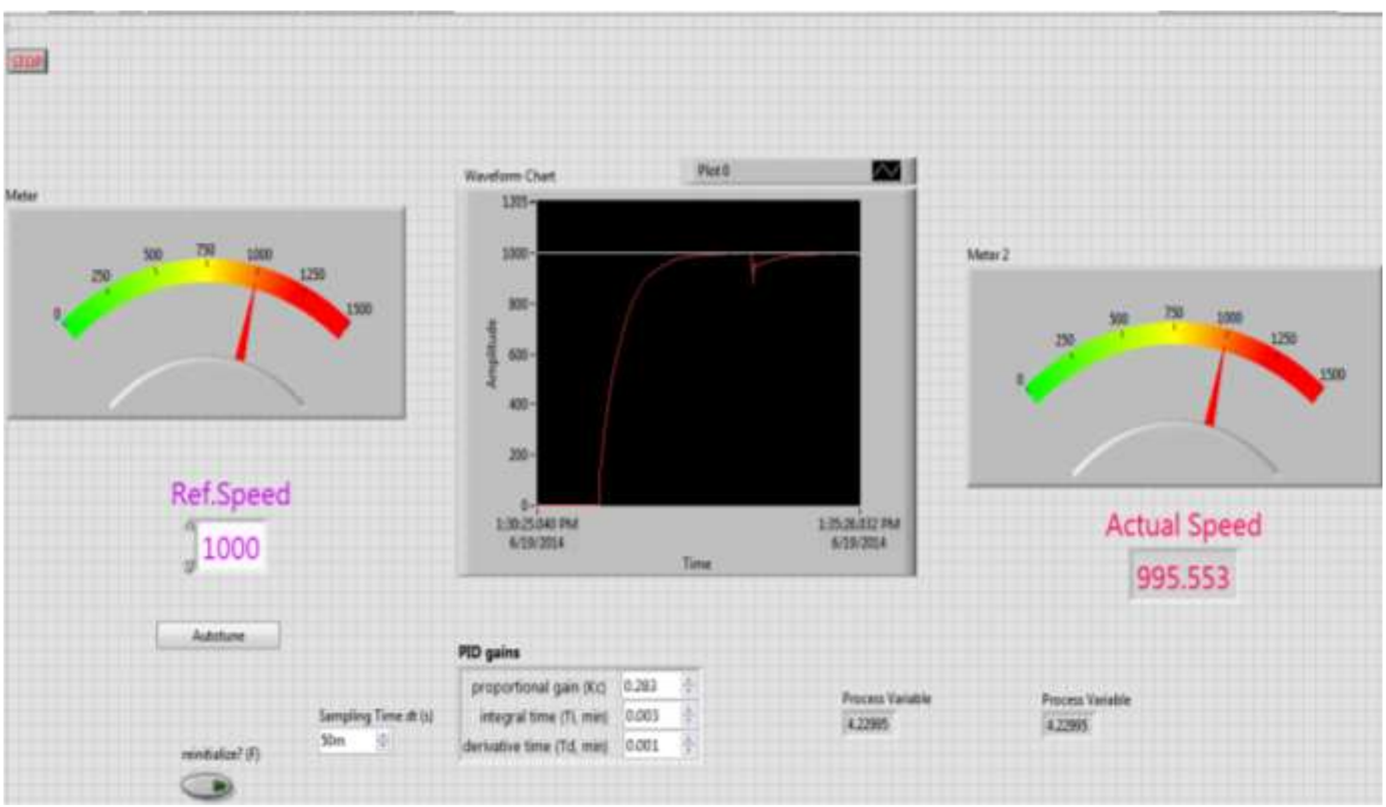


Fig.3.2 LabView front panel diagram for closed loop control of DC motor- generator set with load

PID control always sees the motor speed following set speed or not. As motor speed reduces due to loading speed error becomes positive then PID controller increases the controller voltage till motor reaches set speed. A graph is plotted between set speed and actual speed of motor by getting data from LabView using LVM file and drawn in Excel sheet, we can observe variation in speed from the plot very easily. This experimental setup can be used as constant speed drive system in industry even load varies on the system.

speed control of dc motor can be done from following relation by varying firing angle of thyristor drive which indirectly depends on controller voltage from PID controller.

$$w_m = \frac{(V_m/\prod)(1+\cos\alpha)}{K_m} - \frac{r_a}{K_m^2}.T_e$$

Procedure:

1. Connect circuit as per circuit diagram
    i. Connect supply to DC drive
    ii. Connect output of DC drive to armature and field supplies of DC motor
    iii. Connect field supply to DC generator
    iv. Connect speed sensor & DC drive variable point to DAQ assistant
2. Develop LabView diagram in back panel consists of reference speed, PID controller design and speed feedback.
3. Set the reference speed to some value say 1000 RPM
4. Tune the PID controller using auto-tune block till we get desired P, I , D values.
5. Ensure that motor speed follows the set speed or reference speed.
6. Add load on DC generator in steps
7. Take the data to excel file from LabView, draw the set speed and actual speed on a single plot
8. Observe the response of speed control loop using plot
9. Vary the P, I, D gains around the tune values and see the response.
10. Design the PI controller and repeat the step 3 to 9.

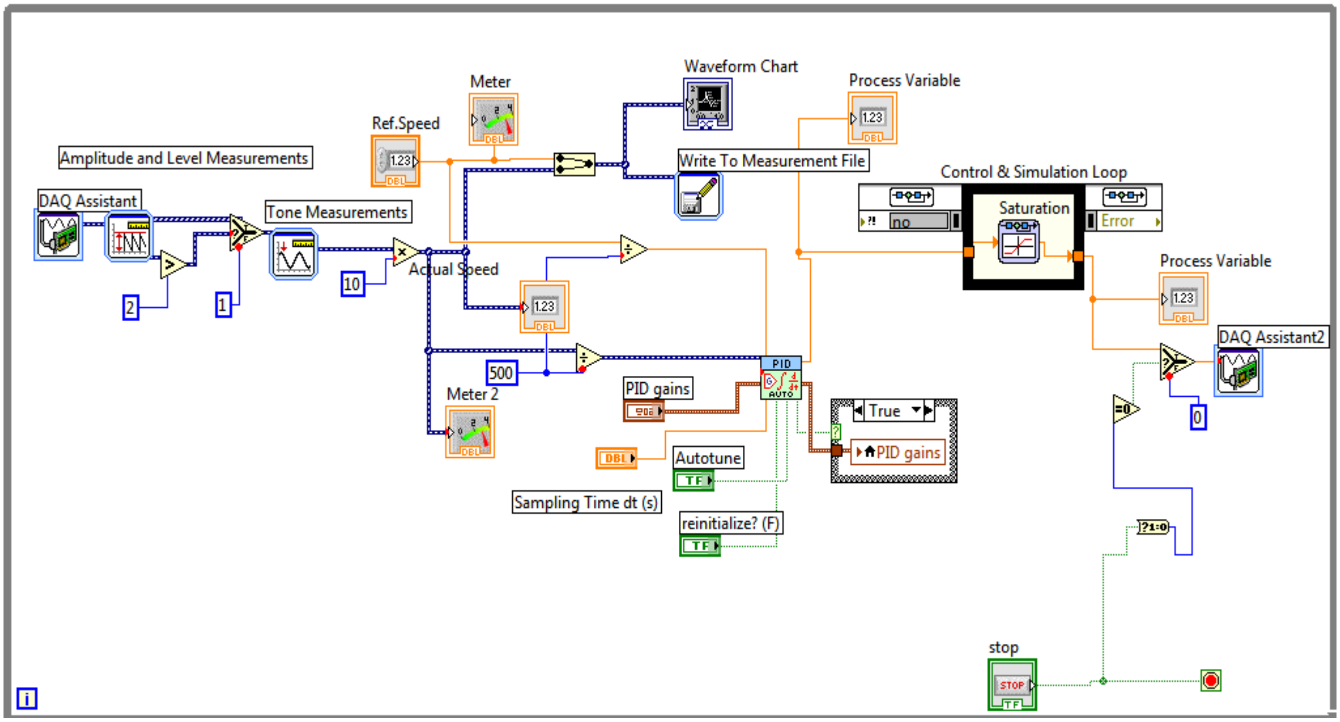


Fig.3.3 LabView back panel diagram for closed loop control of DC motor- generator set with load

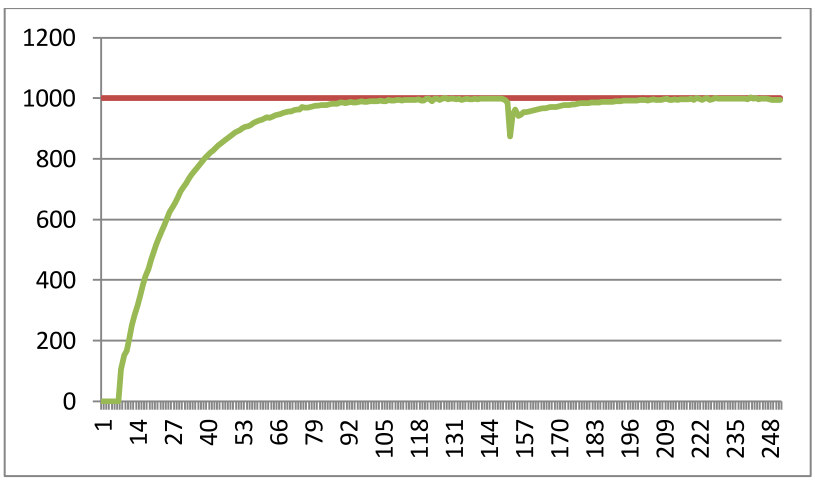


Fig.3.4 speed response plot of closed loop control of DC motor –generator set with load

Table:

Reference Speed	PI gains		PD gains	
	P=	I=	P=	D=
	P=	I=	P=	D=

Table 2: Different set speeds & P, I, D gains

Result: closed loop speed control of DC motor-DC generator set with load is done and speed response is plotted.

4. STEP,RAMP AND PARABOLIC SPEED RESPONSE OF SECOND ORDER DC MOTOR SYSTEM ON LABVIEW

AIM: To find step, ramp and parabolic speed response of second order DC motor system on LabView.

Apparatus:

i. NI LabView Software, DAQ
ii. Thyristorised DC drive
iii. DC motor
iv. Proximity Sensor

Specifications:

DC Drive	***DC motor, DC generator***
Thyristorized Bridge Rectifier: 0-220V DC	*Armature voltage:* 220V DC
Diode Bridge Rectifier : 220V DC	*Current:* 2Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Most of the control systems use time as its independent variable, so it is important to analyse the response given by the system for the applied excitation which is function of time. The evaluation of system is based on the analysis of such response. The complete base of stability analysis, system accuracy and complete evaluation is always based on the time response analysis.

In many practical cases, the desired performance characteristics of control systems can be given in terms of transient response specifications and step, ramp, and parabolic inputs are commonly used as input for this purpose, since such an input is easy to generate. Mathematically, if the response of a linear system to a step input is known, by principle of superposition and linear theory assumptions, it is possible to compute the system's response to any input. However, the transient response of a system to a unit step input depends on initial conditions. If the inputs to a control system are gradually changing functions of time, then a ramp function of time may be a good test signal. If the inputs to a control system are gradually changing functions of time, then a parabolic function of time may be a good test signal.

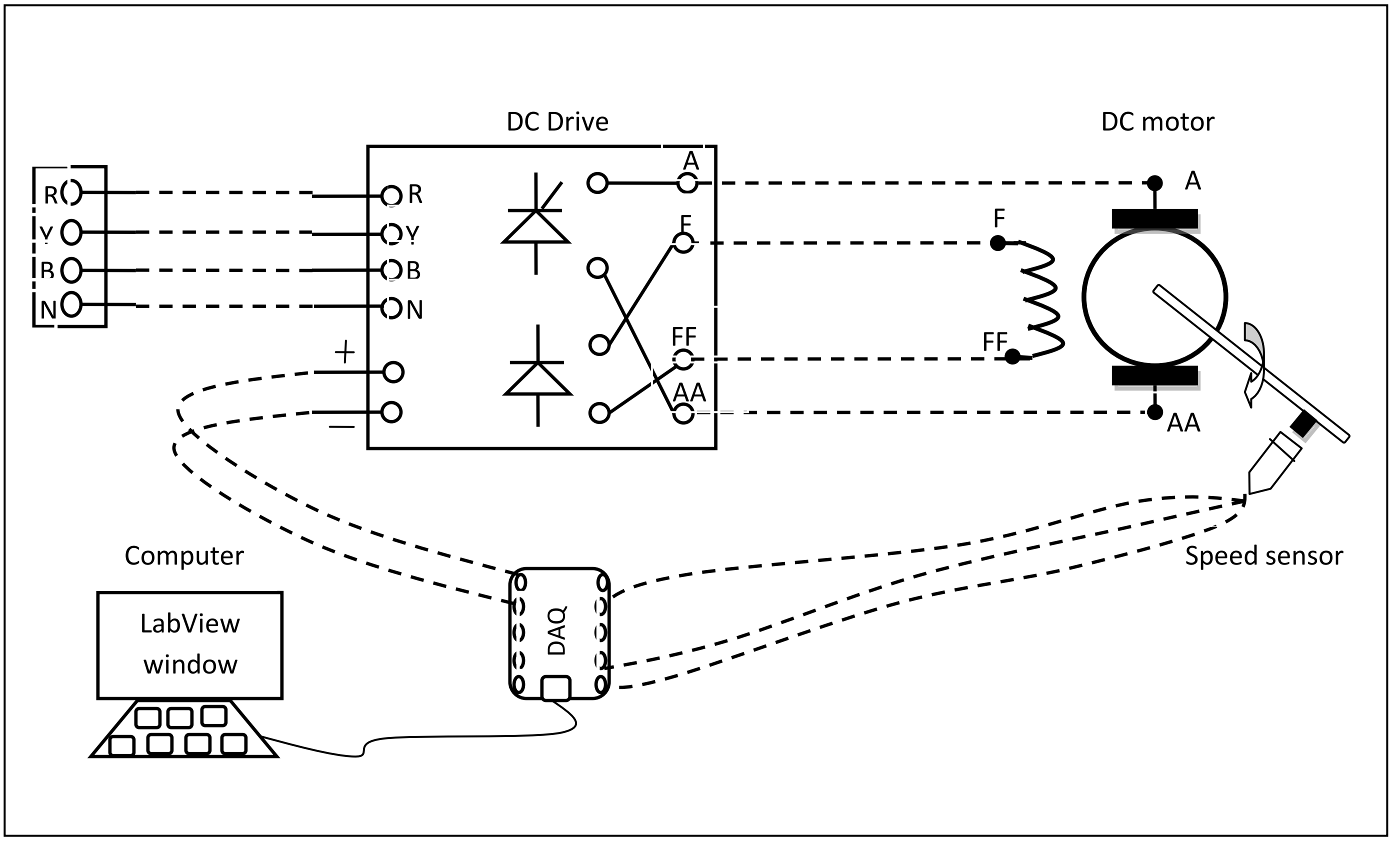


Fig.4.1 Circuit diagram for step, ramp, parabolic response of second order DC motor system

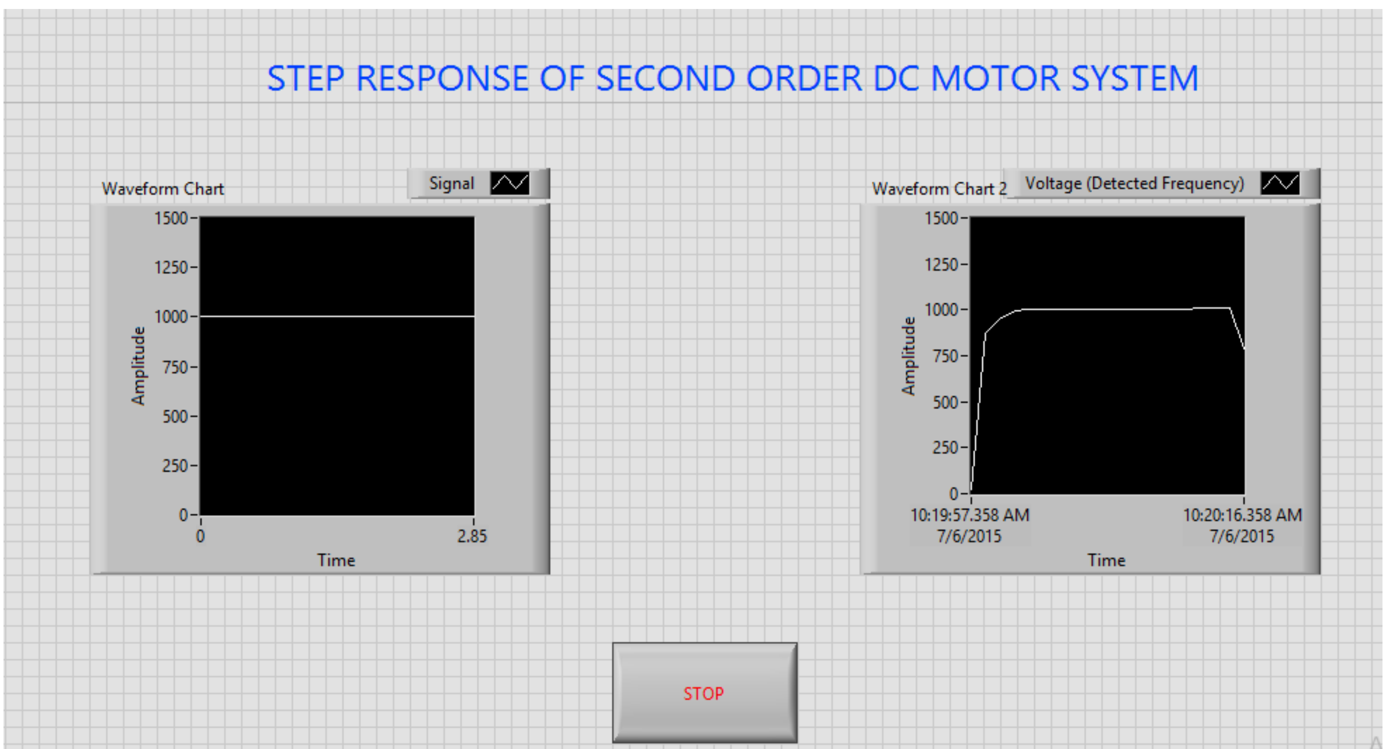


Fig.4.2 front panel diagram of step response of second order DC motor system

Step Function: Mathematically, a unit step function can be described by

$$f(t) = \begin{cases} 0, & t < 0 \\ 1, & t \geq 0 \end{cases}$$

In order to determine the response of a dynamic system to a step function, it is convenient to use Laplace Transform. The Laplace Transform of a unit step function is

$$L\{u(t)\} = \frac{1}{S}$$

The unit Step response of second order system is given by

$$C(s) = G(s)R(s) = \frac{w_n^2}{s(s^2 + 2\xi w_n s + w_n^2)}$$

Ramp Function: The Ramp signal is a signal which starts at a value of zero and increases linearly with time. Mathematically, a unit ramp function can be described by

$$r(t) = \begin{cases} At, & t > 0 \\ 0, & t < 0 \end{cases}$$

In order to determine the response of a dynamic system to a step function, it is convenient to use Laplace Transform. The Laplace Transform of a unit ramp function is

$$L\{u(t)\} = \frac{1}{S^2}$$

The unit Ramp response of second order system is given by

$$C(s) = G(s)R(s) = \frac{w_n^2}{s^2(s^2 + 2\xi w_n s + w_n^2)}$$

Parabolic Function: The Parabolic signal is a signal which starts at a value of zero and increases linearly with time. Mathematically, a unit parabolic function can be described by

$$r(t) = \begin{cases} At^2/2 & t > 0 \\ 0 & t < 0 \end{cases}$$

In order to determine the response of a dynamic system to a step function, it is convenient to use Laplace Transform. The Laplace Transform of a unit parabolic function is $L\{u(t)\} = \frac{1}{S^3}$

The unit parabolic response of second order system is given by $C(s) = G(s)R(s) = \frac{w_n^2}{s^3(s^2 + 2\xi w_n s + w_n^2)}$

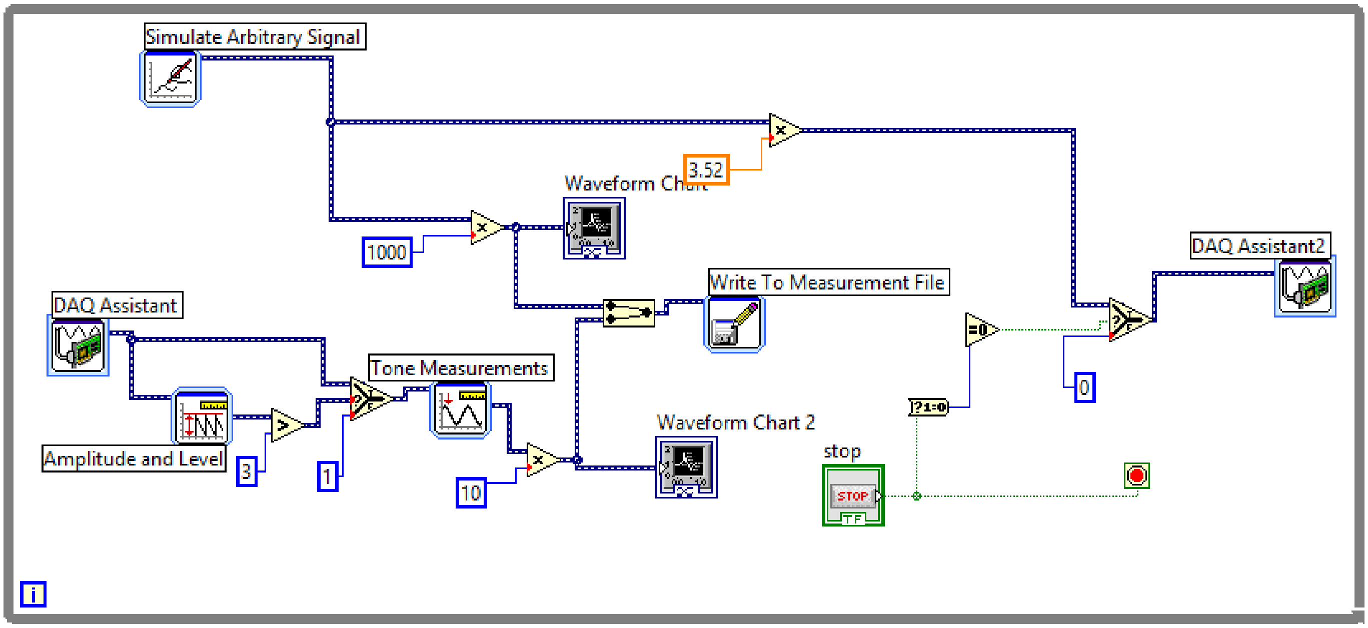


Fig.4.3 block diagram of step response of second order DC motor system

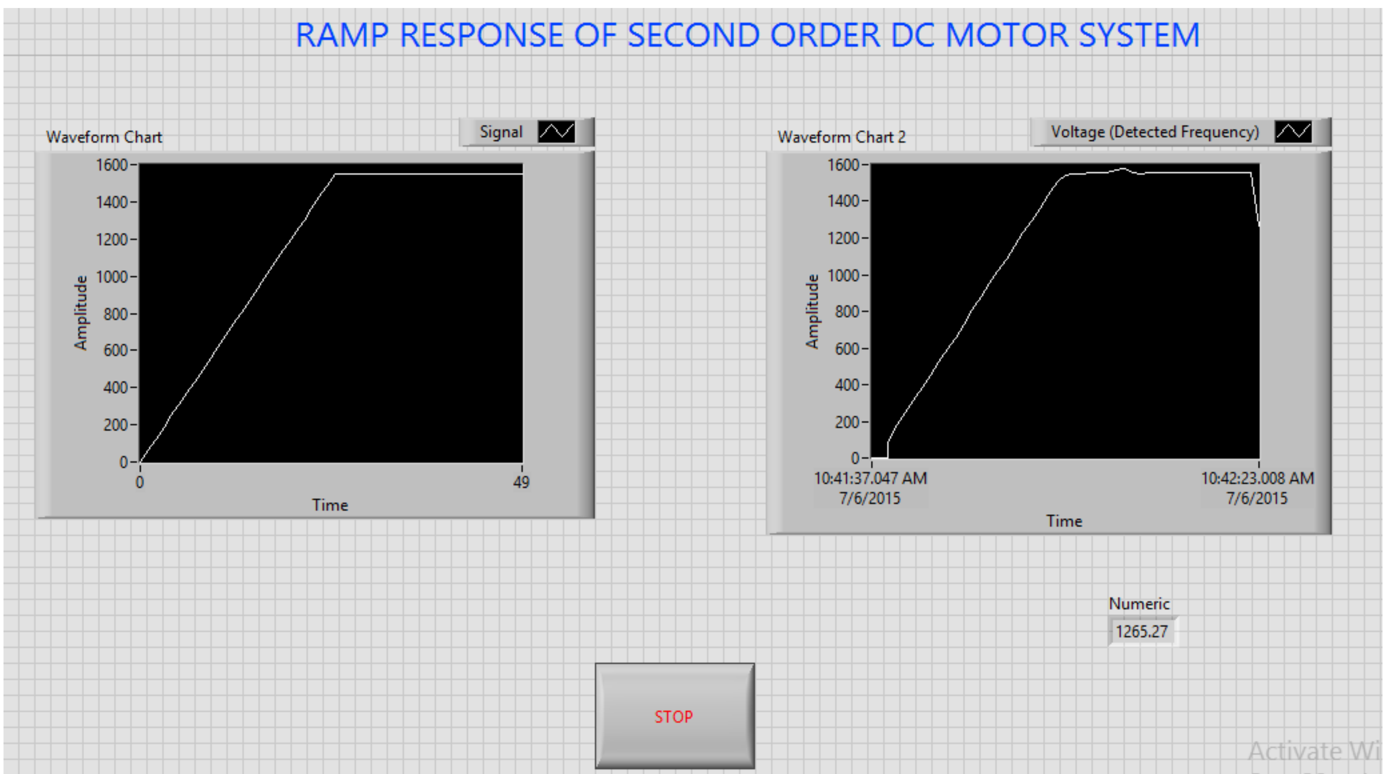


Fig.4.4 front panel of ramp response of second order DC motor system

Circuit diagram for step response of second order DC motor system is shown in fig4.1 it consists of same elements present in block diagram 2.1, power modulator control power flow from source to motor. Controlled voltage is generated from the step response of second order system i.e developed in LAB VIEW. Step signal is taken as reference speed signal. DC Motor receives the proportional voltage according to the step signal designed in LAB VIEW. We can observe the step speed response of second order DC Motor by speed characteristics. Circuit diagrams for ramp, parabolic is same as step signal and response of second order DC motor is obtained.

The closed loop transfer function of second order DC Motor is given by

$$\frac{\theta(s)}{R(s)} = \frac{K_p K_m}{s^2 T_m + s + K_p K_m}$$

Procedure:

1. Connect circuit as per circuit diagram
   i. Connect supply to DC drive
   ii. Connect output of DC drive to armature and field supplies of DC motor
   iii. Connect speed sensor & DC drive variable point to DAQ assistant
2. Develop LabView diagram in back panel consists of reference speed signal and speed feedback.
3. Construct reference speed signal as step signal using simulate arbitrary signal.
4. Run the LabView diagram for some time duration say 2mins.
5. Ensure that motor speed follows the set speed or reference speed.
6. Take the data to excel file, draw the set speed and actual speed on a single plot
7. Observe the response of speed control loop using plot
8. Construct Ramp & Parabolic signals and repeat the step 4 to 7.

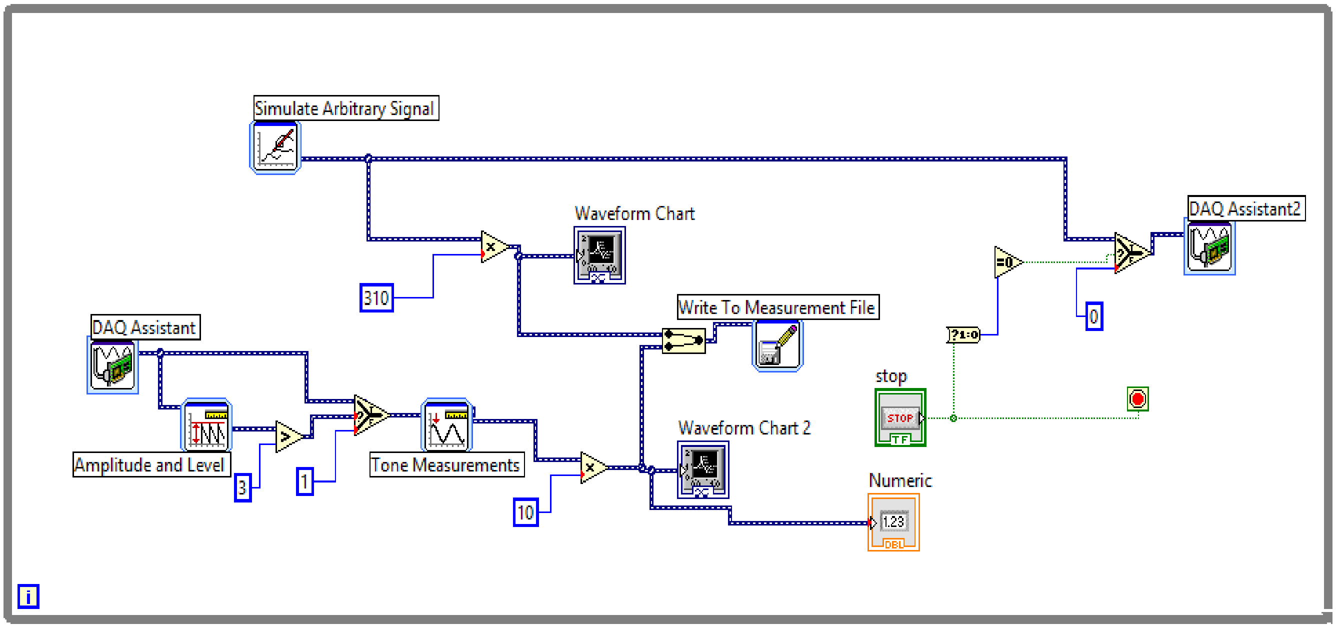


Fig.4.5 block diagram of ramp response of second order DC motor system

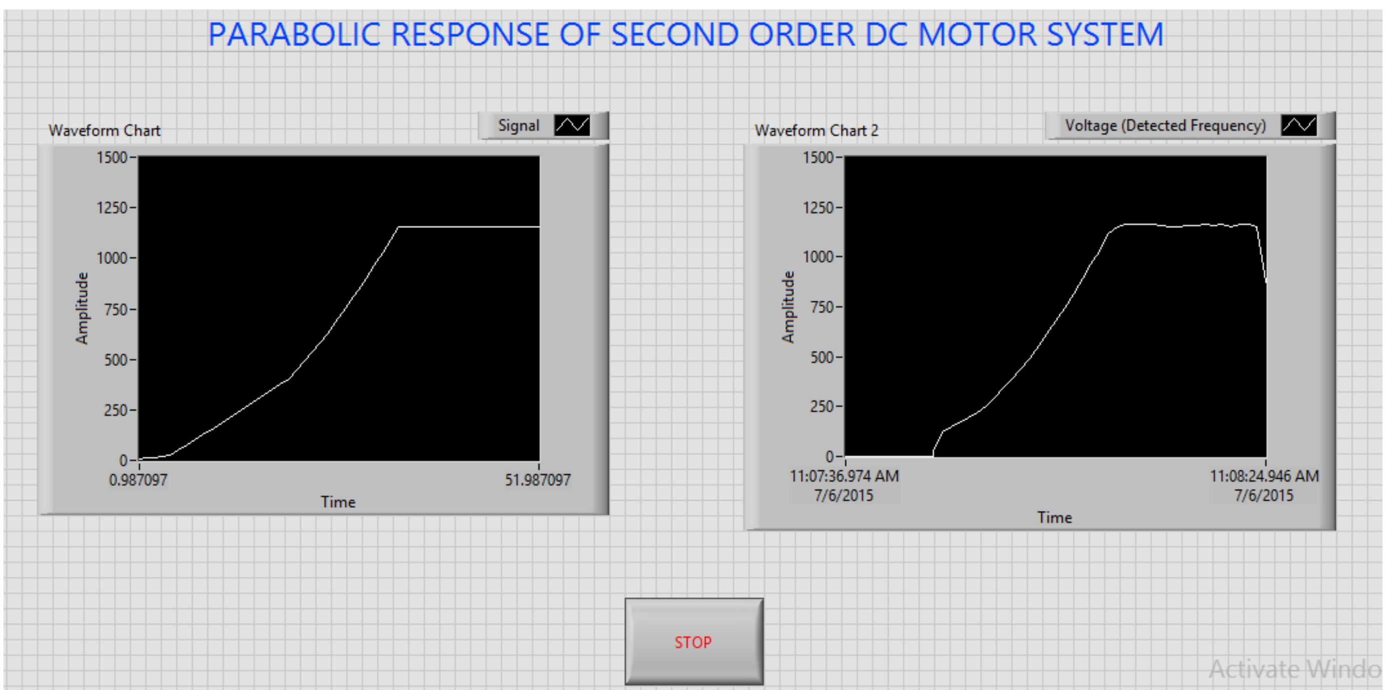


Fig.4.6 front panel of parabolic response of second order DC motor system

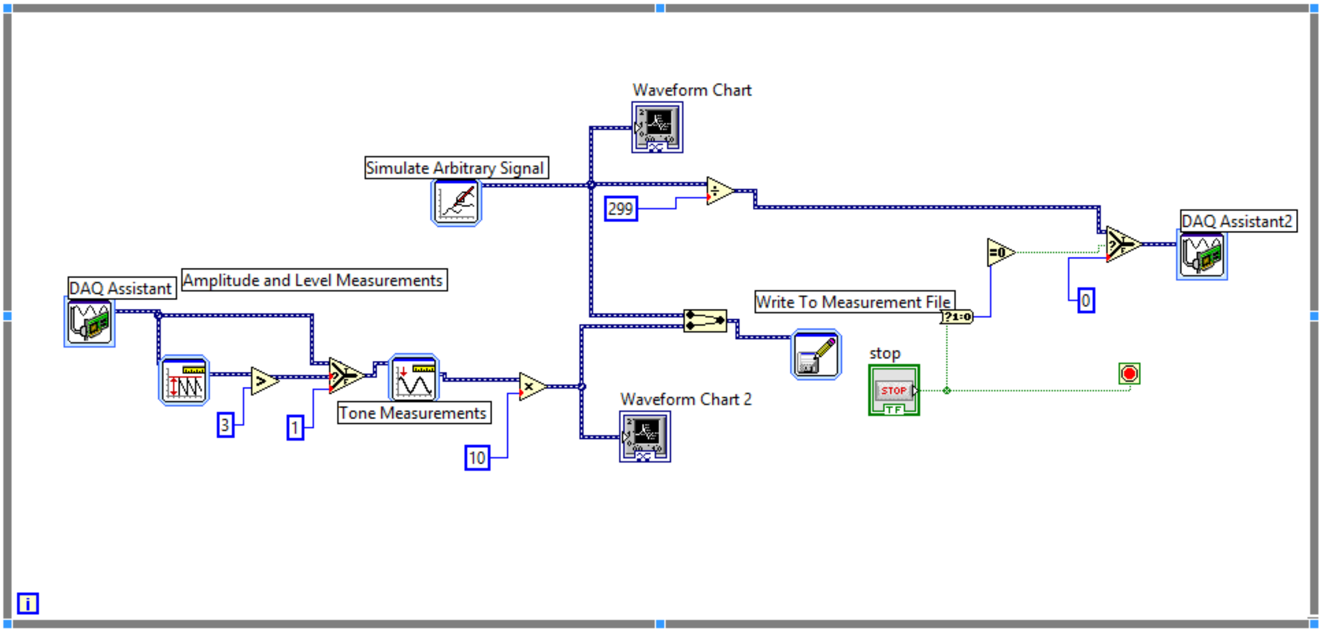


Fig.4.7 block diagram of parabolic response of second order DC motor system

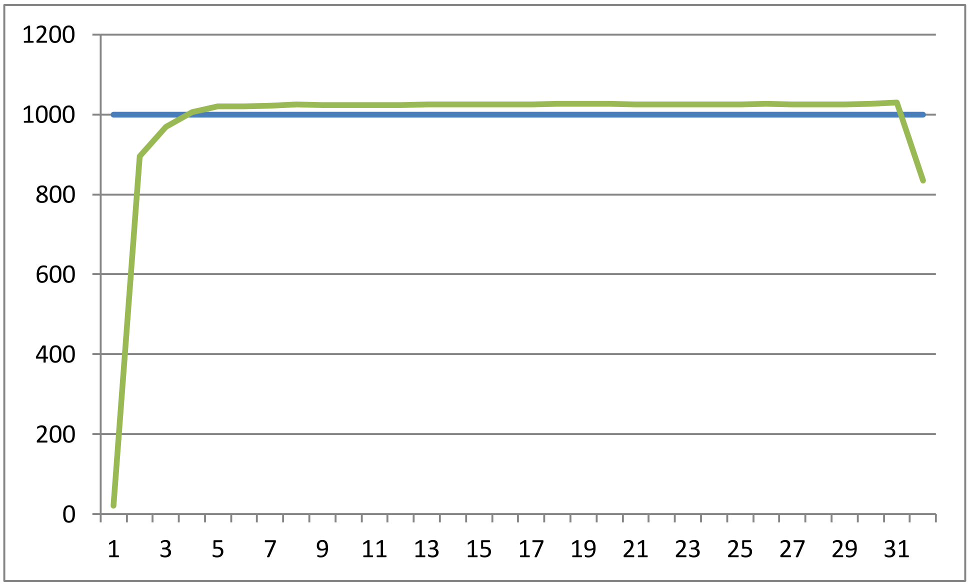


Fig.4.8 speed response plot of second order DC motor system with step input

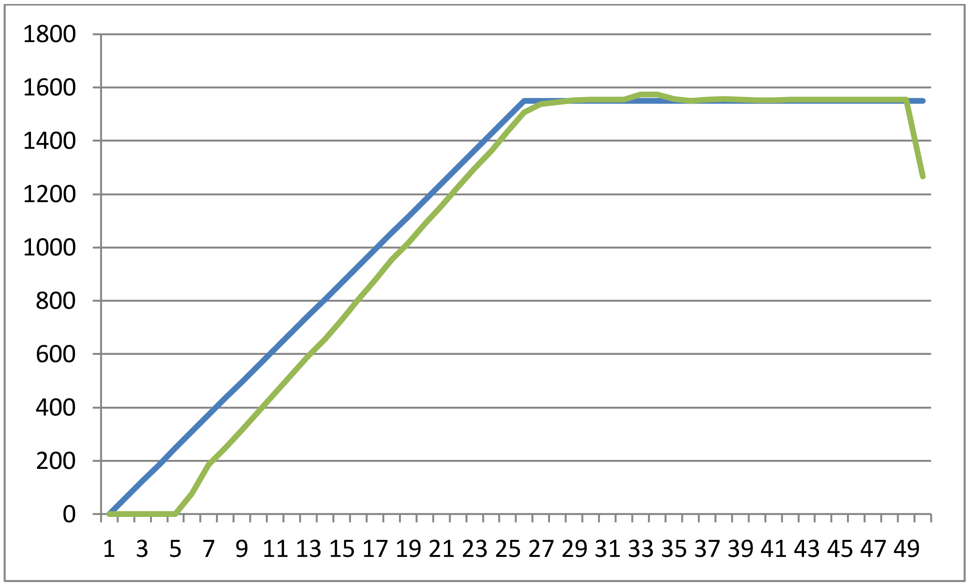


Fig.4.9 speed response plot of second order DC motor system with ramp input

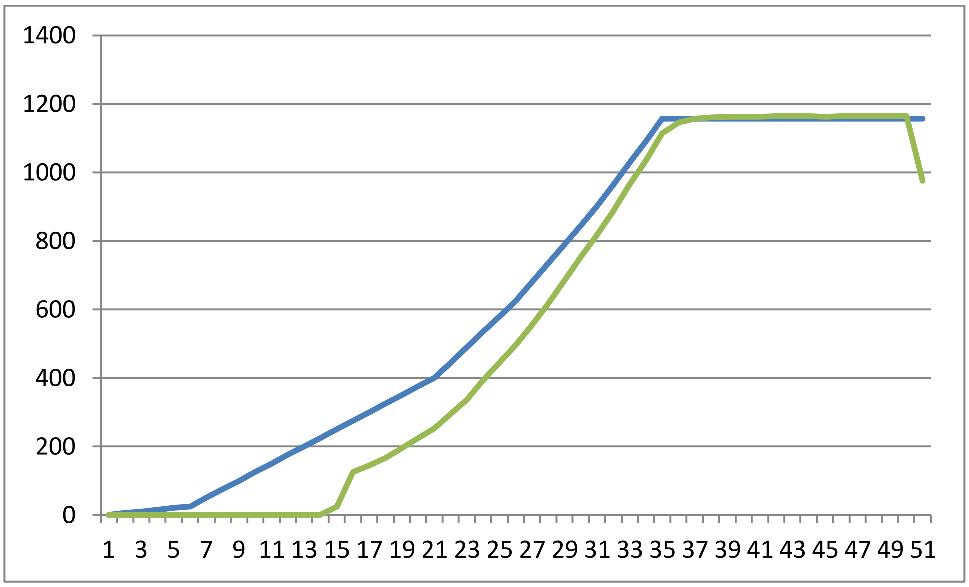


Fig.4.9 speed response plot of second order DC motor system with parabolic input

Result: speed response of second order DC motor system with step, ramp, parabolic inputs is obtained and speed response is plotted.

5. CLOSED LOOP SPEED CONTROL OF DC MOTOR USING STEP, RAMP, PARABOLIC INPUTS AND WITH PI, PID CONTROLLERS

AIM: To design and tune proper PI, PID controllers for speed control of DC motor Drive with step, ramp and parabolic as reference inputs.

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. Thyristorised DC drive
iv. DC motor
v. Proximity Sensor

Specifications:

DC Drive		***DC motor***	
Thyristorized Bridge Rectifier:	0-220V DC	*Armature voltage:*	220V DC
Diode Bridge Rectifier :	220V DC	*Current:*	2Amps
		Speed:	1500 RPM
		Power:	0.5 HP

Theory:

The proportional integral derivative (PID) controller is the most common form of feedback used in the control systems. It can be used for various Industrial applications. One of the applications used here is to control the speed of the DC motor. Controlling the speed of a DC motors is very important as any small change can lead to instability of the closed loop system. The aim of this experiment is to show how DC motor can be controlled by using a Step,ramp, parabolic inputs and PID controller in LabVIEW.

Closed loop speed control of DC motor is shown in fig.5.1 it consists of same elements present in block diagram 2.1, power modulator control power flow from source to motor. Power modulator is a DC drive consists of Thyristorised semi converter where output voltage is varied based on controlled voltage given as input to gating circuit, as input voltage varies from 0 to 5V DC drive output varies from 0-220V. Controlled voltage is generated from closed loop with PID control implemented in LabView based on reference speed signal either step, ramp and parabolic.

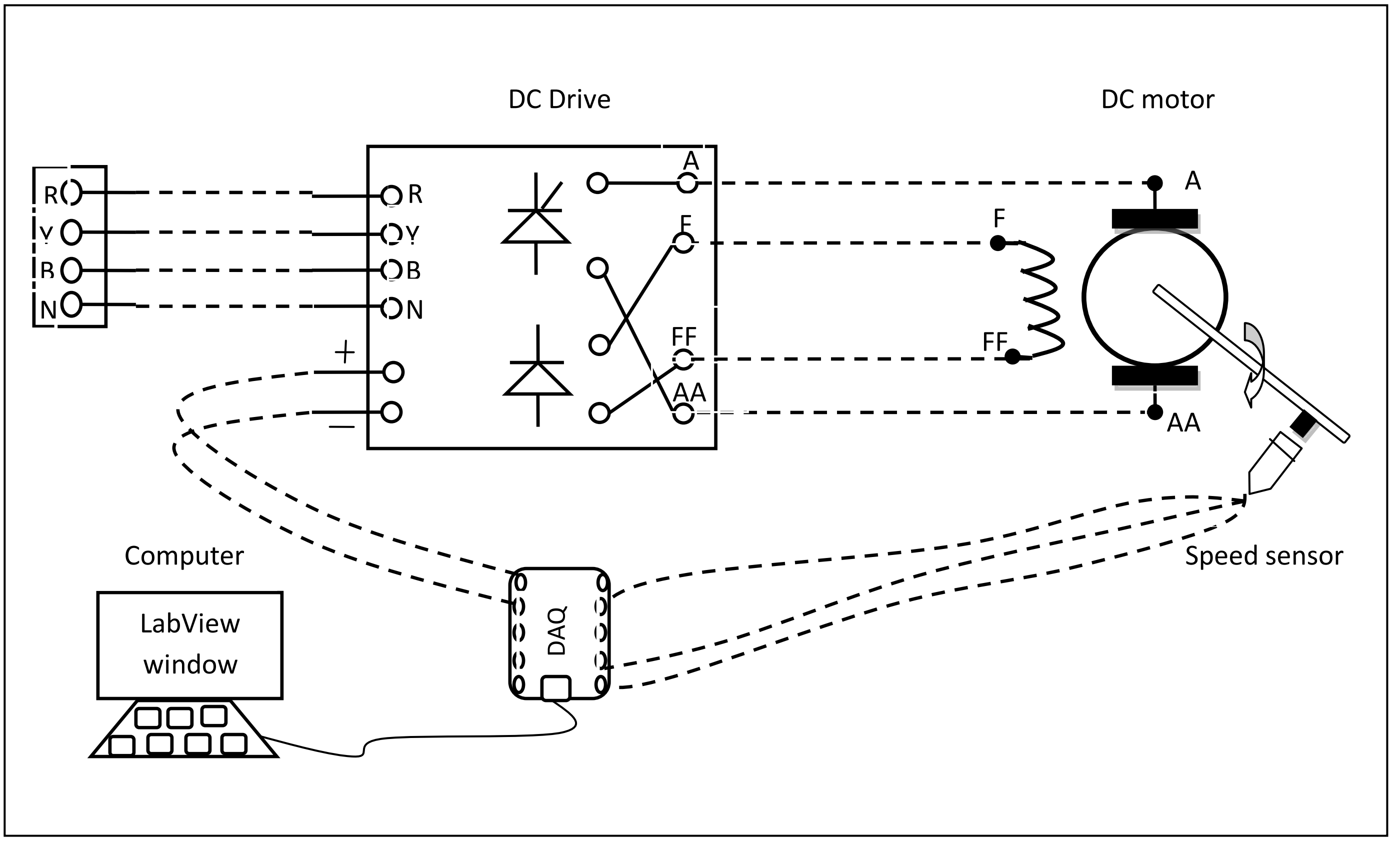


Fig.5.1 circuit diagram of closed loop speed control of DC motor

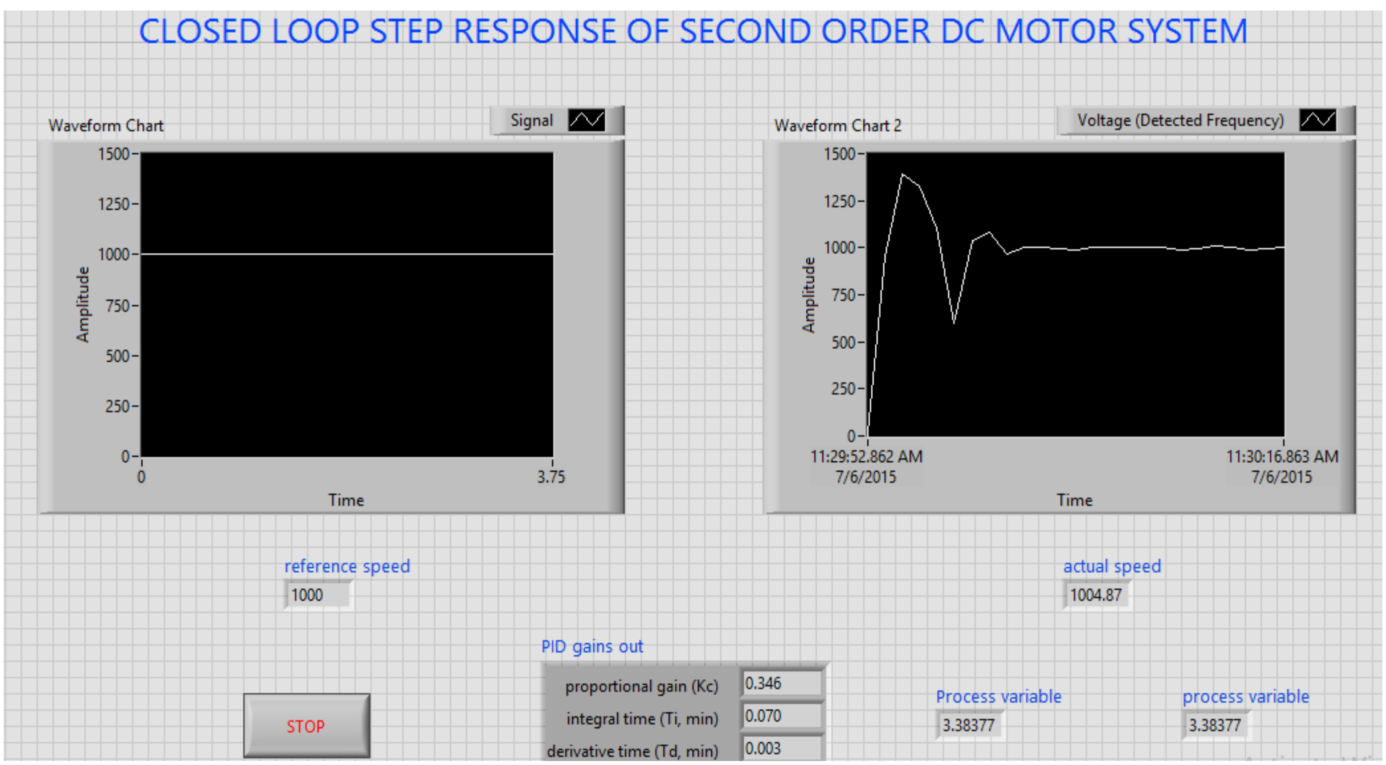


Fig.5.2 front panel of closed loop speed control with step input

Step signal is taken as reference speed signal. Reference speed is set by the designing of step signal in LabView. Actual speed is sensed using proximity speed sensor and compared with reference speed an speed error is generated, if error is positive PID controller increases controlled voltage and if error is negative it decreases the controlled voltage till the motor speed attains set reference speed. Saturation limiter is limits the output voltage always in between 0 -5V even though PID controller output varies 100 to +100. PID controller is tuned using auto tune blocks available in control design & simulation tool box.

A graph is plotted between step signal speed and actual speed of motor by getting data from LabView using LVM file and drawn in Excel sheet, we can observe the step speed response of second order DC Motor with PID controller by speed characteristics. Similarly response of ramp and parabolic signals obtained.

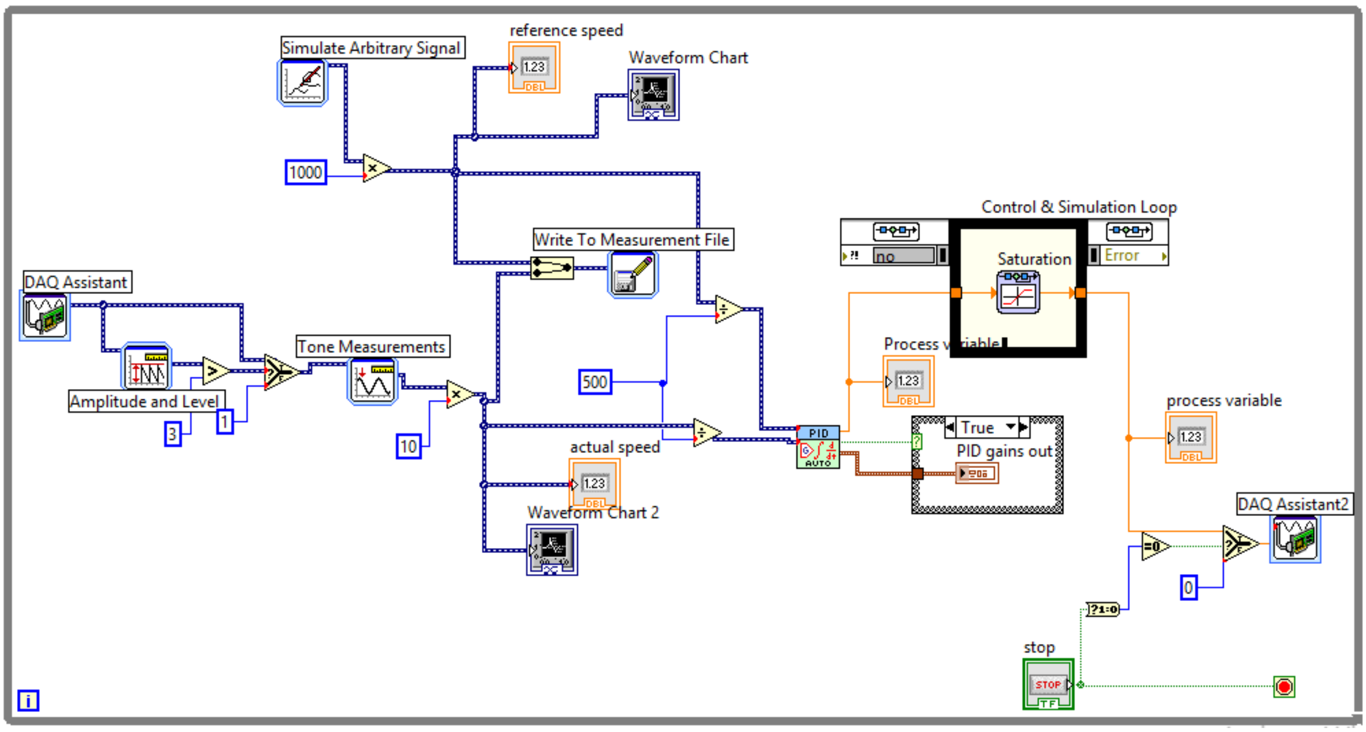


Fig.5.3 block diagram of closed loop speed control DC motor with step input

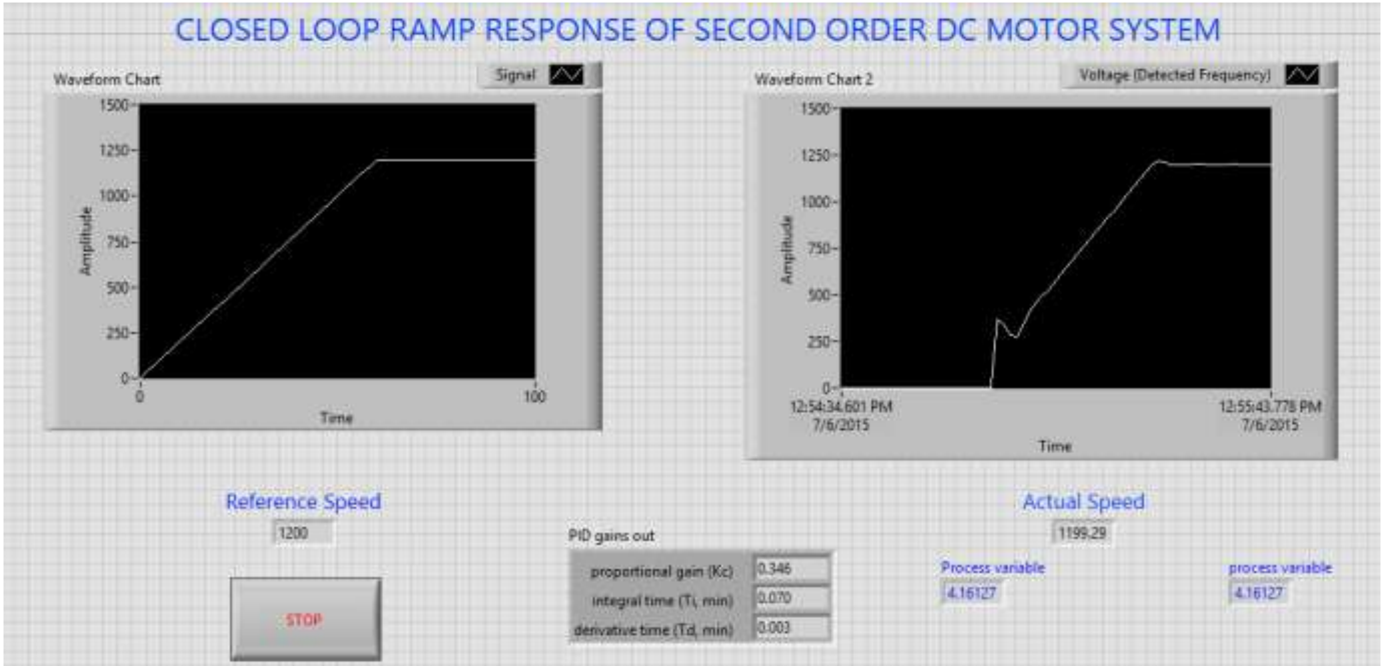


Fig.5.4 front panel diagram of closed loop speed control of DC motor with ramp input

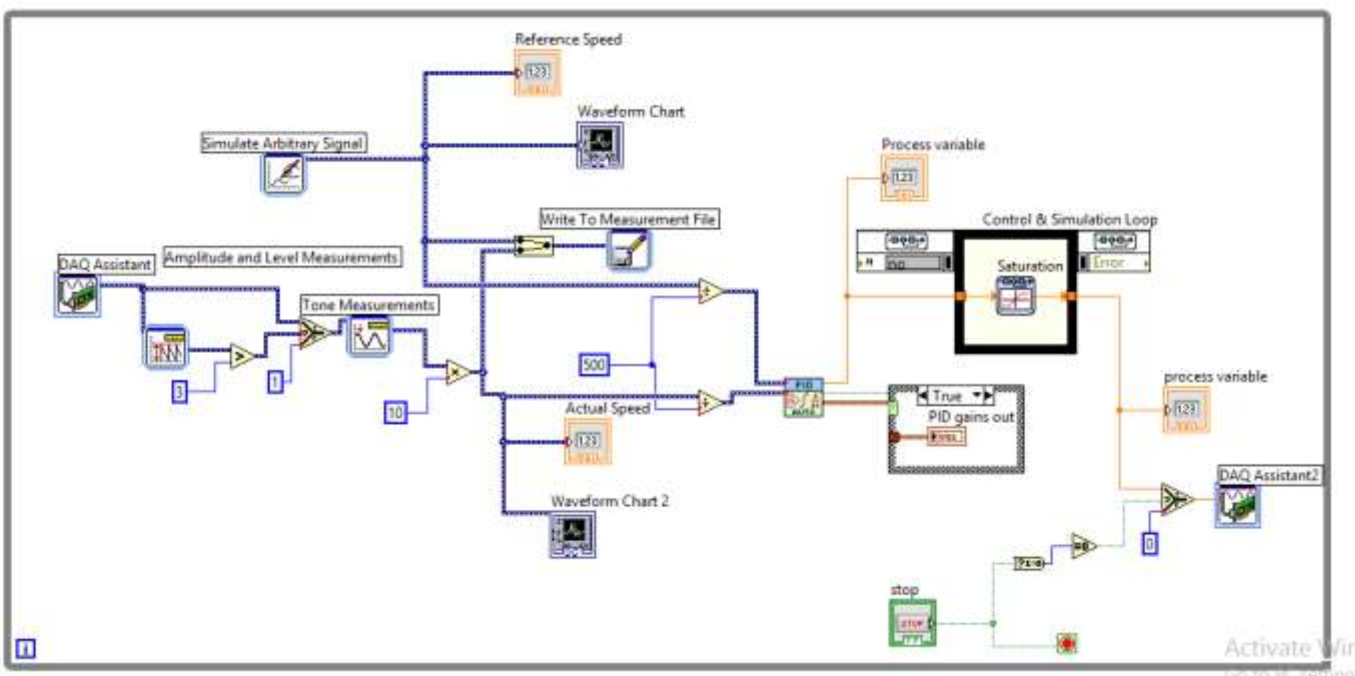


Fig.5.5 block diagram of closed loop speed control DC motor with step input

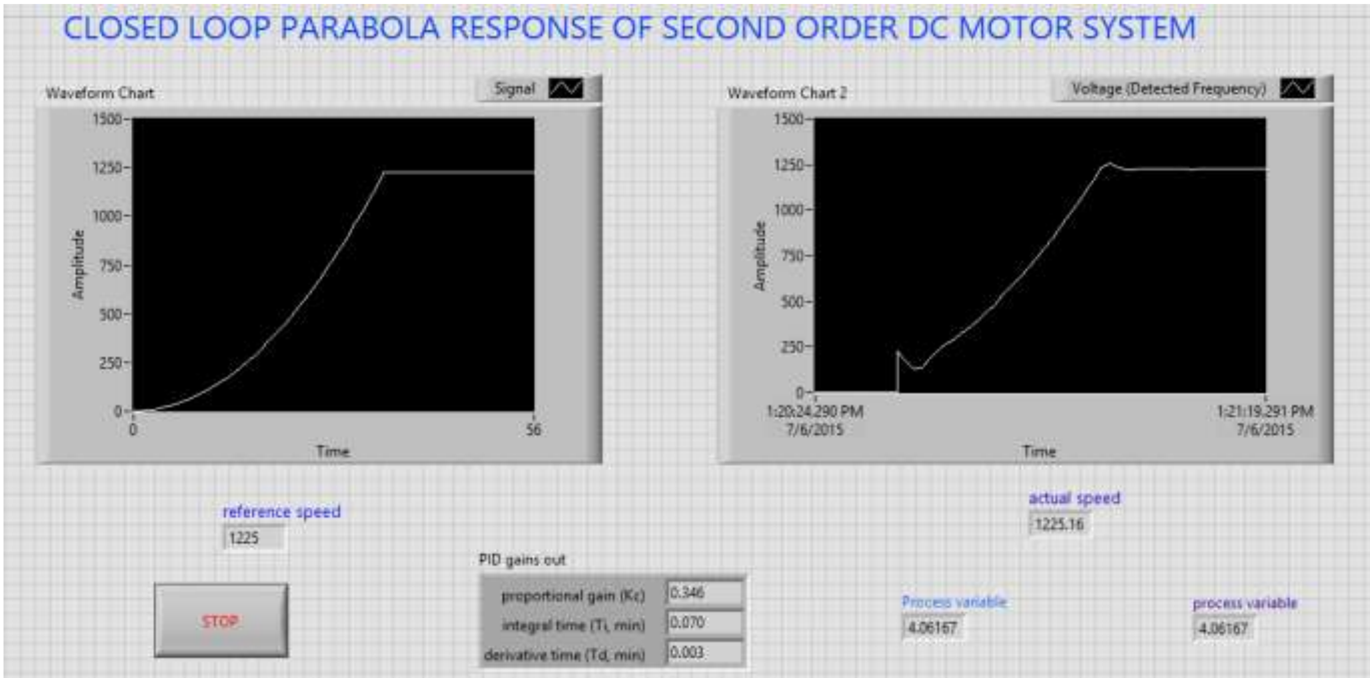


Fig.5.6 front panel diagram of closed loop speed control of DC motor with parabolic input

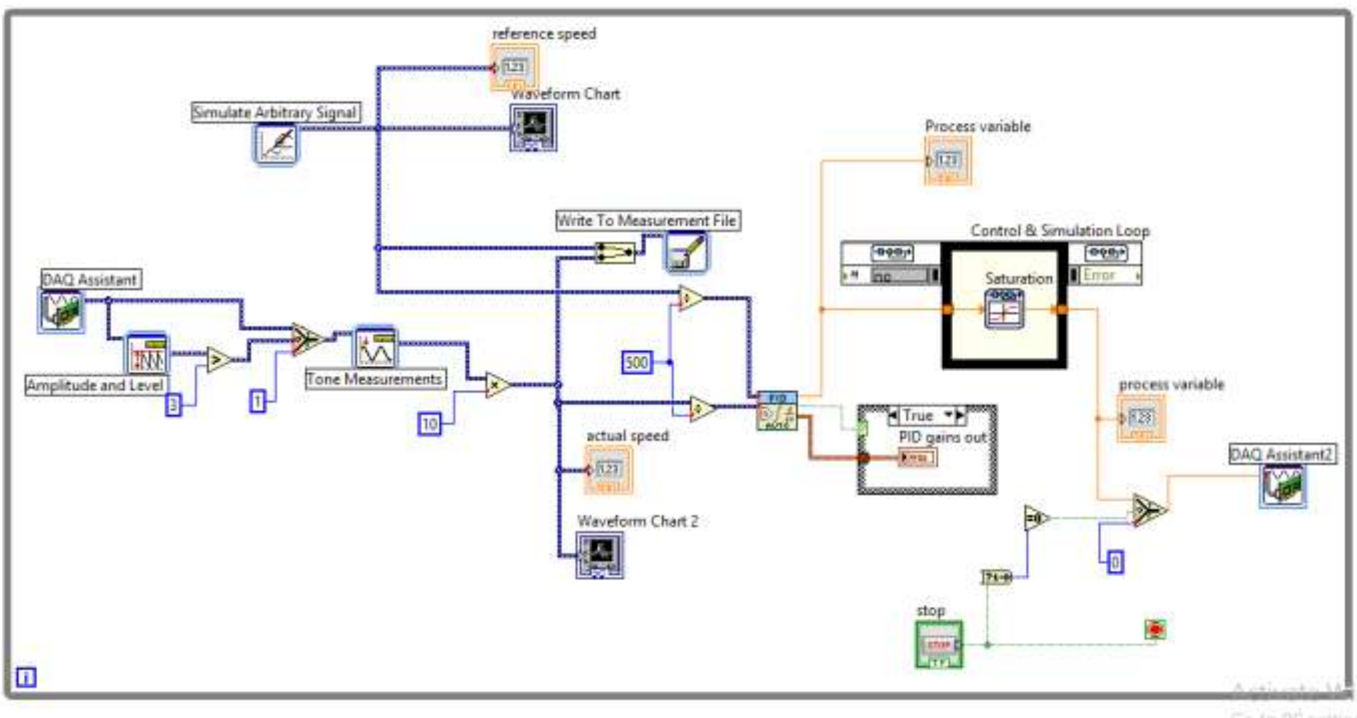


Fig.5.5 block diagram of closed loop speed control DC motor with parabolic input

Procedure:

1. Connect circuit as per circuit diagram

    i. Connect supply to DC drive

    ii. Connect output of DC drive to armature and field supplies of DC motor

    iii. Connect speed sensor & DC drive variable point to DAQ assistant

2. Develop LabView diagram in back panel consists of reference speed, PID controller design and speed feedback.

3. Construct reference speed signal as step signal using simulate arbitrary signal.

4. Run the LabView diagram Tune the PID controller using auto-tune block till we get desired P, I , D values.

5. Ensure that motor speed follows the set speed or reference speed.

6. Take the data to excel file, draw the set speed and actual speed on a single plot

7. Observe the response of speed control loop using plot

8. Vary the P, I, D gains around the tune values and see the response

9. Construct the ramp, parabolic signals and repeat the step 4 to 7

10. Design the PI controller and repeat the step 3 to 9.

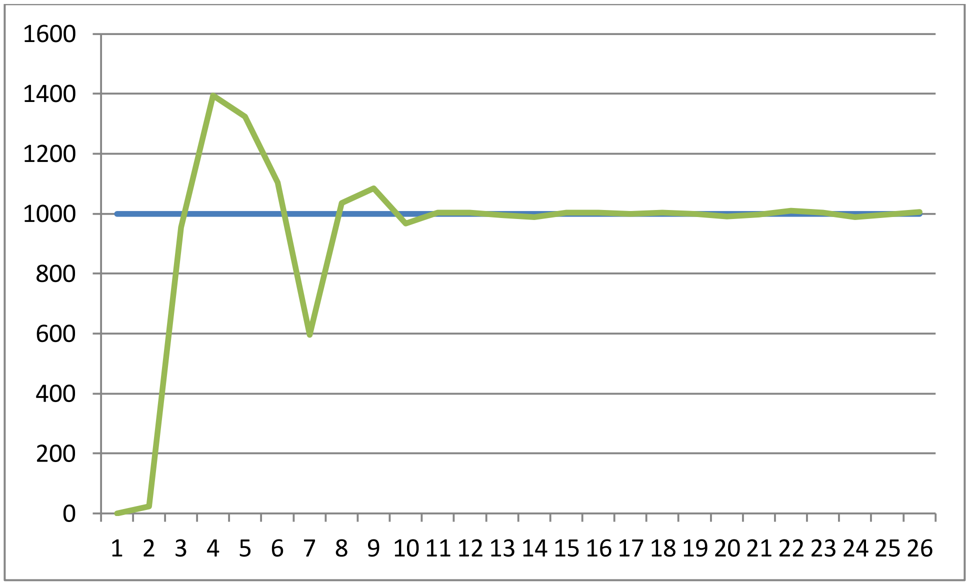


Fig.5.7 speed response of DC motor with step input

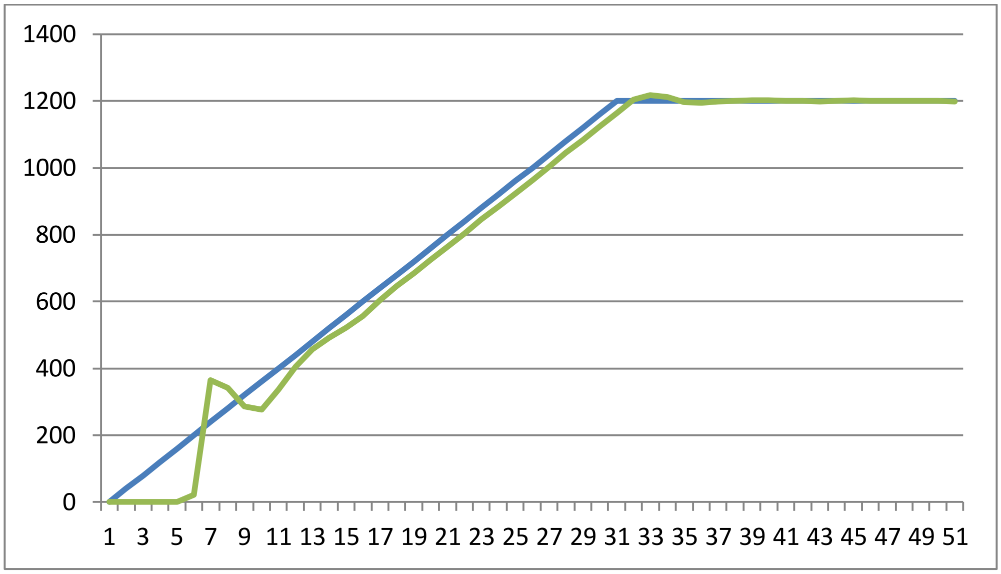


Fig.5.8 ramp response of DC motor with ramp response

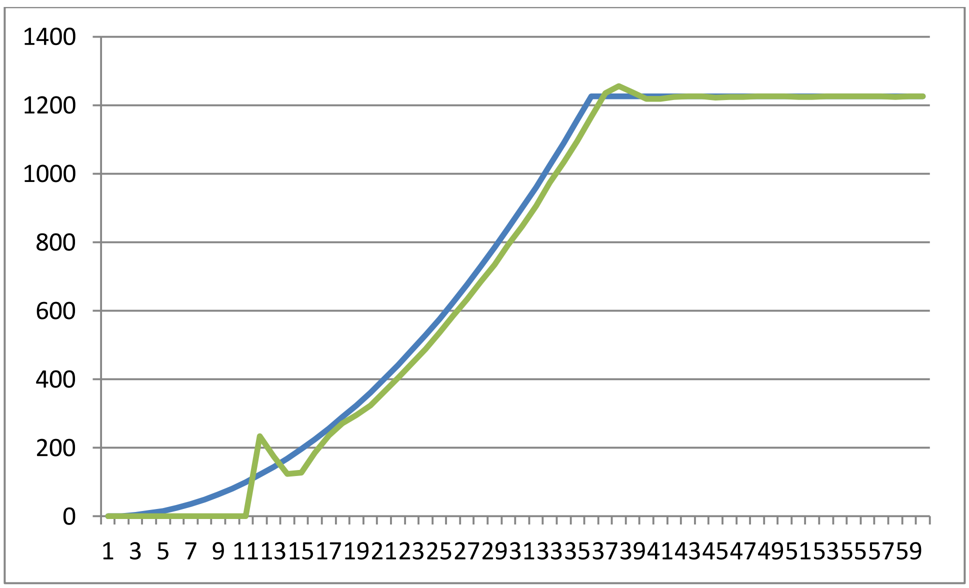


Fig.5.9 speed response of DC motor with parabolic input

Table:

Reference Speed	PI gains	PD gains
	P= I=	P= D=
	P= I=	P= D=

Table 1: Different set speeds & P, I, D gains

Result: closed loop speed control of second order DC motor system is obtained and speed response is plotted.

6. INDIRECT SPEED CONTROL OF DC MOTOR USING ARMATURE VOLTAGE CONTROL WITH PI,PID CONTROLLERS

AIM: To design and tune proper PI, PID controllers for indirect speed control of DC motor Drive using armature voltage control method.

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. Thyristorised DC drive
iv. DC motor
v. Voltage sensor.
vi. Proximity Sensor.

Specifications:

DC Drive	***DC motor***
Thyristorized Bridge Rectifier: 0-220V DC	*Armature voltage:* 220V DC
Diode Bridge Rectifier : 220V DC	*Current:* 2Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Speed of DC motor can be controlled by armature voltage control method. The speed of DC motor is directly proportional to armature voltage and inversely proportional to flux in field winding. In armature controlled DC motor the desired speed is obtained by varying the armature voltage. This speed control system is an electromechanical control system. The electrical system consists of the armature and the field circuit. Armature circuit is taken for analysis with field excitation is constant. The mechanical system consists of the rotating part of the motor and load connected to the shaft of the motor. The transfer function of armature controlled dc motor can be expressed in another standard form as shown below.

$$\frac{\theta(s)}{V_a(s)} = \frac{K_t}{s\left[(1+sT_a)(1+sT_m)+\frac{K_bK_t}{R_aB}\right]}$$

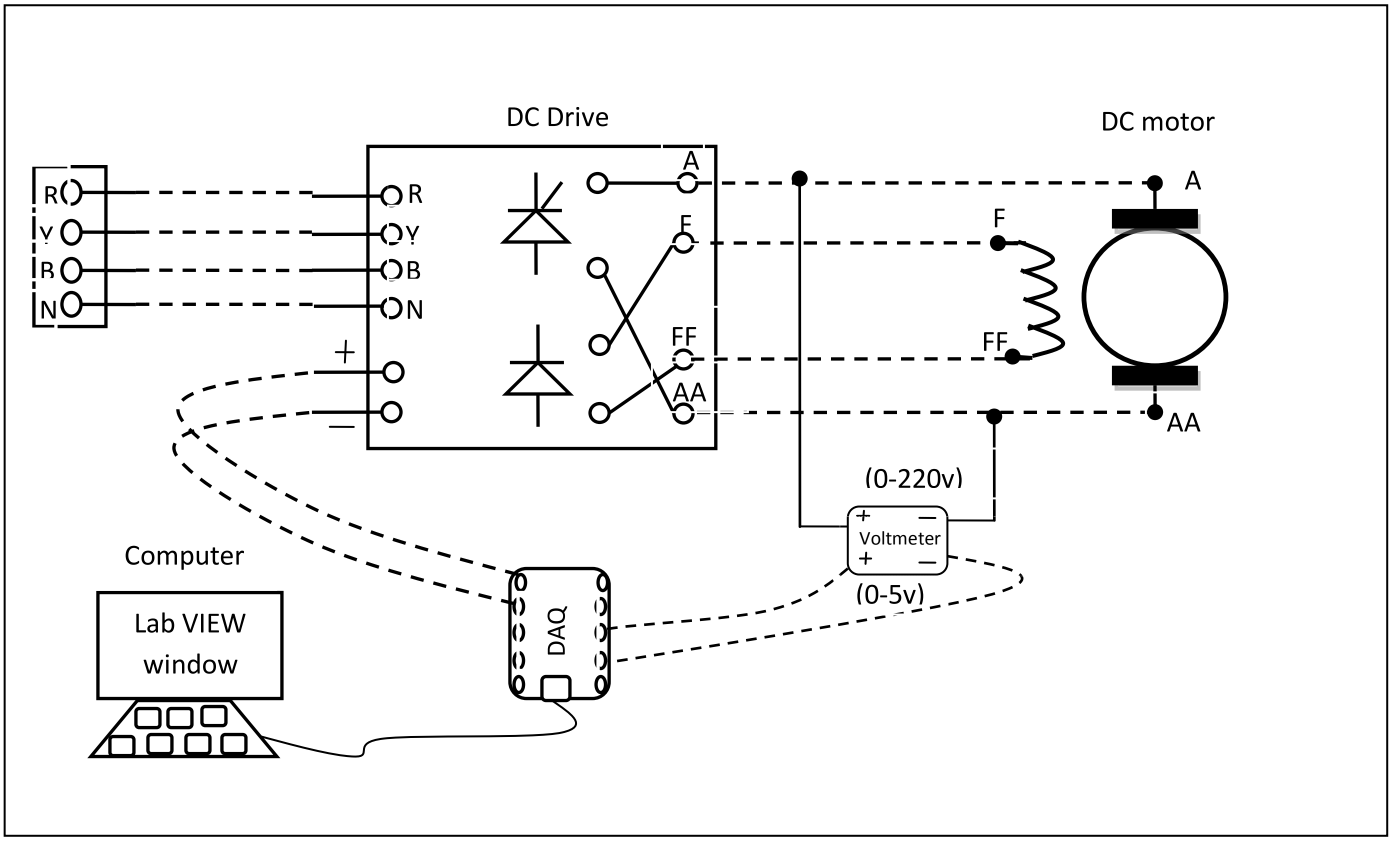


Fig.6.1 circuit diagram for voltage control of DC motor

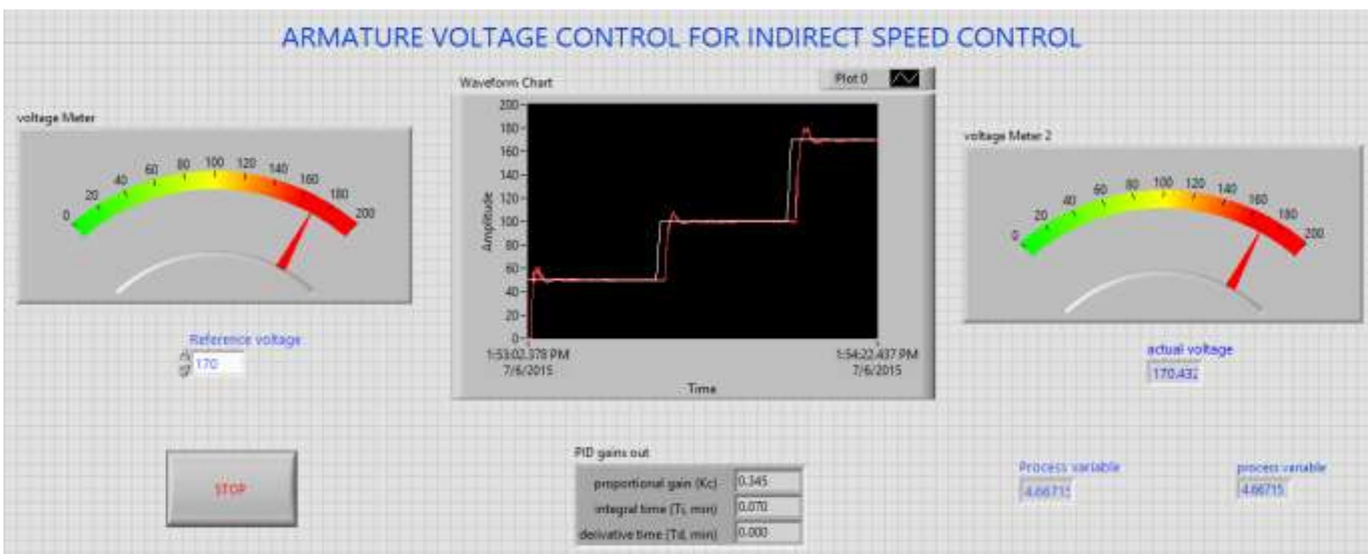


Fig.6.2 front panel diagram of armature voltage control of DC motor in LabVIEW

Closed loop indirect speed control of DC motor is shown in fig.6. Thyristor drive gives the required DC voltage to drive motor at desired voltage according to output voltage variable from PID controller. PID controller adjusts the output voltage variable till the motor armature voltage reaches desired voltage.

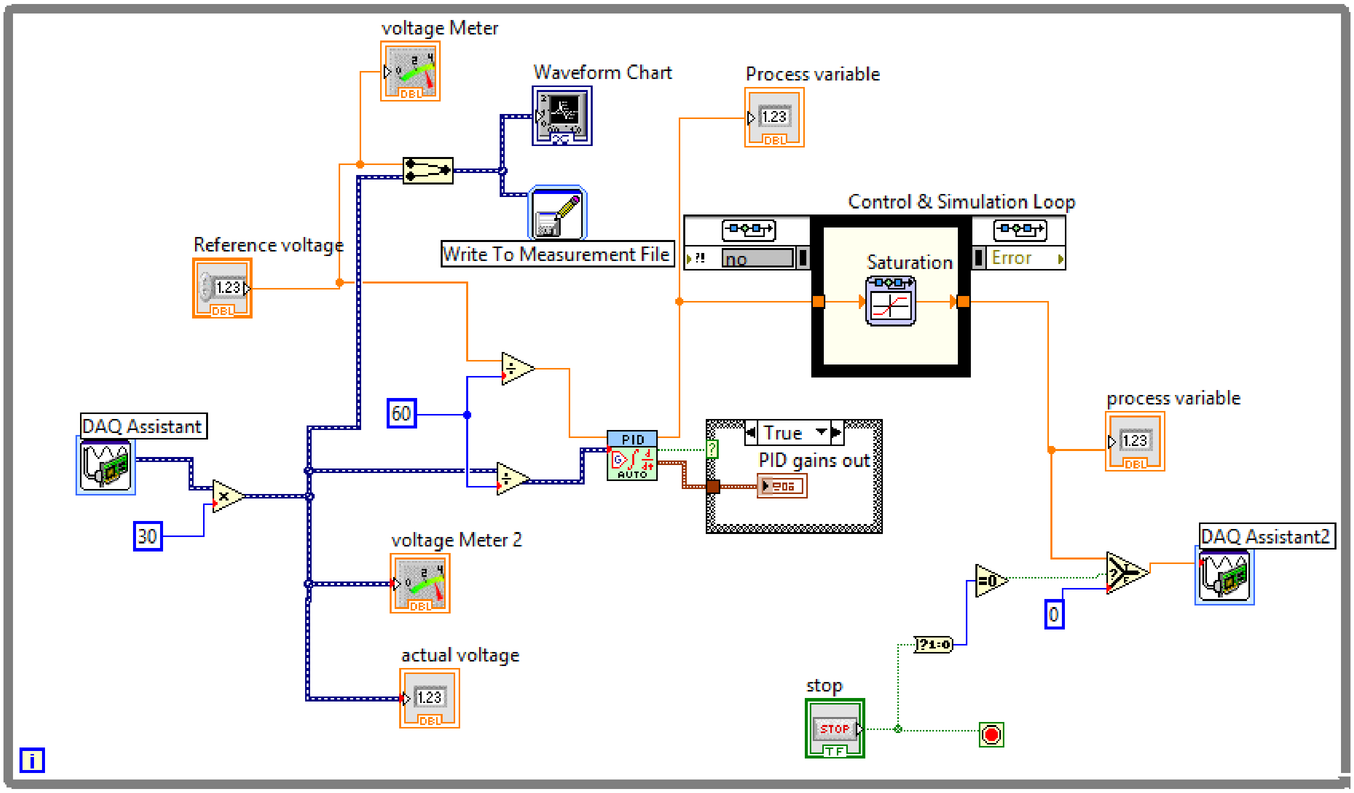


Fig.6.3 block diagram of armature voltage controlled DC motor in LabVIEW

Procedure:

1. Connect circuit as per circuit diagram
    i. Connect supply to DC drive
    ii. Connect output of DC drive to armature and field supplies of DC motor
    iii. Connect voltage sensor & DC drive variable point to DAQ assistant
2. Develop LabView diagram in back panel consists of reference voltage, PID controller design and voltage feedback.
3. Set the reference voltage to some value say 2 volts.
4. Run the LabView diagram Tune the PID controller using auto-tune block till we get desired P, I , D values.
5. Ensure that motor voltage follows the set voltage or reference voltage.
6. Take the data to excel file, draw the set voltage and actual voltage on a single plot

7. Observe the response of voltage control loop using plot
8. Vary the P, I, D gains around the tune values and see the response.

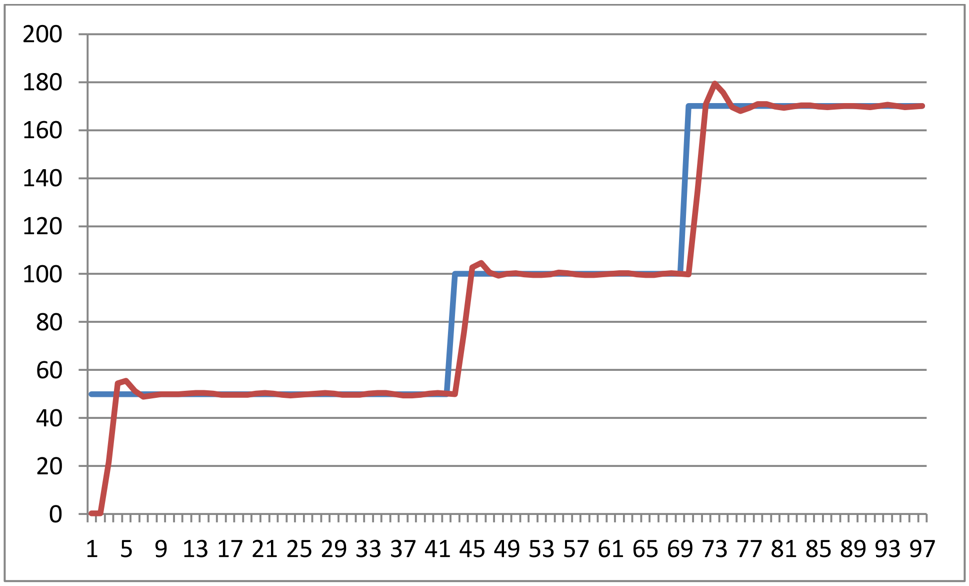


Fig.6.4 voltage response of DC motor in armature voltage control

Result: indirect speed control of DC motor with armature voltage control is done and speed response is plotted.

7. V/F CONTROL OF AC DRIVE CONNECTED TO AC MOTOR SYSTEM ON LABVIEW

AIM: To obtain V/F control of AC drive connected to AC motor system on LabView.

Apparatus:

i. NI LabView Software, DAQ
ii. V/F AC drive
iii. Induction motor
iv. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

The Principle of Constant V/Hz for AC Induction Motor is explained as follows:

Applied voltage to armature is proportional to frequency and air gap flux of induction motor. i.e.

$$V \approx \phi . f$$

$$V/f \approx \phi = \text{constant}$$

If we maintain voltage to frequency ratio constant than flux in machine is constant. And torque is independent of supply frequency. The ratio between the magnitude and frequency of the stator voltage is usually based on the rated values of these variables, or motor ratings. However, when the frequency and hence also the voltage are low, the voltage drop across the stator resistance cannot be neglected and must be compensated. At frequencies higher than the rated value, the constant V/Hz principle also have to be violated because, to avoid insulation break down, the stator voltage must not exceed its rated value.

The figure 7.1 shows an AC drive with V/F control concept inbuilt in the drive. By varying controlled voltage to the drive from 0-10V speed of induction motor connected to AC drive varies from 0 to 1500 rpm.

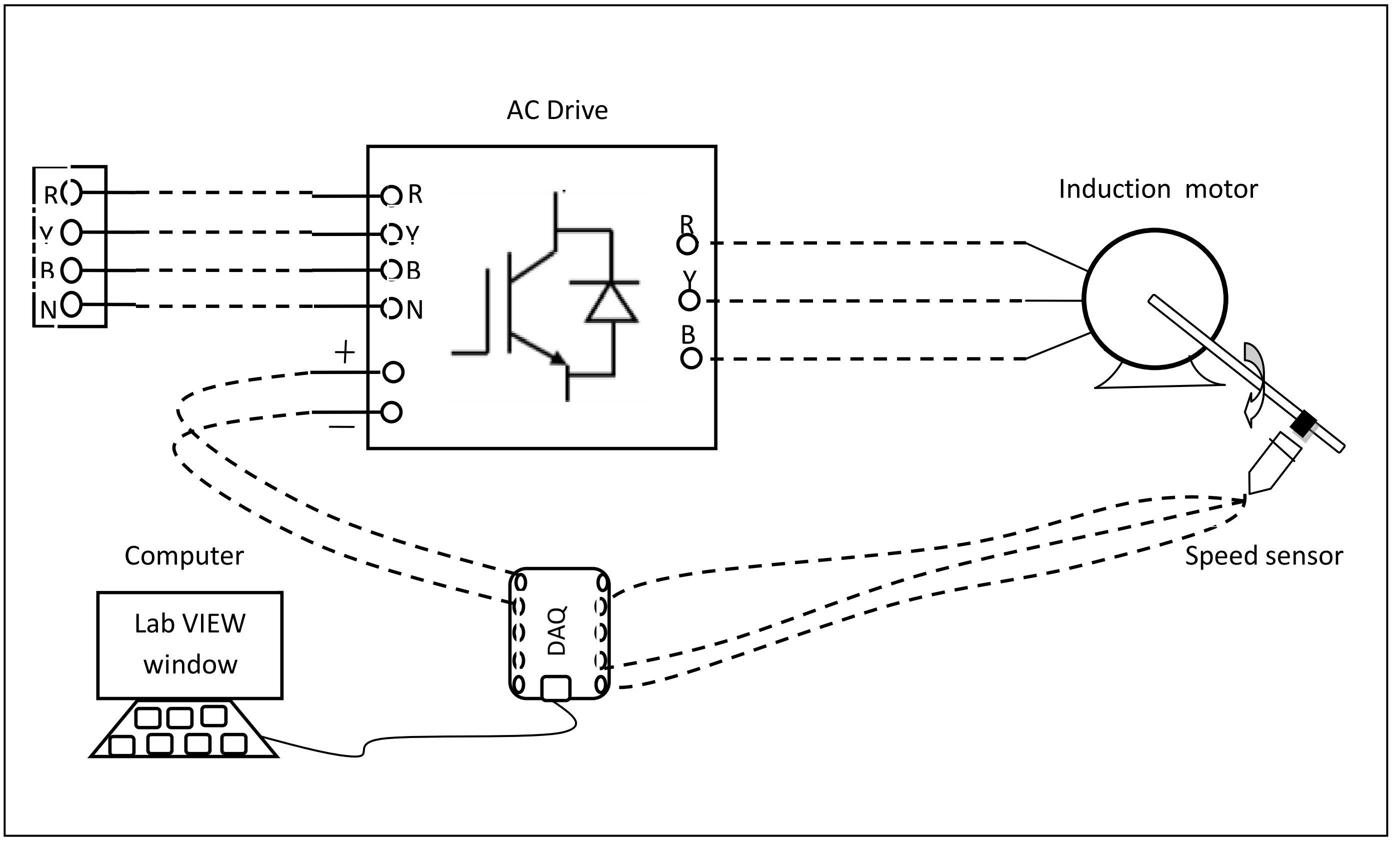


Fig.7.1 circuit diagram of V/F control of AC motor

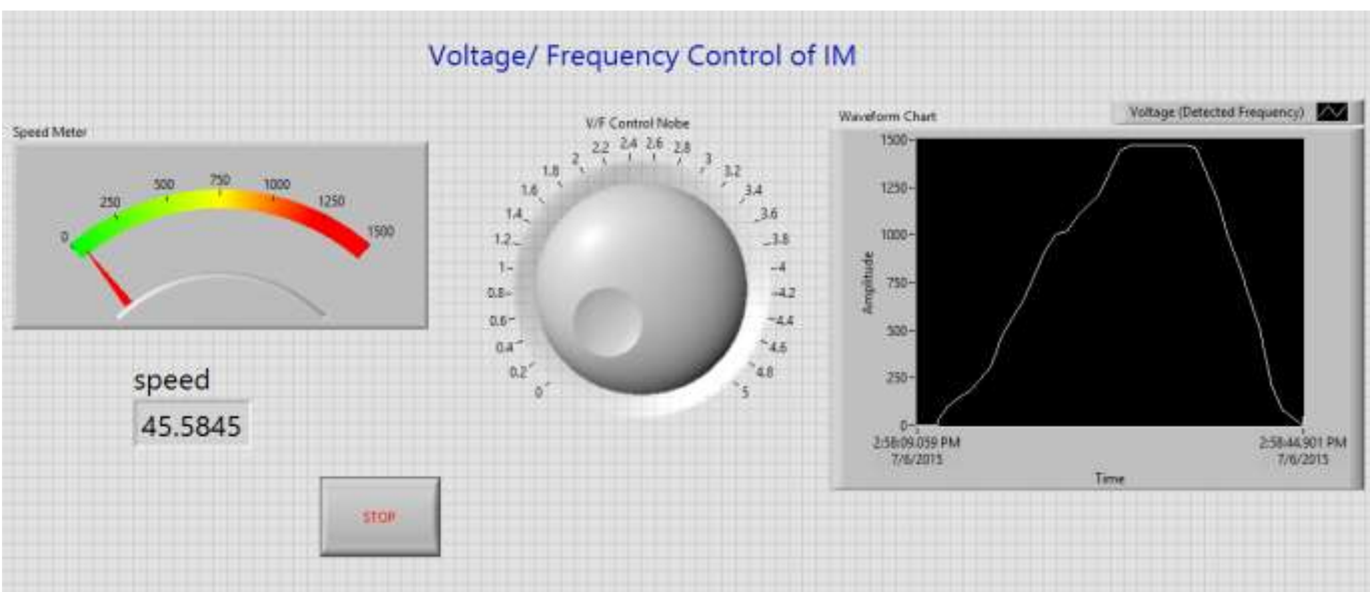


Fig.7.2 front panel diagram of V/F control of AC motor in LabVIEW

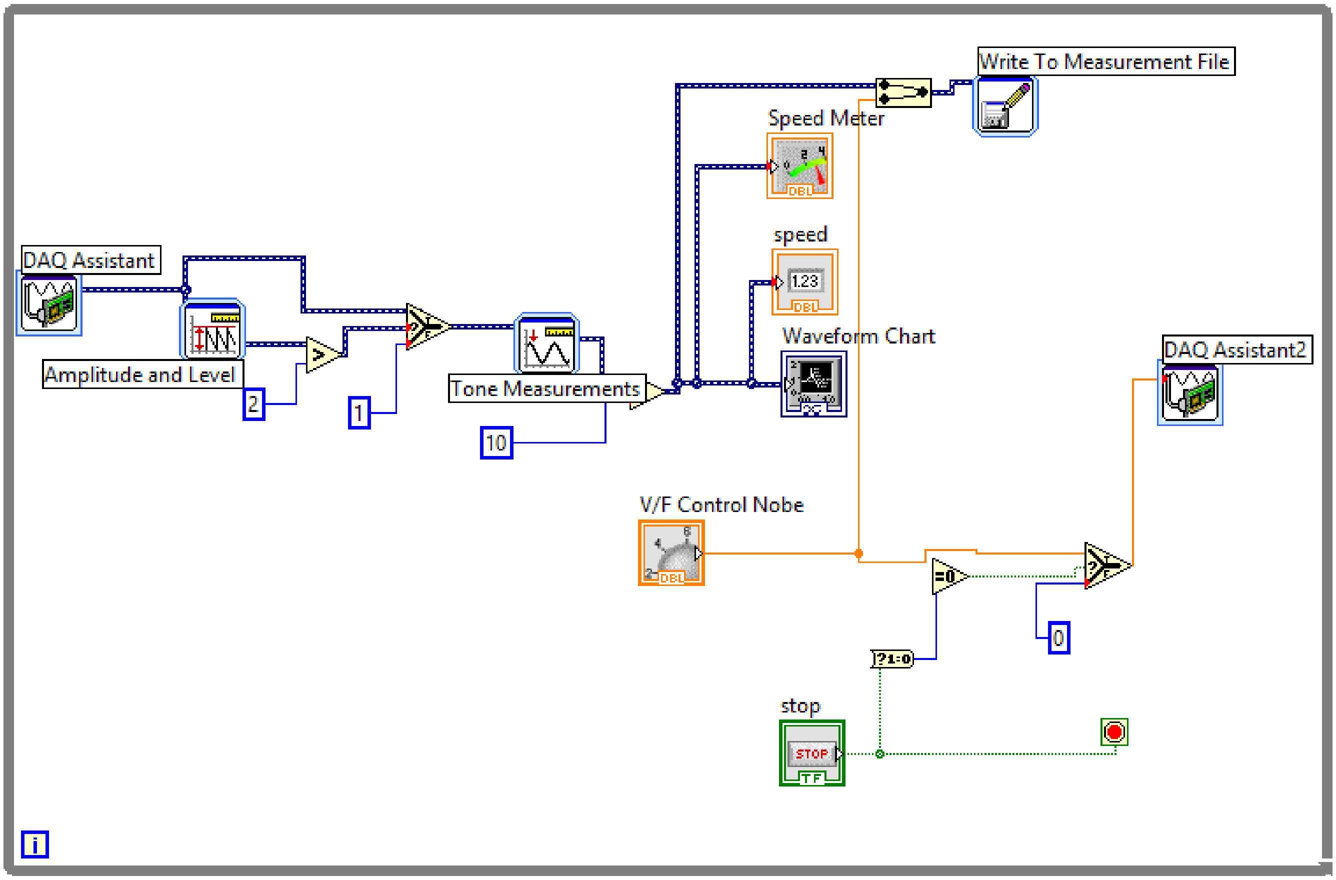


Fig.7.3 block diagram of V/F control of induction motor

Procedure:

1. Connect circuit as per circuit diagram

   i. Connect supply to AC drive

   ii. Connect output of AC drive to armature and field supplies of Induction motor

   iii. Connect speed sensor & AC drive variable point to DAQ assistant

2. Develop LabView diagram in back panel consists of V/F nobe and speed feedback.

3. Obtain the speed response by adjusting V/F nobe and plot the speed response.

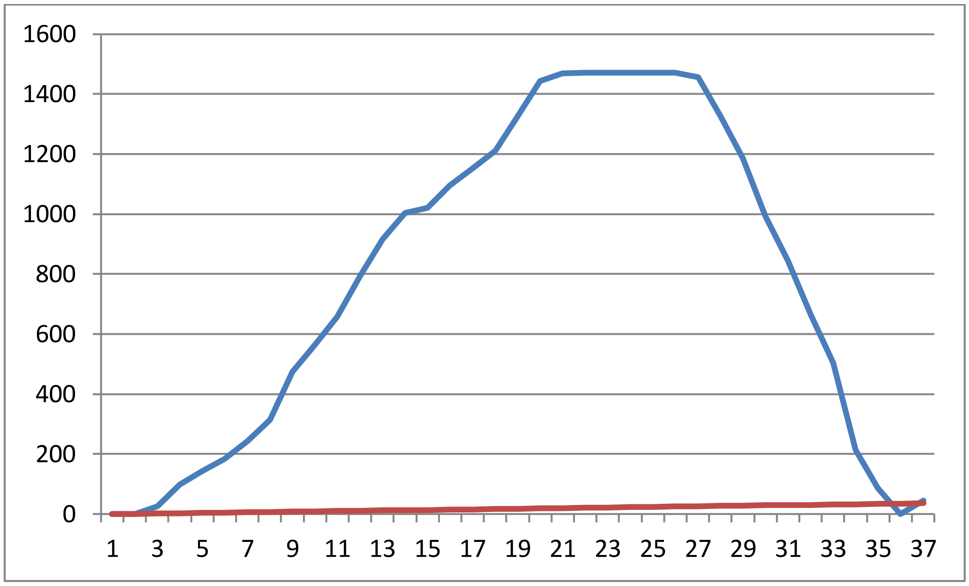


Fig.7.4 speed response of V/F control of induction motor

Result: V/F control of AC motor is done and speed response is plotted.

8. CLOSED LOOP SPEED CONTROL OF AC MOTOR USING PI, PD AND PID CONTROLLERS

AIM: To design and tune proper PI, PD & PID controllers for speed control of AC motor Drive.

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. V/F AC drive
iv. Induction motor
v. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Motion control is required in large number of industrial and domestic applications like transportation systems, rolling mills, fans, pumps & robots etc. systems employed for motion control are called drives. Drives employing electric motors are called electrical drives.

Block diagram of electric drive is shown in figure 8.1

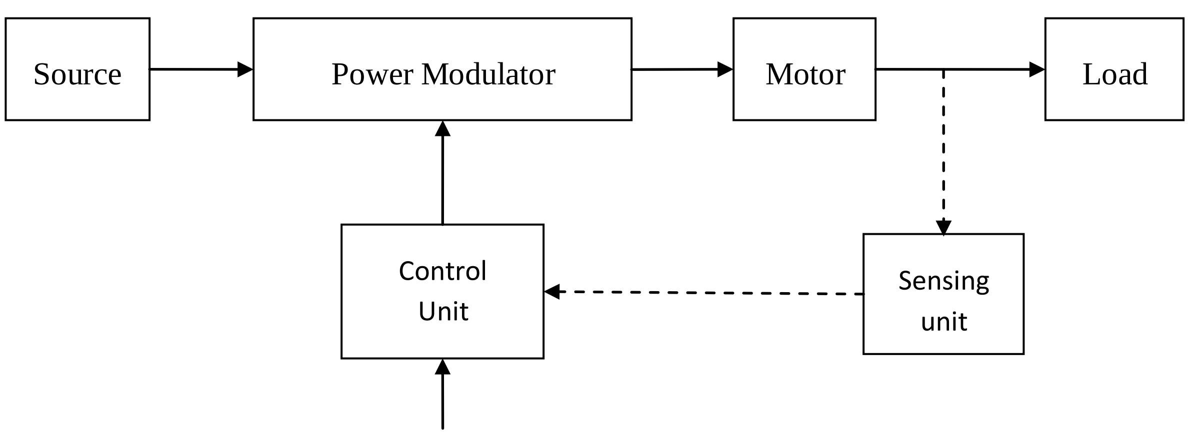


Fig.8.1 Block diagram of electric drive

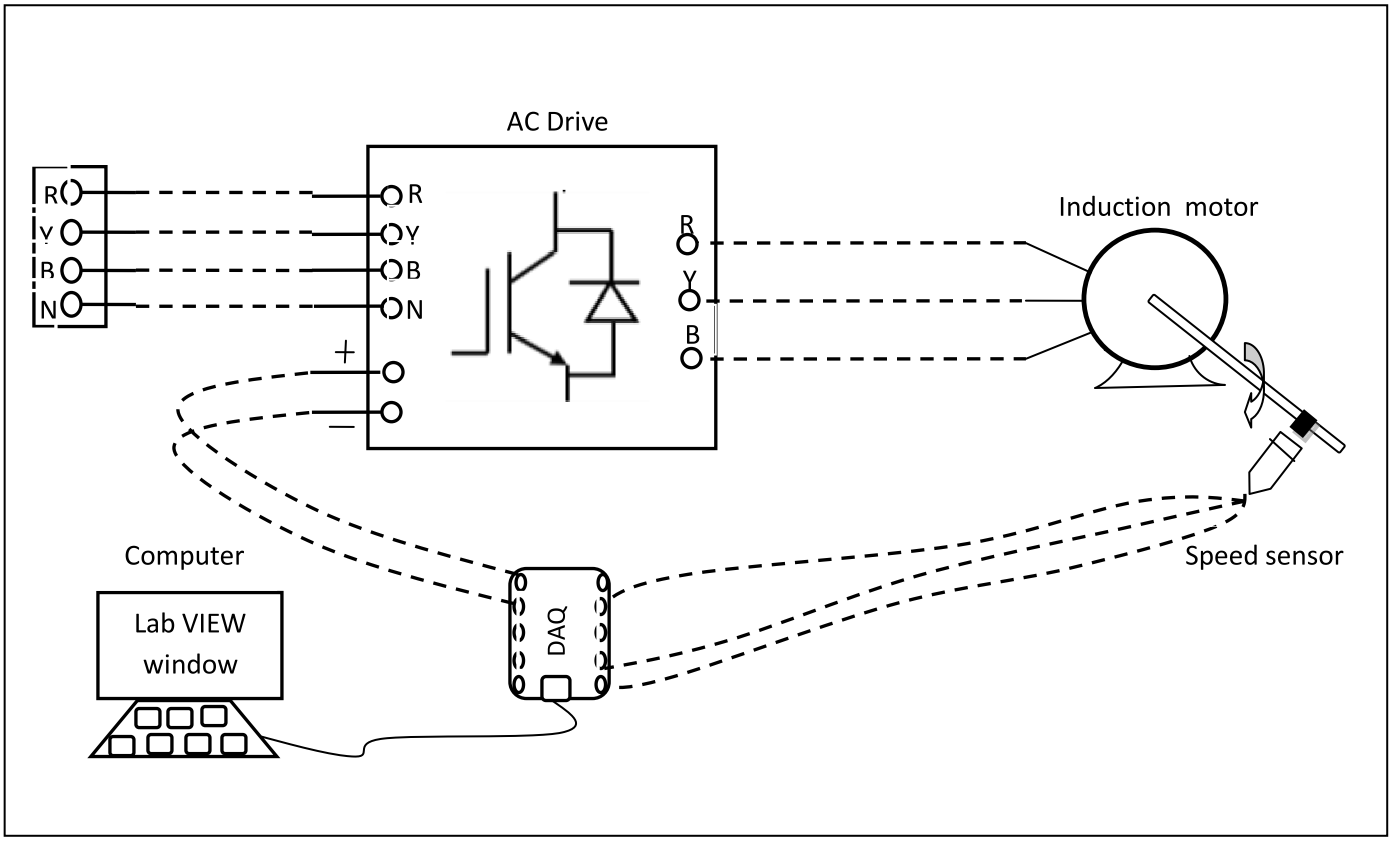


Fig.8.2 circuit diagram of closed loop speed control of AC motor

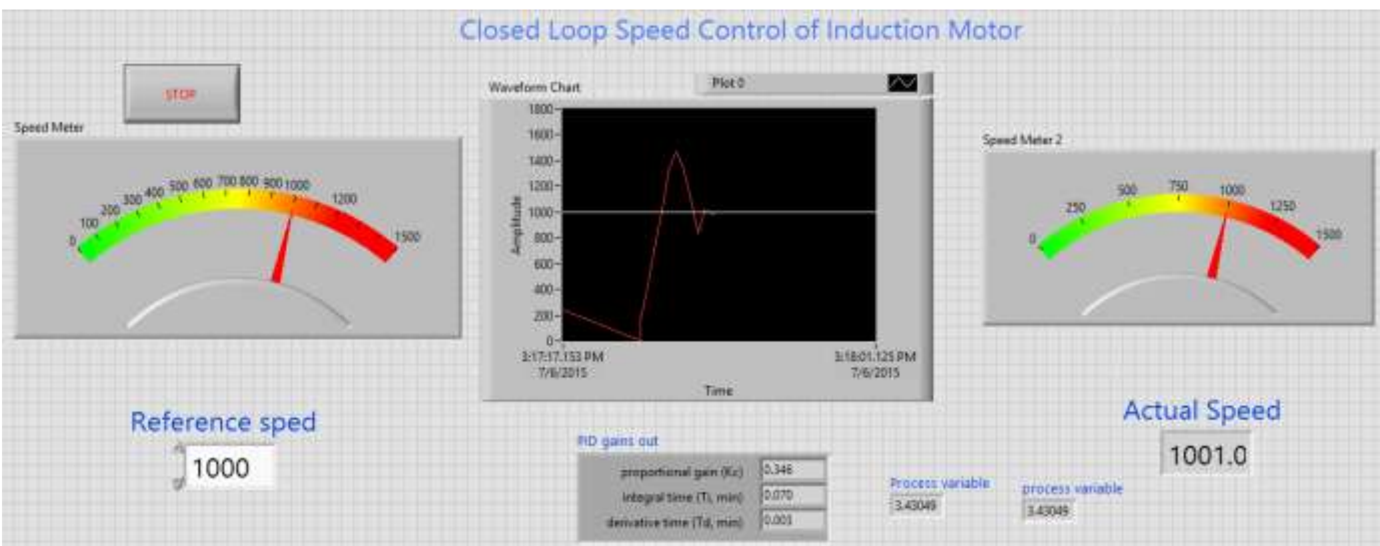


Fig.8.3 LabVIEW front panel diagram of closed loop speed control of AC motor

Load is usually machinery designed to accomplish a given task. Usually load requirements can be specified in terms of speed control and torque demands. A motor having speed-torque characteristics and capabilities compatible with load demands. Power modulator modulates flow of power from the source to the motor in such a manner that motor is imparted speed-torque characteristics required by load. Controls for power modulator built in control unit which usually operates at much lower voltage and power levels.

Closed loop speed control of AC motor is shown in fig8.2 it consists of same elements present in block diagram 8.1, control unit is a computer in which control concept is implemented using LabView where auto tuning of PID control is done to get the motor speed to reference speed or set speed. Invertor drive gives the required AC voltage to drive motor at desired speed according to output voltage variable from PID controller. PID controller adjusts the output voltage variable till the motor speed reaches desired speed.

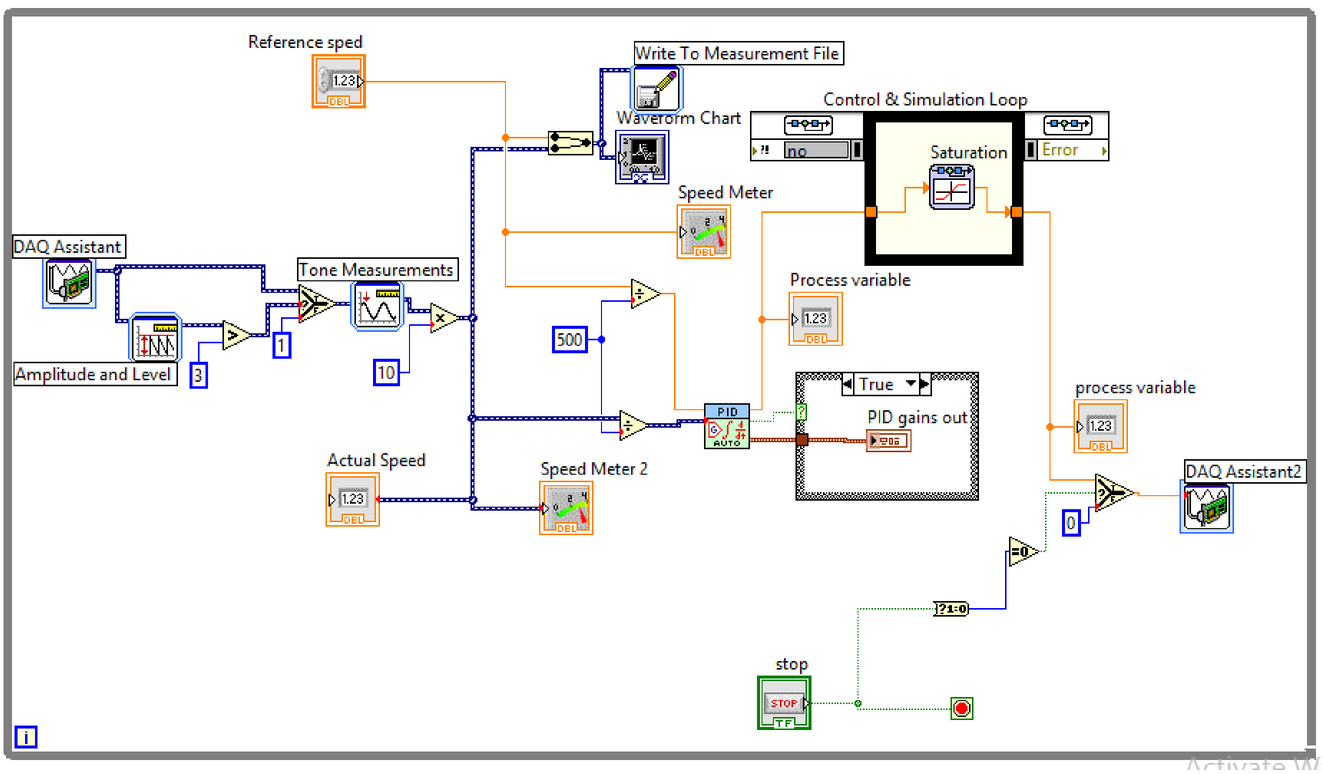


Fig.8.4 LabVIEW block diagram of closed loop speed control of AC motor

Procedure:

1. Connect circuit as per circuit diagram

   iv. Connect supply to AC drive

v. Connect output of AC drive to armature and field supplies of Induction motor

vi. Connect speed sensor & AC drive variable point to DAQ assistant

2. Develop LabView diagram in back panel consists of reference speed, PID controller design and speed feedback.

3. Set the reference speed to some value say 1000 RPM

4. Tune the PID controller using auto-tune block till we get desired P, I , D values.

5. Ensure that motor speed follows the set speed or reference speed.

6. Take the data to excel file from LabView, draw the set speed and actual speed on a single plot

7. Observe the response of speed control loop using plot

8. Vary the P, I, D gains around the tune values and see the response.

9. Design the PI, PD controllers and repeat the step 3 to 8.

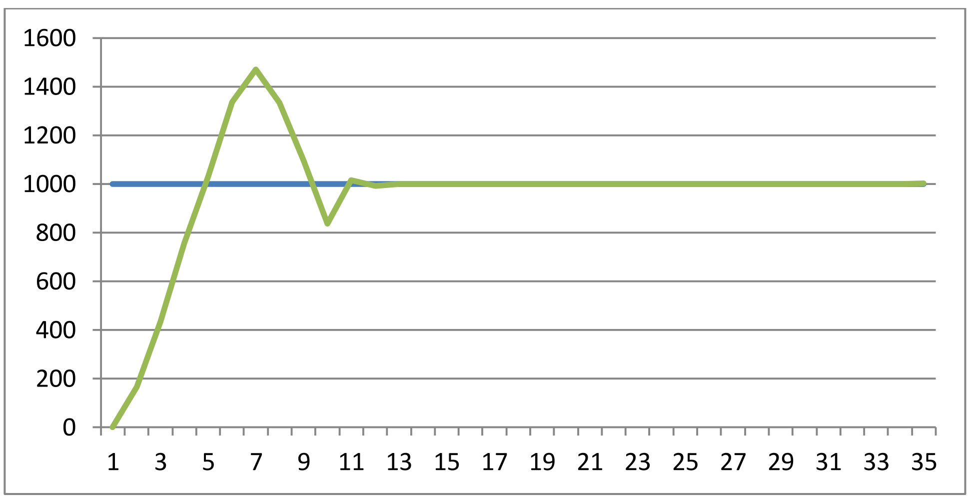


Fig.8.5 speed response of closed loop speed control of AC motor

Table:

Reference Speed	PI gains		PD gains	
	P=	I=	P=	D=
	P=	I=	P=	D=

Table 1: Different set speeds & P, I, D gains

Result: closed loop speed control of AC motor is done and speed response plotted.

9. CLOSED LOOP SPEED CONTROL OF AC MOTOR-GENERATOR SET WITH LOAD USING PI, PID CONTROLLERS

AIM: To design and tune proper PI, PID controllers for speed control of DC motor-generator set with load.

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. V/F AC drive
iv. Induction motor
v. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Closed loop speed control of AC motor –DC generator system is shown in fig 9.1 it consists of same elements present in block diagram 8.1, power modulator control power flow from source to motor. Power modulator is a AC drive consists of inverter where output voltage is varied based on controlled voltage given as input to gating circuit, as input voltage varies from 0 to 10VDC drive output varies from 0-440V. Controlled voltage is generated from closed loop with PID control implemented in LabView based on reference speed set value. Actual speed is sensed using proximity speed sensor and compared with reference speed an speed error is generated, if error is positive PID controller increases controlled voltage and if error is negative it decreases the controlled voltage till the motor speed attains set reference speed. Saturation limiter is limits the output voltage always in between 0 -5V even though PID controller output varies -100 to +100. PID controller is tuned using auto tune blocks available in control design & simulation tool box.

DC generator is connected to AC motor, which generates DC voltage according field supply voltage to generator and motor actual speed. Loading of DC generator is done by using lamp load, as load on generator increases which indirectly loads the motor there by motor speed reduces.

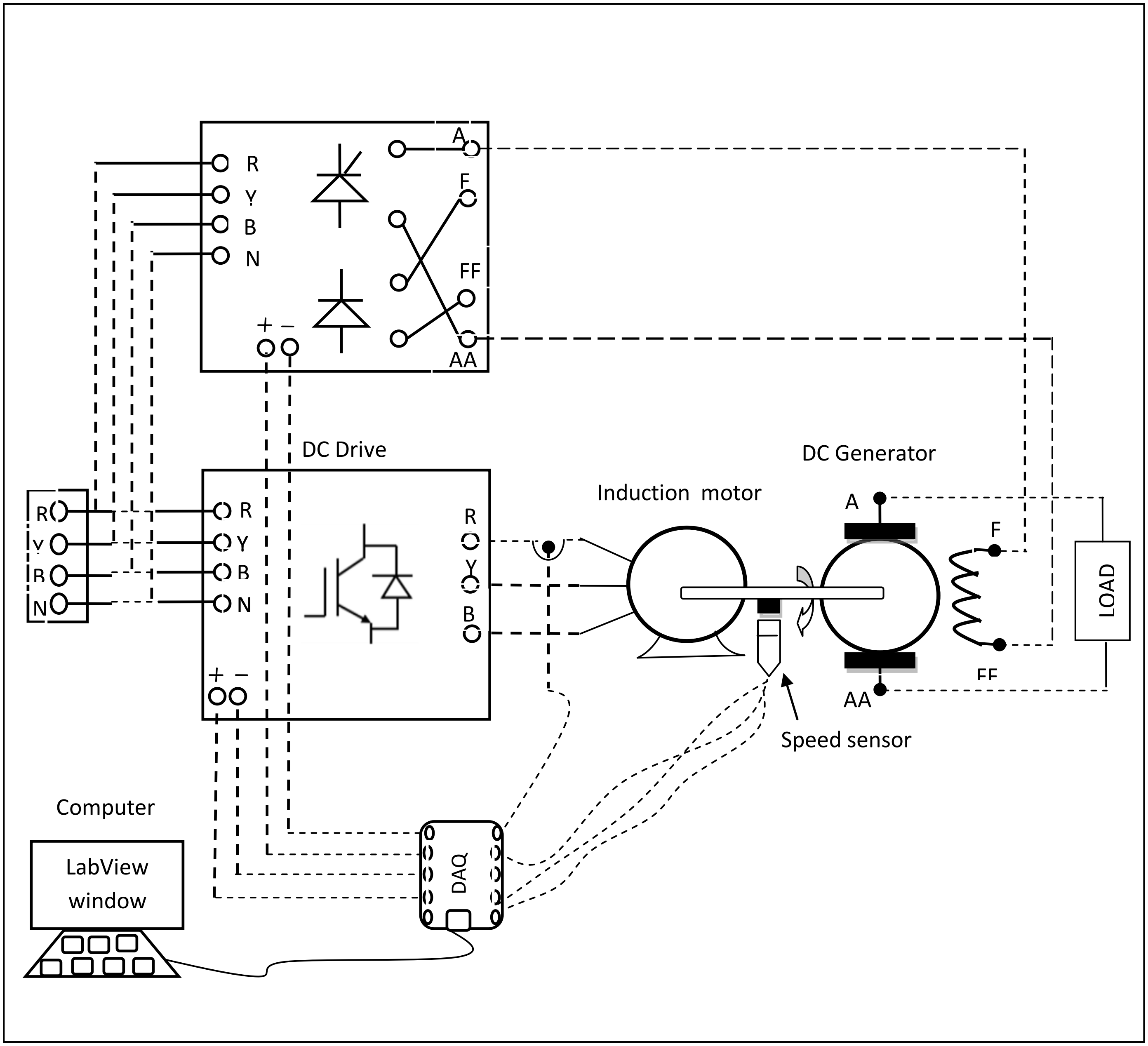


fig.9.1 circuit diagram of closed loop speed control of AC motor –DC generator set with load

PID control always sees the motor speed following set speed or not. As motor speed reduces due to loading speed error becomes positive then PID controller increases the controller voltage till motor reaches set speed. A graph is plotted between set speed and actual speed of motor by getting data from LabView using LVM file and drawn in Excel sheet, we can observe variation in speed from the plot very easily. This experimental setup can be used as constant speed drive system in industry even load varies on the system.

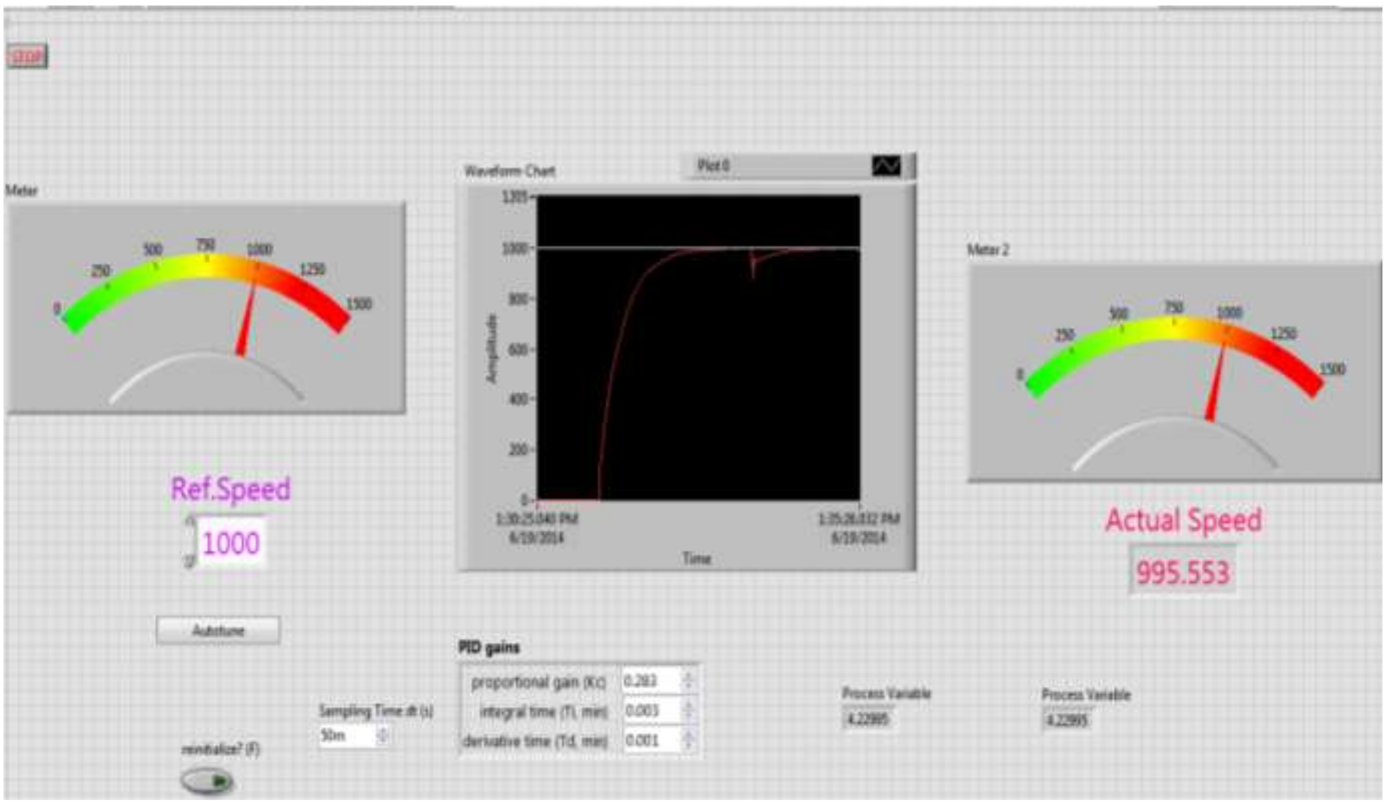


Fig.9.2 LabVIEW front panel diagram of closed loop speed control of AC motor – DC gen.set with load

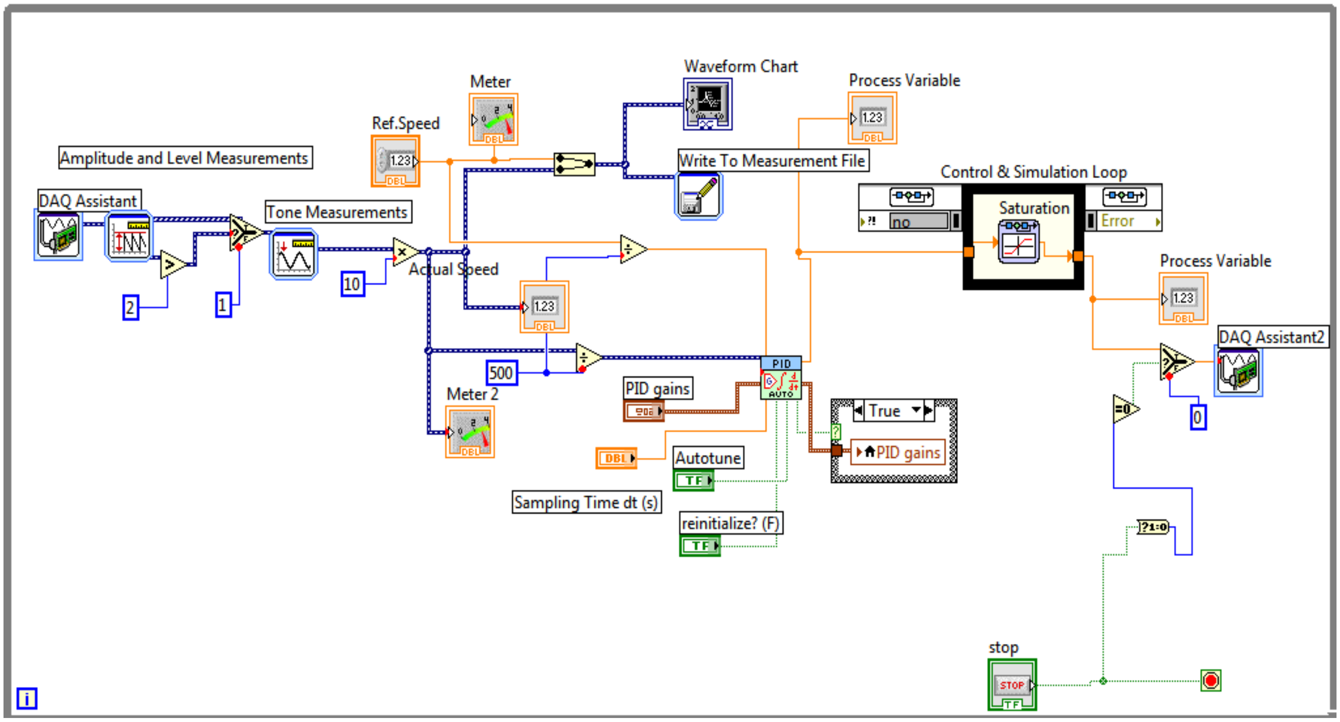


Fig.9.3. LabVIEW block diagram of closed loop speed control of AC motor-DC gen.set with load

Procedure:

1. Connect circuit as per circuit diagram

   i. Connect supply to AC drive

   ii. Connect output of AC drive to armature and field supplies of Inuction motor

   iii. Connect field supply to DC generator

   iv. Connect speed sensor & AC drive variable point to DAQ assistant

2. Develop LabView diagram in back panel consists of reference speed, PID controller design and speed feedback.
3. Set the reference speed to some value say 1000 RPM
4. Tune the PID controller using auto-tune block till we get desired P, I , D values.
5. Ensure that motor speed follows the set speed or reference speed.
6. Add load on DC generator in steps
7. Take the data to excel file from LabView, draw the set speed and actual speed on a single plot
8. Observe the response of speed control loop using plot
9. Vary the P, I, D gains around the tune values and see the response.
10. Design the PI controller and repeat the step 3 to 9.

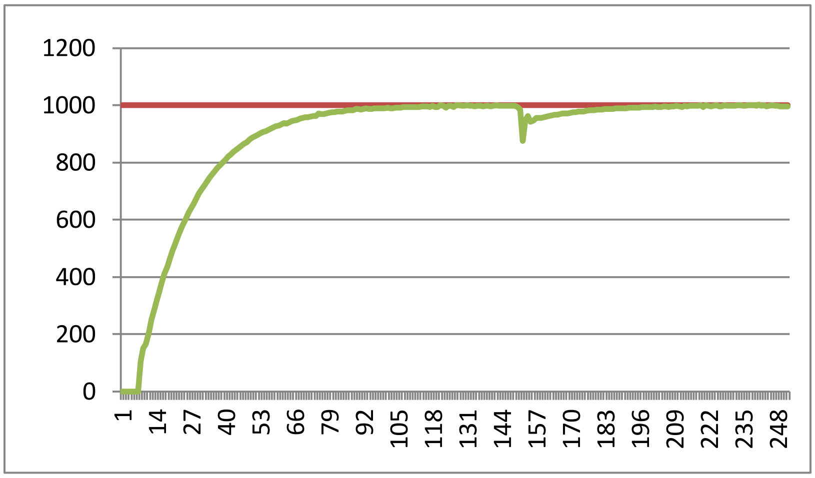


Fig.9.4 speed response of closed loop AC motor –DC gen. set with load

Table:

Reference Speed	PI gains		PD gains	
	P=	I=	P=	D=
	P=	I=	P=	D=

Table 1: Different set speeds & P, I, D gains

Result: closed loop speed control of AC motor-DC generator set with load is done and speed response plotted.

10. STEP,RAMP AND PARABOLIC SPEED RESPONSE OF SECOND ORDER AC MOTOR SYSTEM ON LABVIEW

AIM: To find step, ramp and parabolic speed response of second order AC motor system on LabView.

Apparatus:

i. NI LabView Software, DAQ
ii. V/F AC drive
iii. Induction motor
iv. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Most of the control systems use time as its independent variable, so it is important to analyse the response given by the system for the applied excitation which is function of time. The evaluation of system is based on the analysis of such response. The complete base of stability analysis, system accuracy and complete evaluation is always based on the time response analysis.

In many practical cases, the desired performance characteristics of control systems can be given in terms of transient response specifications and step, ramp, and parabolic inputs are commonly used as input for this purpose, since such an input is easy to generate. Mathematically, if the response of a linear system to a step input is known, by principle of superposition and linear theory assumptions, it is possible to compute the system's response to any input. However, the transient response of a system to a unit step input depends on initial conditions. If the inputs to a control system are gradually changing functions of time, then a ramp function of time may be a good test signal. If the inputs to a control system are gradually changing functions of time, then a parabolic function of time may be a good test signal.

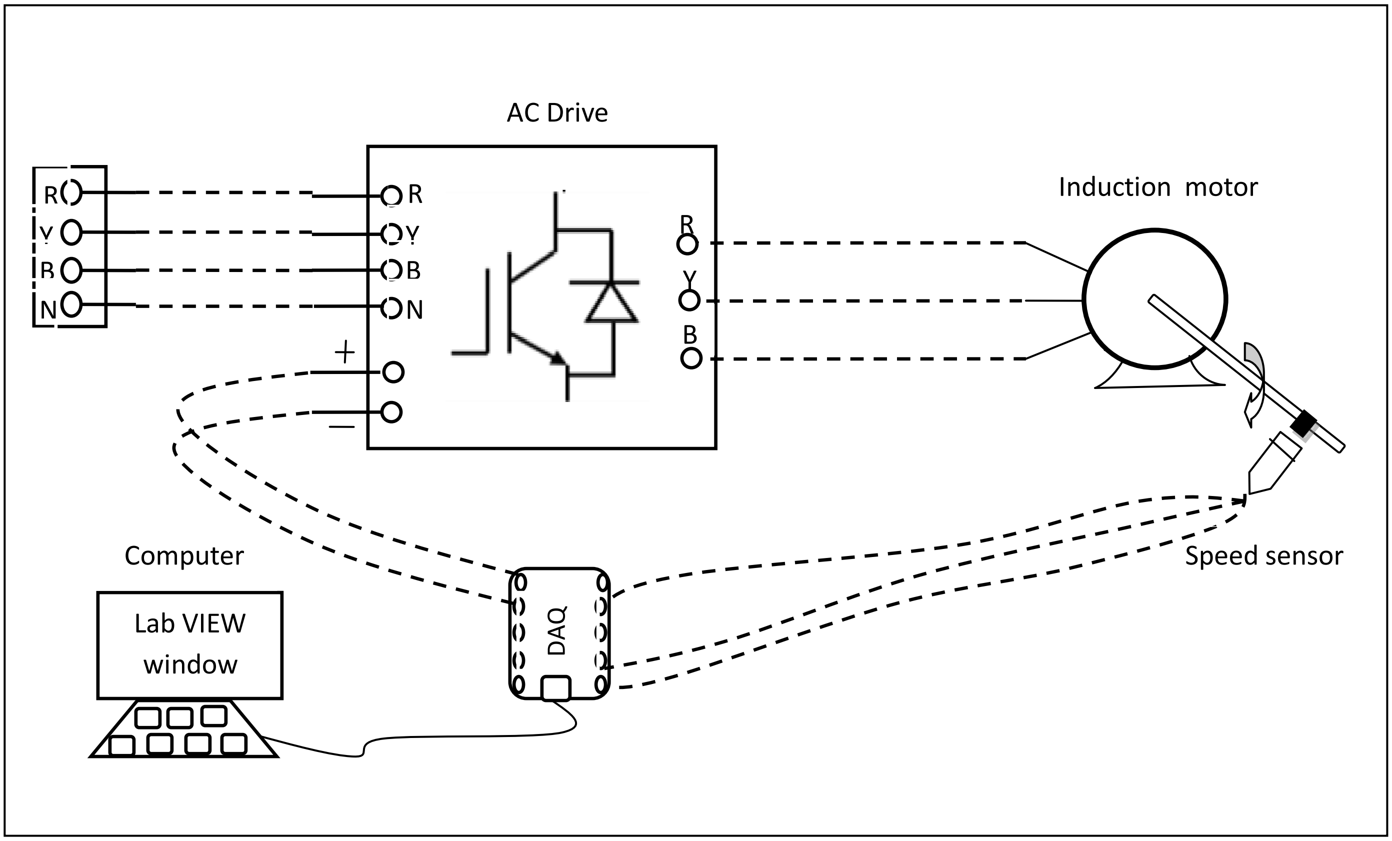


Fig.10.1 circuit diagram of AC motor speed response with step, ramp, parabolic inputs

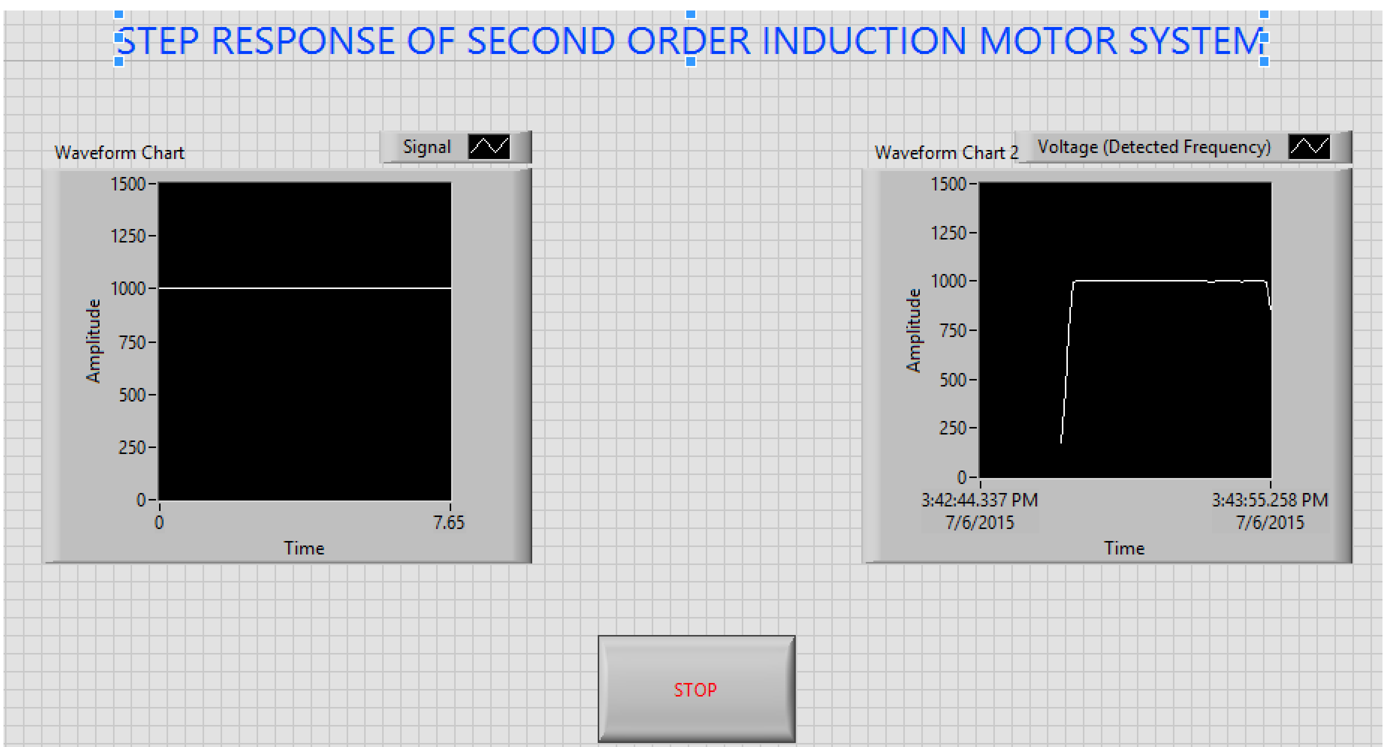


Fig.10.2 LabVIEW front panel diagram of second order AC motor system with step input

Step Function: Mathematically, a unit step function can be described by

$$f(t)=\begin{cases}0, & t<0\\ 1, & t\geq 0\end{cases}$$

In order to determine the response of a dynamic system to a step function, it is convenient to use Laplace Transform. The Laplace Transform of a unit step function is

$$L\{u(t)\}=\frac{1}{S}$$

The unit Step response of second order system is given by

$$C(s)=G(s)R(s)=\frac{w_n^2}{s(s^2+2\xi w_n s+w_n^2)}$$

Ramp Function: The Ramp signal is a signal which starts at a value of zero and increases linearly with time. Mathematically, a unit ramp function can be described by

$$r(t)=\begin{cases}At, & t>0\\ 0, & t<0\end{cases}$$

In order to determine the response of a dynamic system to a step function, it is convenient to use Laplace Transform. The Laplace Transform of a unit ramp function is

$$L\{u(t)\}=\frac{1}{S^2}$$

The unit Ramp response of second order system is given by

$$C(s)=G(s)R(s)=\frac{w_n^2}{s^2(s^2+2\xi w_n s+w_n^2)}$$

Parabolic Function: The Parabolic signal is a signal which starts at a value of zero and increases linearly with time. Mathematically, a unit parabolic function can be described by

$$r(t)=\begin{cases}At^2/2 & t>0\\ 0 & t<0\end{cases}$$

In order to determine the response of a dynamic system to a step function, it is convenient to use Laplace Transform. The Laplace Transform of a unit parabolic function is $L\{u(t)\}=\frac{1}{S^3}$

The unit parabolic response of second order system is given by $C(s)=G(s)R(s)=\frac{w_n^2}{s^3(s^2+2\xi w_n s+w_n^2)}$

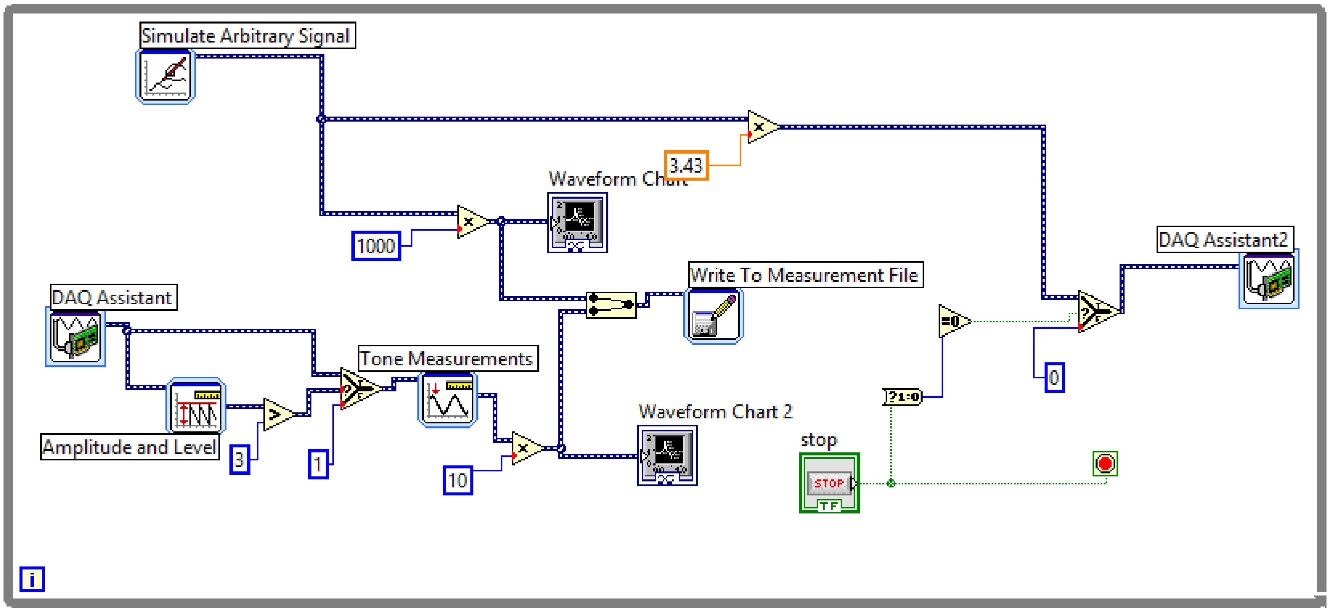


Fig.10.3 LabVIEW block diagram of second order AC motor system with step input

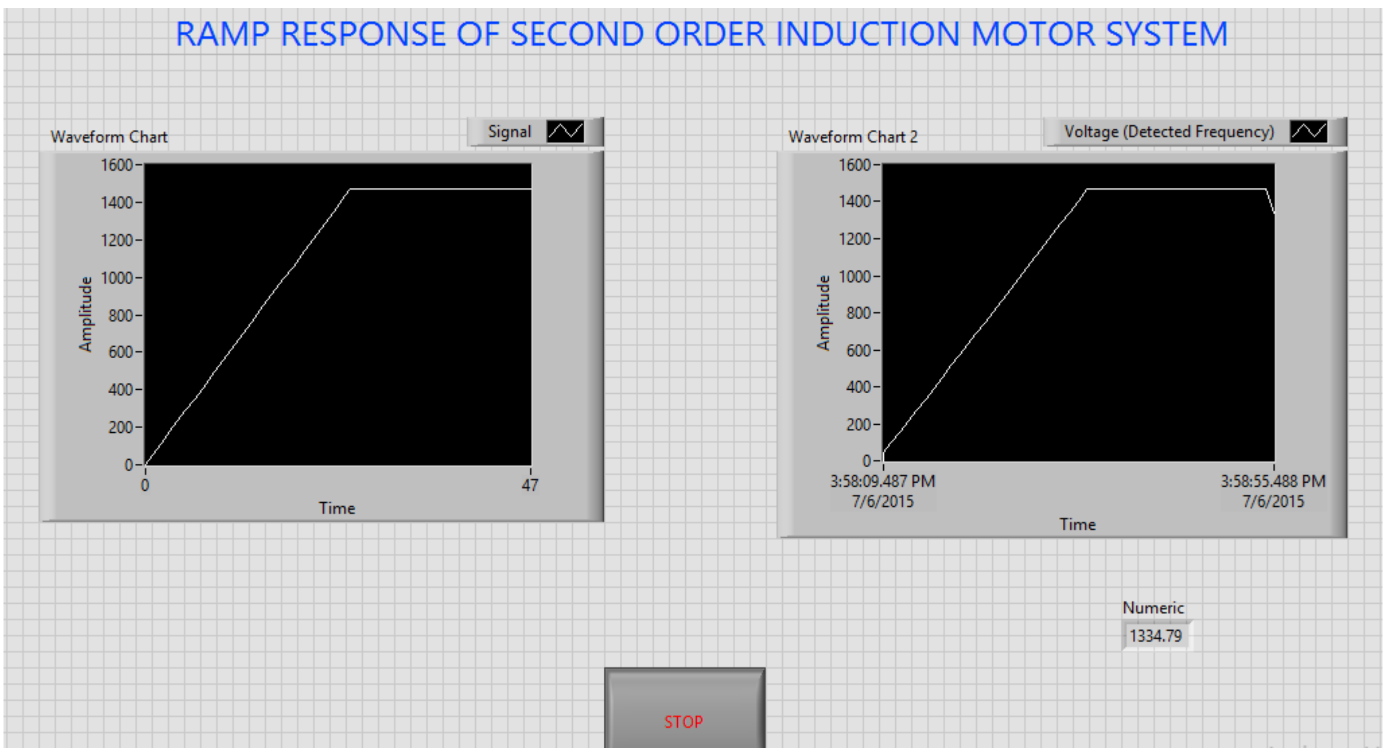


Fig.10.4 LabVIEW front panel diagram of second order AC motor system with ramp input

Circuit diagram for step response of second order AC motor system is shown in fig10.1 it consists of same elements present in block diagram 8.1, power modulator control power flow from source to motor. Controlled voltage is generated from the step response of second order system i.e developed in LAB VIEW. Step signal is taken as reference speed signal. AC Motor receives the proportional voltage according to the step signal designed in LAB VIEW. We can observe the step speed response of second order AC Motor by speed characteristics. Circuit diagrams for ramp, parabolic is same as step signal and response of second order AC motor is obtained.

The closed loop transfer function of second order AC Motor is given by

$$\frac{\theta(s)}{R(s)} = \frac{K_p K_m}{s^2 T_m + s + K_p K_m}$$

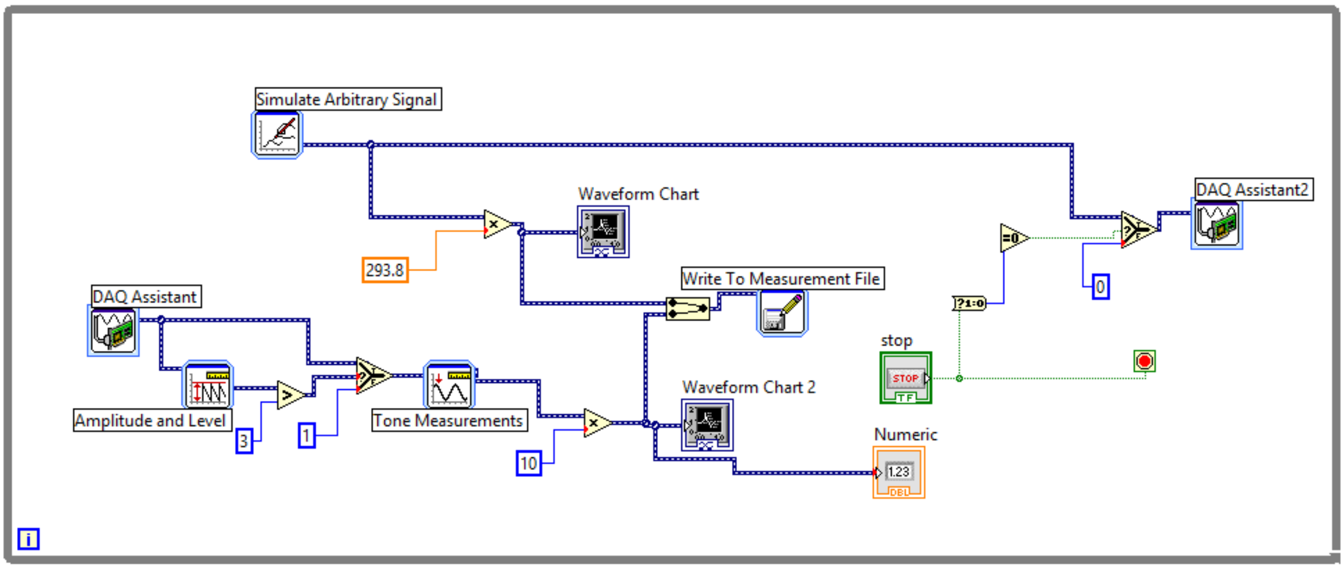


Fig.10.5 LabVIEW block diagram of second order AC motor system with ramp input

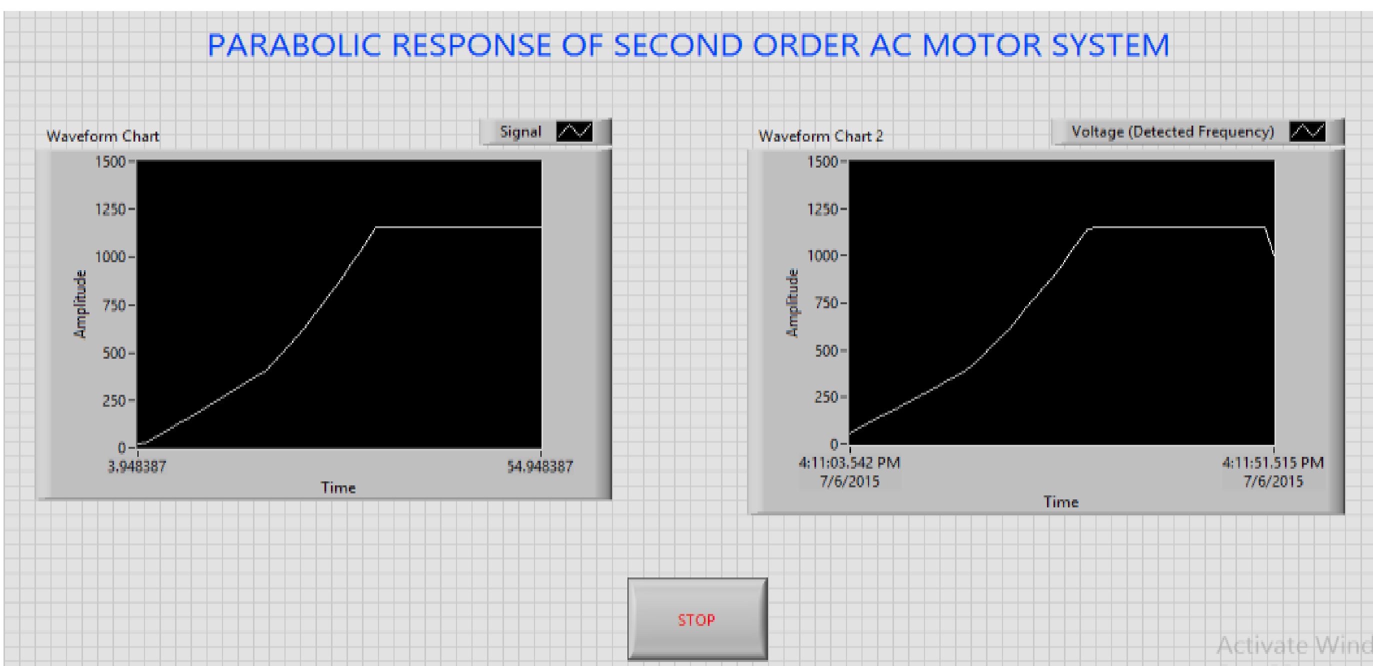


Fig.10.6 LabVIEW front panel diagram of second order AC motor system with parabolic input

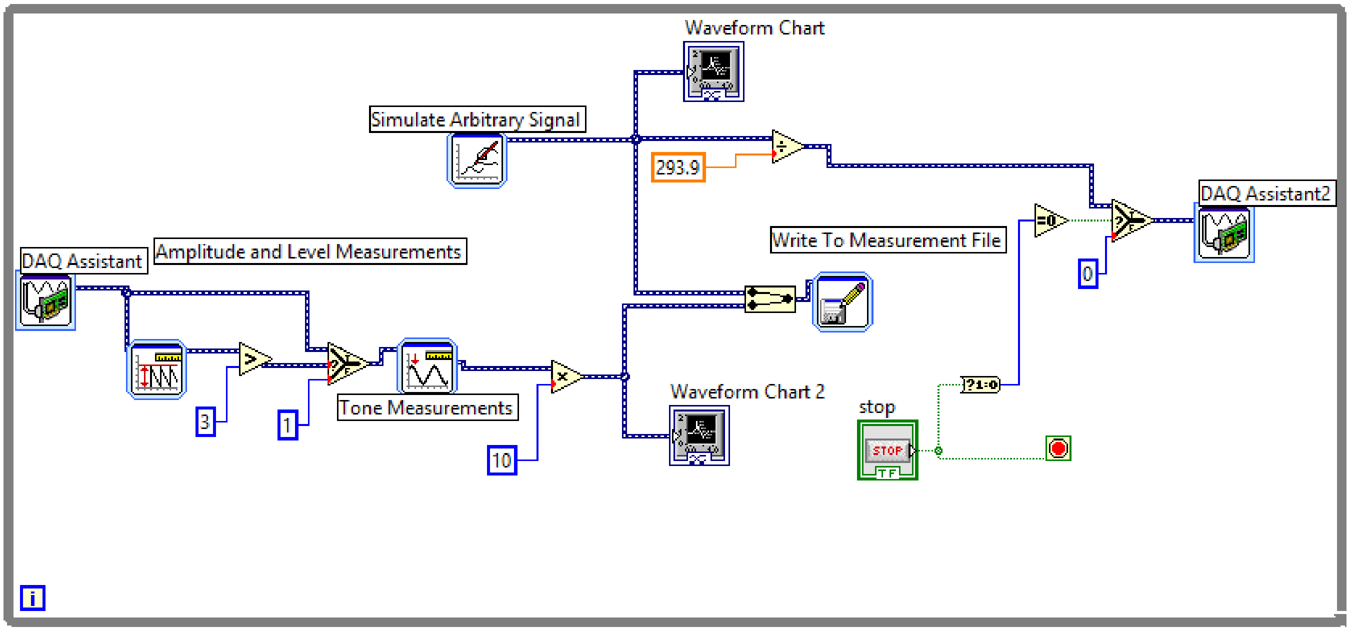


Fig.10.7 LabVIEW block diagram of second order AC motor system with parabolic input

Procedure:

1. Connect circuit as per circuit diagram

   i. Connect supply to AC drive

   ii. Connect output of AC drive to armature and field supplies of Inuction motor

   iii. Connect speed sensor & AC drive variable point to DAQ assistant

2. Develop LabView diagram in back panel consists of reference speed signal and speed feedback.

3. Construct reference speed signal as step signal using simulate arbitrary signal.

4. Run the LabView diagram for some time duration say 2mins.

5. Ensure that motor speed follows the set speed or reference speed.

6. Take the data to excel file, draw the set speed and actual speed on a single plot

7. Observe the response of speed control loop using plot

8. Construct Ramp & Parabolic signals and repeat the step 4 to 7.

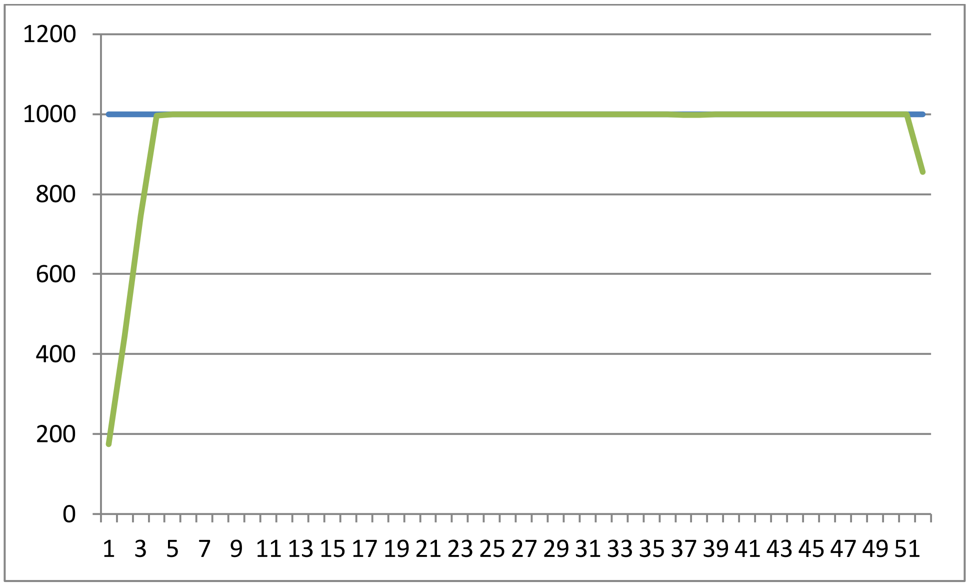


Fig.10.8 speed response of second order AC motor system with step input

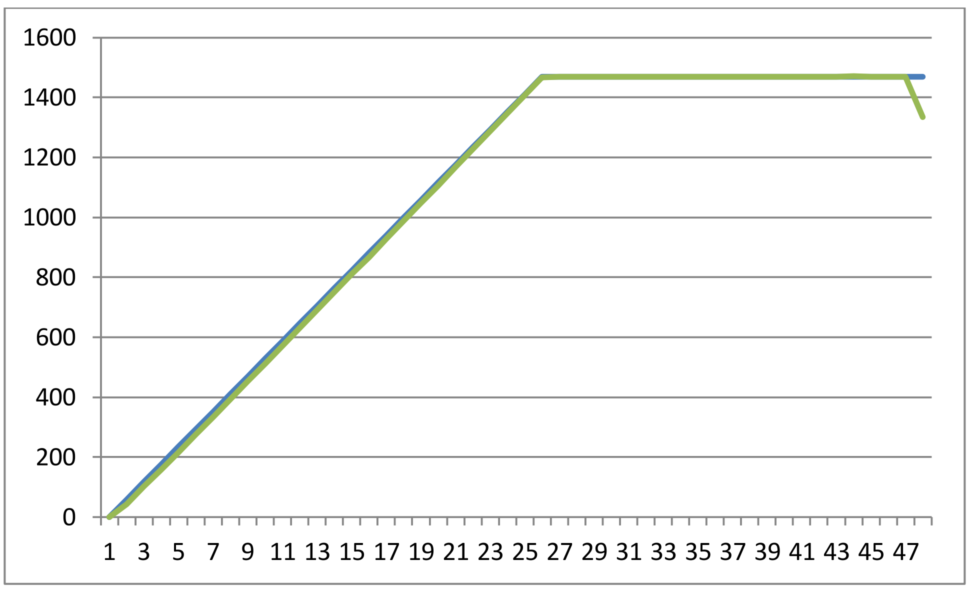


Fig.10.9 speed response of second order AC motor system with ramp input

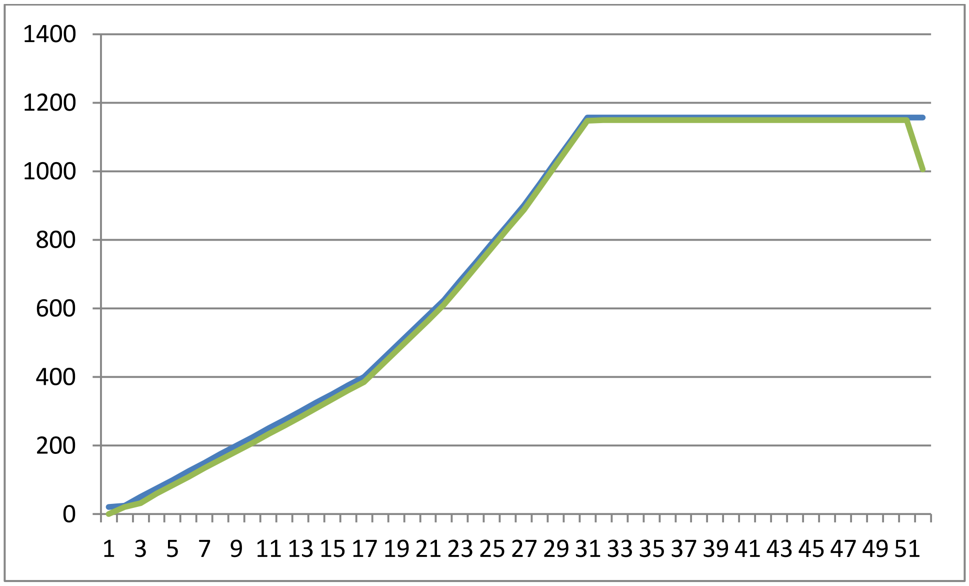


Fig.10.10 speed response of second order AC motor sytem with parabolic input

Result: speed response of second order AC motor system with step, ramp, parabolic inputs is done and speed response is plotted.

11. CLOSED LOOP SPEED CONTROL OF AC MOTOR USING STEP, RAMP, PARABOLIC INPUTS AND PI, PID CONTROLLERS

AIM: To design and tune proper PI, PID controllers for speed control of AC motor Drive with step, ramp and parabolic as reference inputs.

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. V/F AC drive
iv. Induction motor
v. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

The proportional integral derivative (PID) controller is the most common form of feedback used in the control systems. It can be used for various Industrial applications. One of the applications used here is to control the speed of the AC motor. Controlling the speed of a AC motors is very important as any small change can lead to instability of the closed loop system. The aim of this experiment is to show how AC motor can be controlled by using a Step,ramp, parabolic inputs and PID controller in LabVIEW.

Closed loop speed control of AC motor is shown in fig11.1 it consists of same elements present in block diagram 8.1, power modulator control power flow from source to motor. Power modulator is a AC drive consists of inverter where output voltage is varied based on controlled voltage given as input to gating circuit, as input voltage varies from 0 to 10V DC drive output varies from 0-220V. Controlled voltage is generated from closed loop with PID control implemented in LabView based on reference speed signal either step, ramp and parabolic.

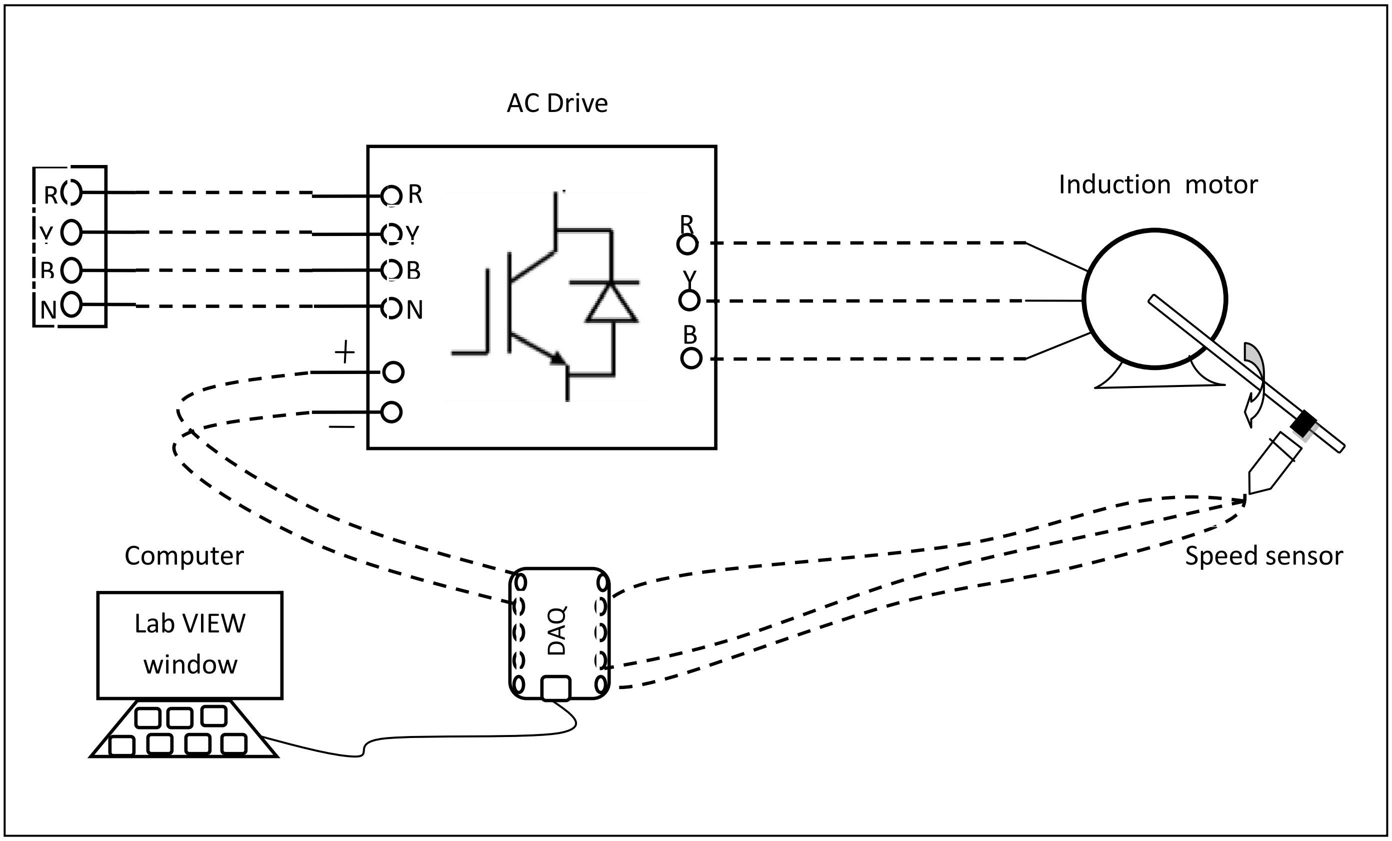


Fig.11.1 circuit diagram of closed loop speed control of second order AC motor system

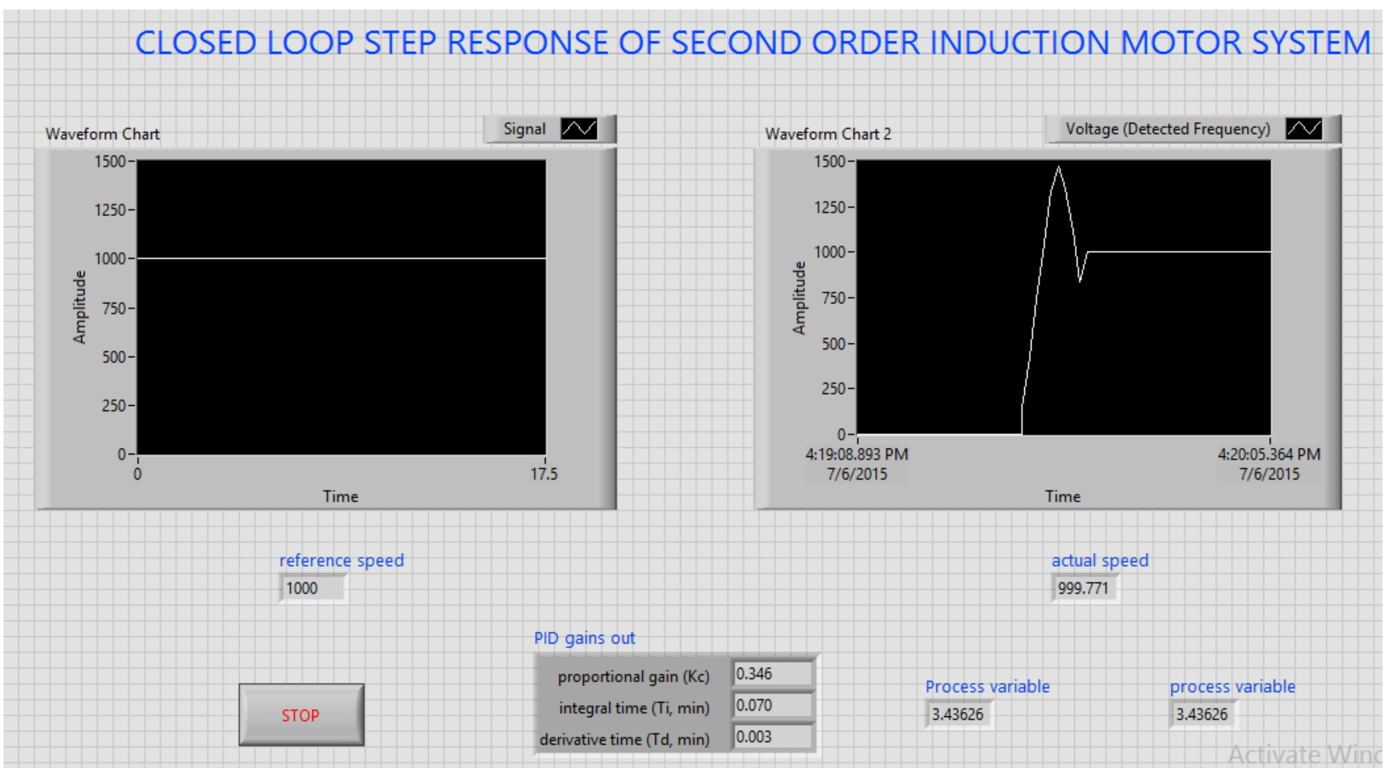


Fig.11.2 LabVIEW front panel diagram of closed loop speed control of second order AC motor system with step input

Step signal is taken as reference speed signal. Reference speed is set by the designing of step signal in LabView. Actual speed is sensed using proximity speed sensor and compared with reference speed an speed error is generated, if error is positive PID controller increases controlled voltage and if error is negative it decreases the controlled voltage till the motor speed attains set reference speed. Saturation limiter is limits the output voltage always in between 0 -5V even though PID controller output varies 100 to +100. PID controller is tuned using auto tune blocks available in control design & simulation tool box.

A graph is plotted between step signal speed and actual speed of motor by getting data from LabView using LVM file and drawn in Excel sheet, we can observe the step speed response of second order AC Motor with PID controller by speed characteristics. Similarly response of ramp and parabolic signals obtained.

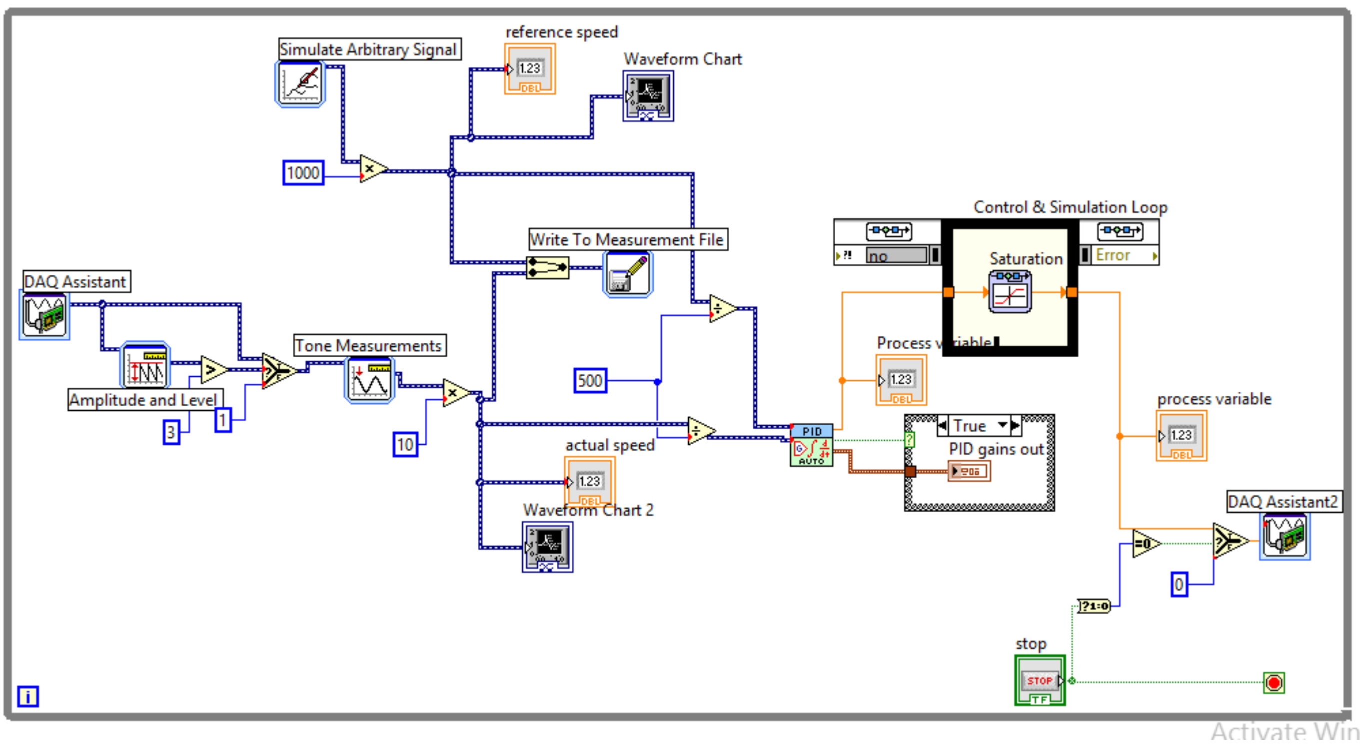


Fig.11.3 LabVIEW block diagram of closed loop speed control of AC motor with step input

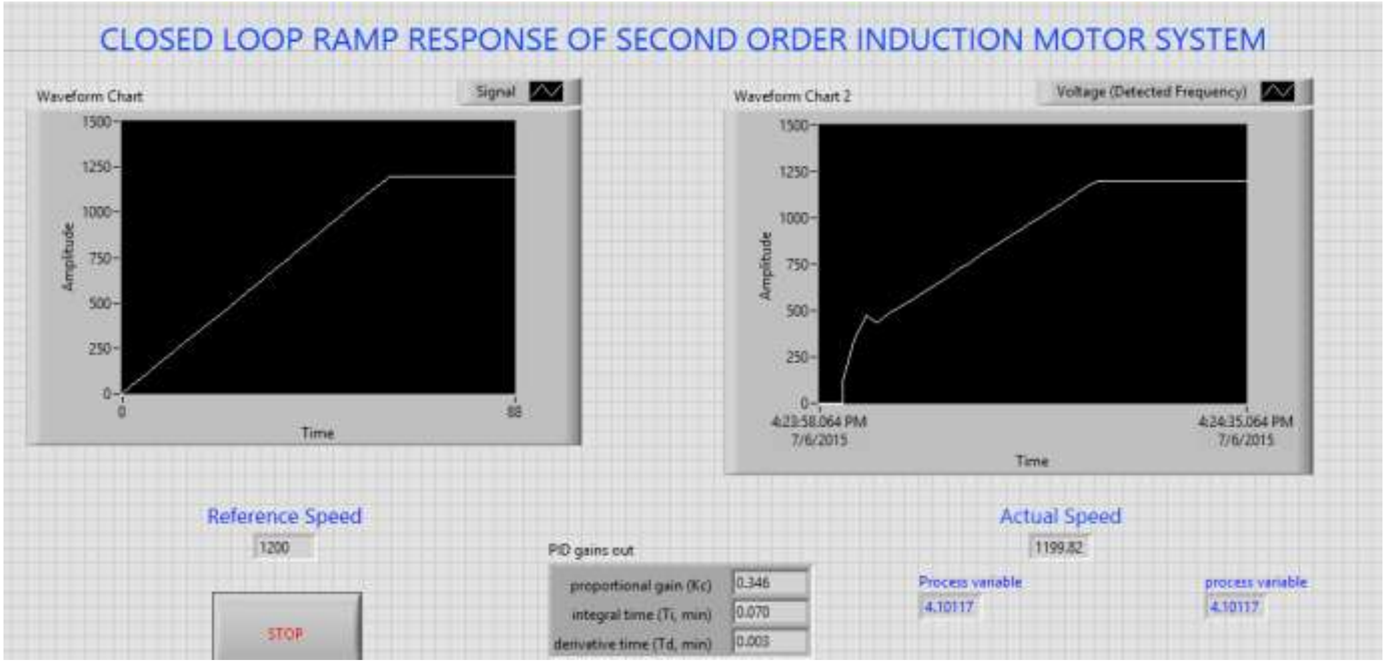


Fig.11.4 LabVIEW front panel diagram of closed loop speed control of second order AC motor system with ramp input

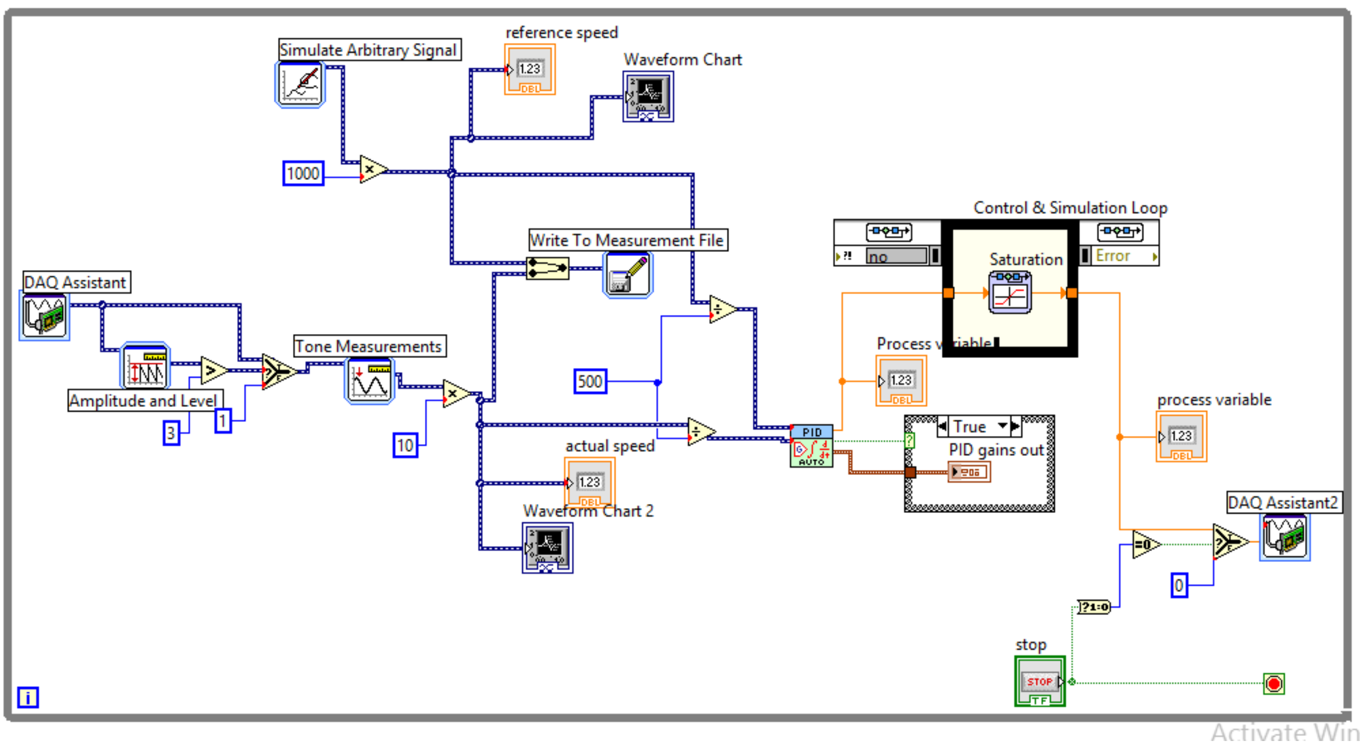


Fig.11.5 LabVIEW block diagram of closed loop speed control of second order AC motor system with ramp input

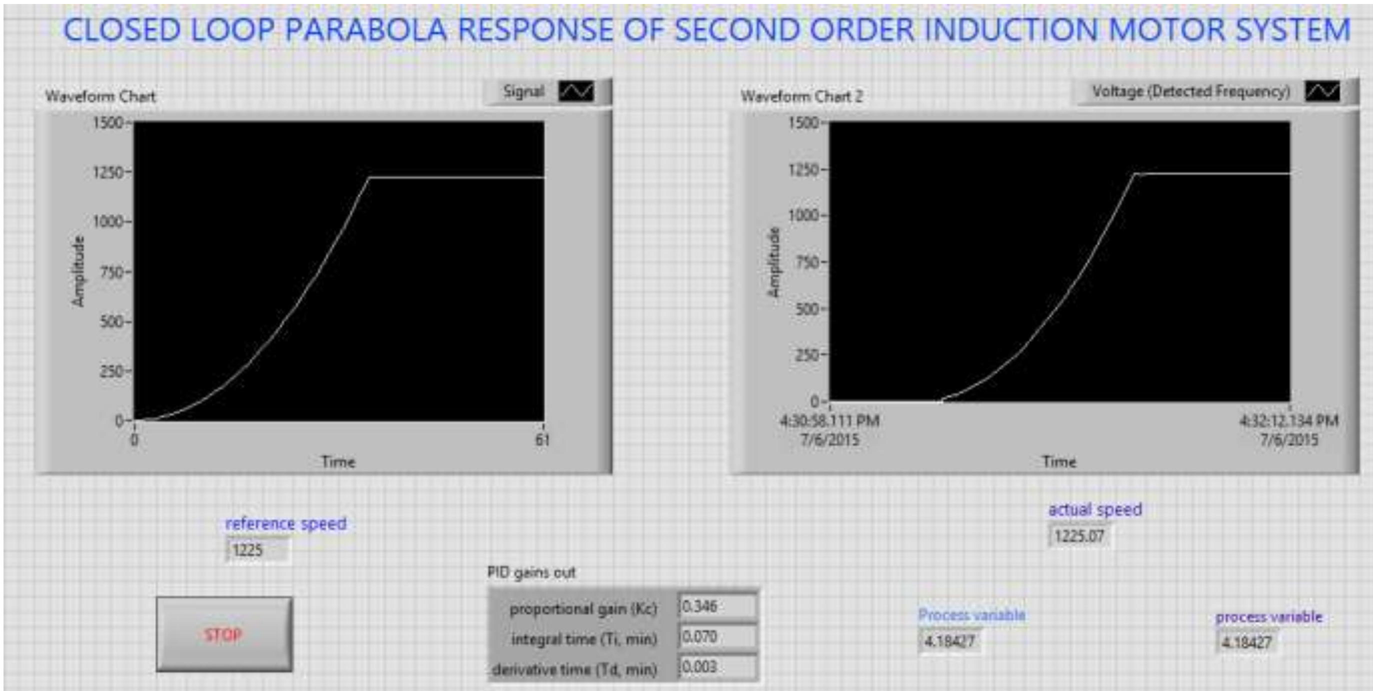


Fig.11.6 LabVIEW front panel diagram of closed loop speed control of second order AC motor system with parabolic input

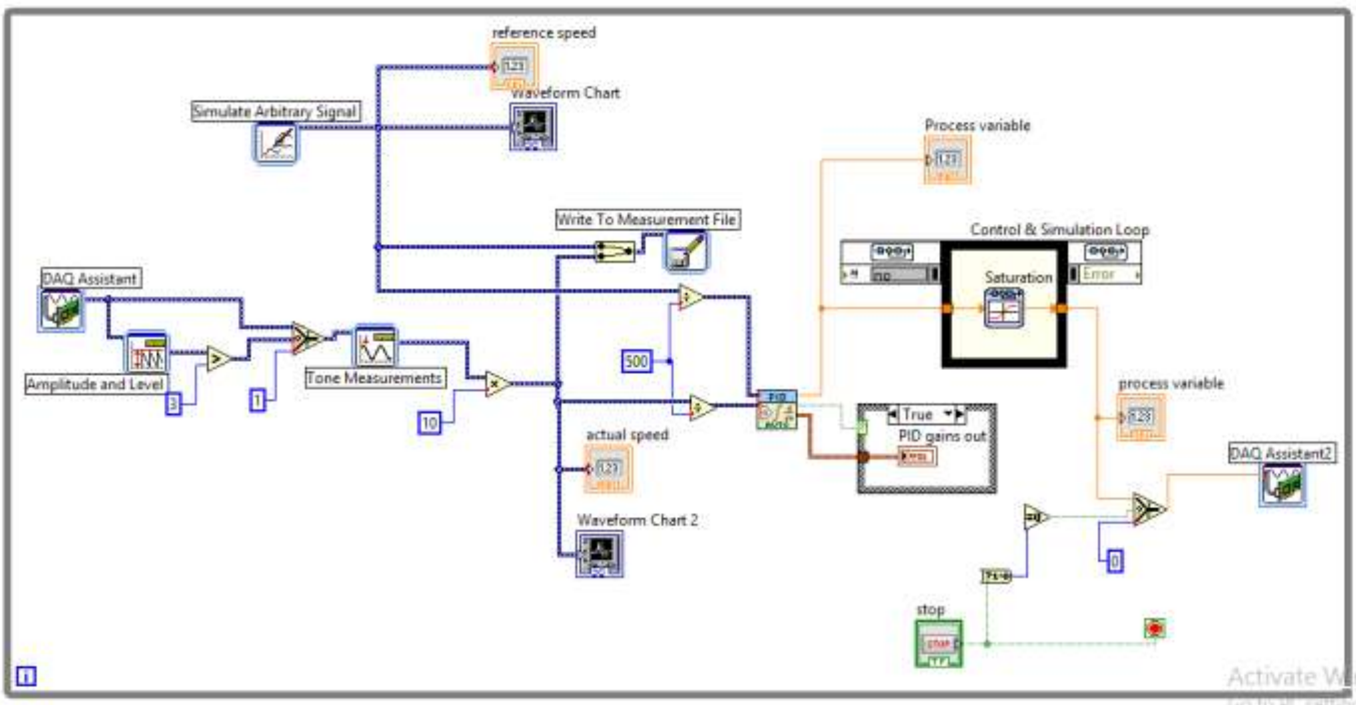


Fig.11.7 LabVIEW block diagram of closed loop speed control of second order AC motor system with parabolic input

Procedure:

1. Connect circuit as per circuit diagram

    i. Connect supply to AC drive

    ii. Connect output of AC drive to armature and field supplies of Induction motor

    iii. Connect speed sensor & AC drive variable point to DAQ assistant

2. Develop LabView diagram in back panel consists of reference speed, PID controller design and speed feedback.

3 .Construct reference speed signal as step signal using simulate arbitrary signal.

4 . Run the LabView diagram Tune the PID controller using auto-tune block till we get desired P, I , D values.

5 Ensure that motor speed follows the set speed or reference speed.

6 Take the data to excel file, draw the set speed and actual speed on a single plot

7 Observe the response of speed control loop using plot

8 Vary the P, I, D gains around the tune values and see the response

9 Construct the ramp, parabolic signals and repeat the step 4 to 7

10 Design the PI controller and repeat the step 3 to 9.

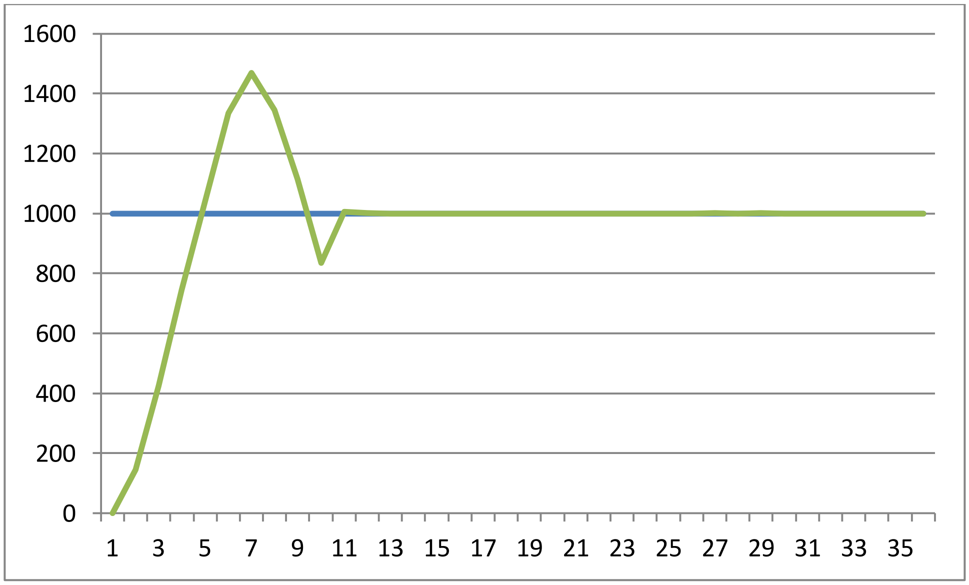


Fig.11.8 speed response of second order AC motor system with step input

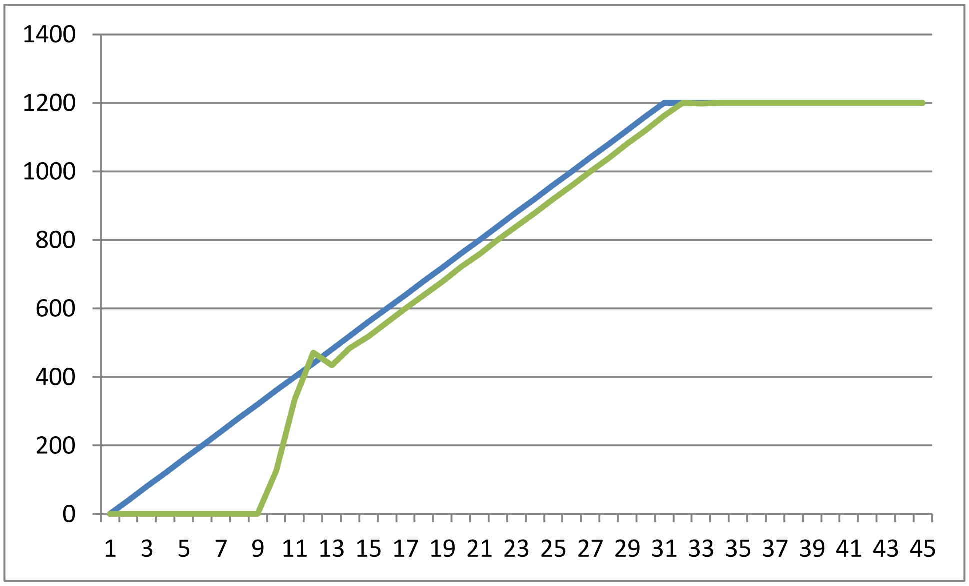


Fig.11.9 speed response of second order AC motor system with ramp input

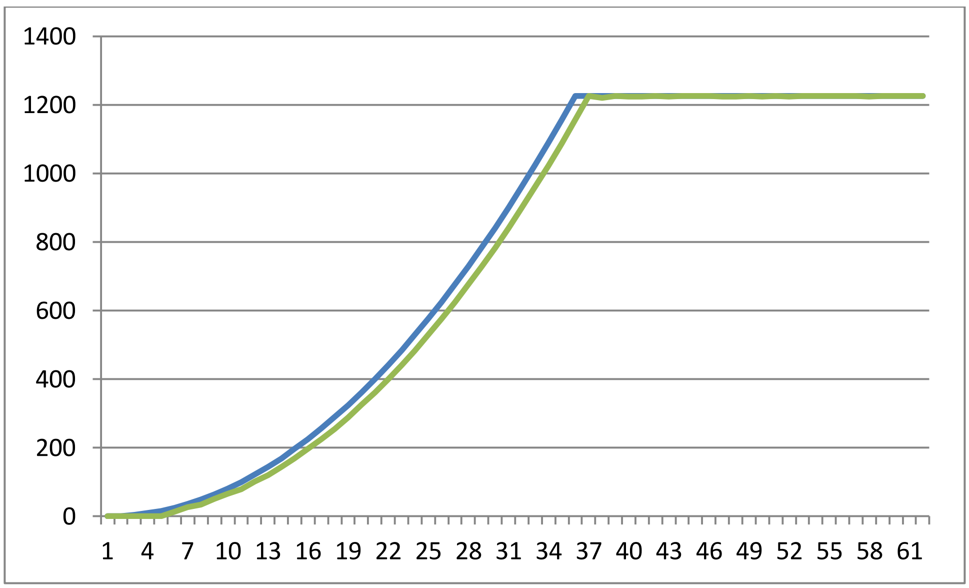


Fig.11.10 speed response of second order AC motor system with parabolic input

Table:

Reference Speed	PI gains		PD gains	
	P=	I=	P=	D=
	P=	I=	P=	D=

Table 1: Different set speeds & P, I, D gains

Result: closed loop speed control of second order AC motor with step, ramp and parabolic inputs is done and speed response plotted.

12. INDIRECT SPEED CONTROL OF AC MOTOR USING ARMATURE VOLTAGE CONTROL WITH PI,PID CONTROLLERS

AIM: To design and tune proper PI, PID controllers for indirect speed control of AC motor Drive using armature V/F control method.

Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. V/F AC drive
iv. Induction motor
v. Voltage sensor
vi. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

Speed of AC motor can be controlled by armature voltage control method. The speed of AC motor is directly proportional to armature voltage and inversely proportional to flux. In armature controlled AC motor the desired speed is obtained by varying the armature voltage. This speed control system is an electromechanical control system. The electrical system consists of the armature. Armature circuit is taken for analysis and the mechanical system consists of the rotating part of the motor and load connected to the shaft of the motor. The transfer function of armature controlled ac motor can be expressed in another standard form as shown below.

$$\frac{\theta(s)}{V_a(s)} = \frac{K_t}{s\left[(1+sT_a)(1+sT_m)+\frac{K_bK_t}{R_aB}\right]}$$

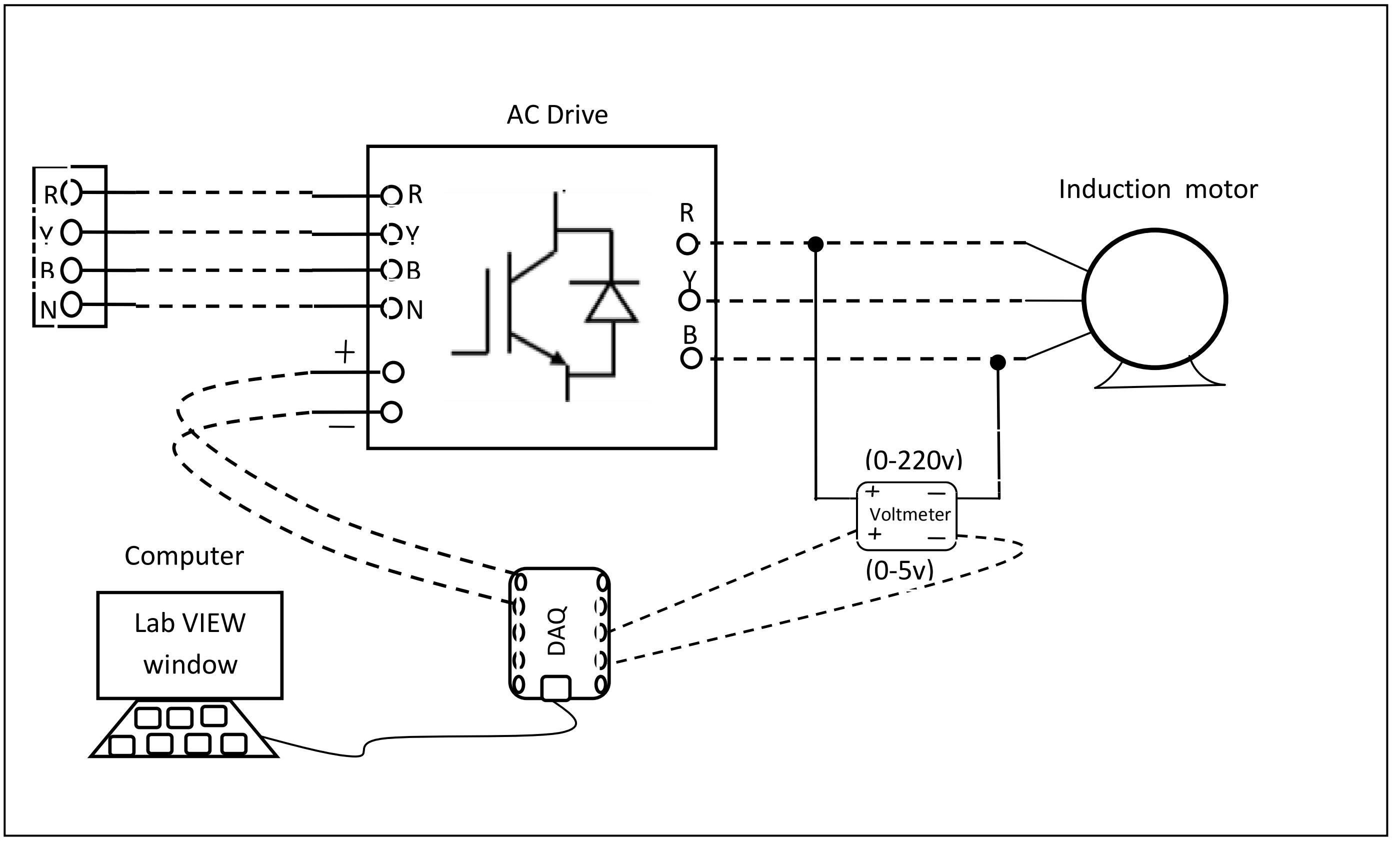


Fig.12.1 circuit diagram of indirect speed control of AC motor with voltage control

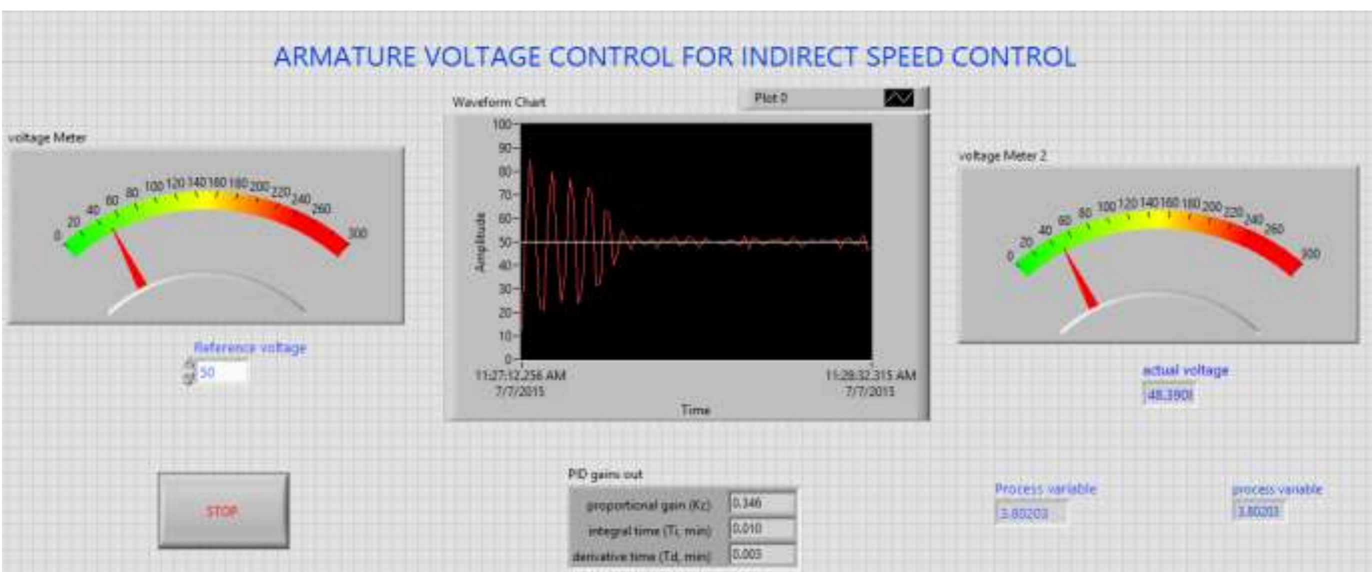


Fig.12.2 LabVIEW front panel diagram of indirect speed control with armature voltage control

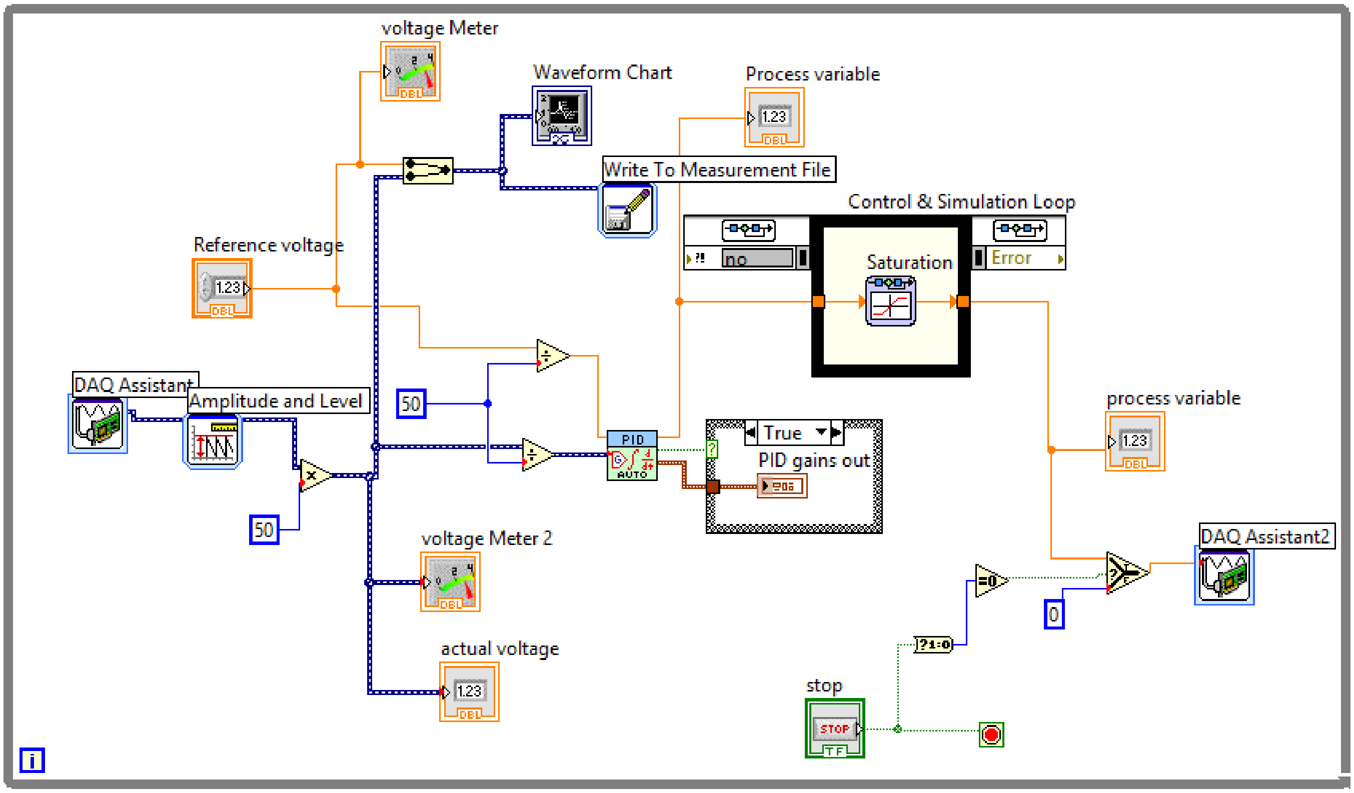


Fig.12.3 LabVIEW block diagram of indirect speed control of AC motor with armature voltage control

Procedure:

1. Connect circuit as per circuit diagram

   i. Connect supply to AC drive

   ii. Connect output of AC drive to armature and field supplies of Induction motor

   iii. Connect voltage sensor & AC drive variable point to DAQ assistant

2. Develop LabView diagram in back panel consists of reference voltage, PID controller design and voltage feedback.
3. Set the reference voltage to some value say 2 volts.
4. Run the LabView diagram Tune the PID controller using auto-tune block till we get desired P, I , D values.
5. Ensure that motor voltage follows the set voltage or reference voltage.
6. Take the data to excel file, draw the set voltage and actual voltage on a single plot
7. Observe the response of voltage control loop using plot
8. Vary the P, I, D gains around the tune values and see the response.

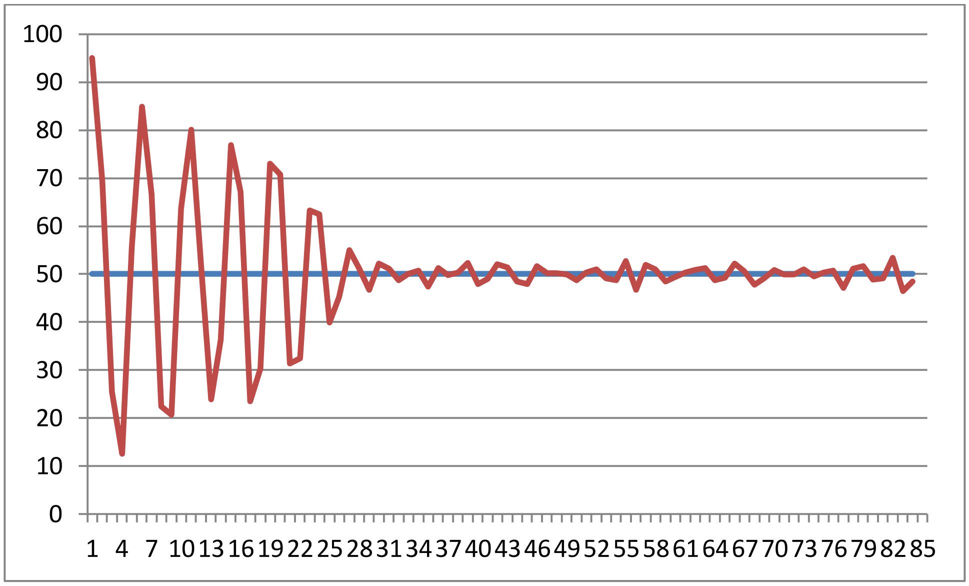


Fig.12.4 voltage response of indirect speed control of AC motor

Table:

Reference Speed	PI gains	PID gains
	P= I=	P= I= D=
	P= I=	P= I= D=

Table 1: Different set speeds & P, I, D gains

Result: indirect speed control of AC motor with armature voltage control is done and speed response plotted.

13. CLOSED LOOP TORQUE CONTROL OF DC MOTOR WITH PI, PID CONTROLLERS

AIM: To design and tune proper PI & PID controllers for closed loop torque control of DC motor Drive.

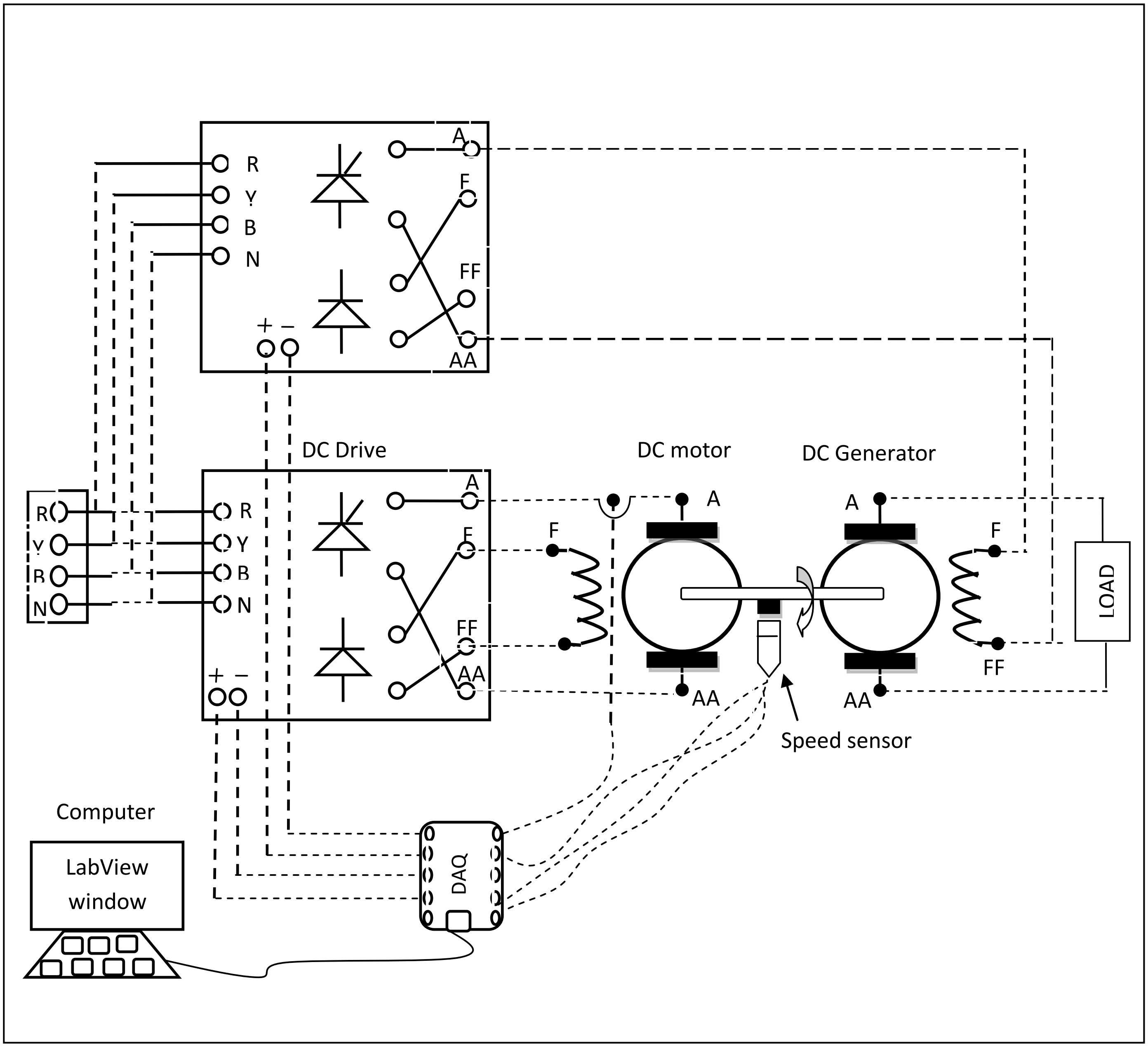
Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. V/F AC drive
iv. Induction motor
v. current sensor
vi. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:


R
Y
B
N
A
F
FF
AA
+ −
DC Drive
DC motor
DC Generator
LOAD
Speed sensor
Computer
LabView
window
DAQ

14. CLOSED LOOP TORQUE CONTROL OF AC MOTOR WITH PI, PID CONTROLLERS

AIM: To design and tune proper PI & PID controllers for closed loop torque control of AC motor Drive.

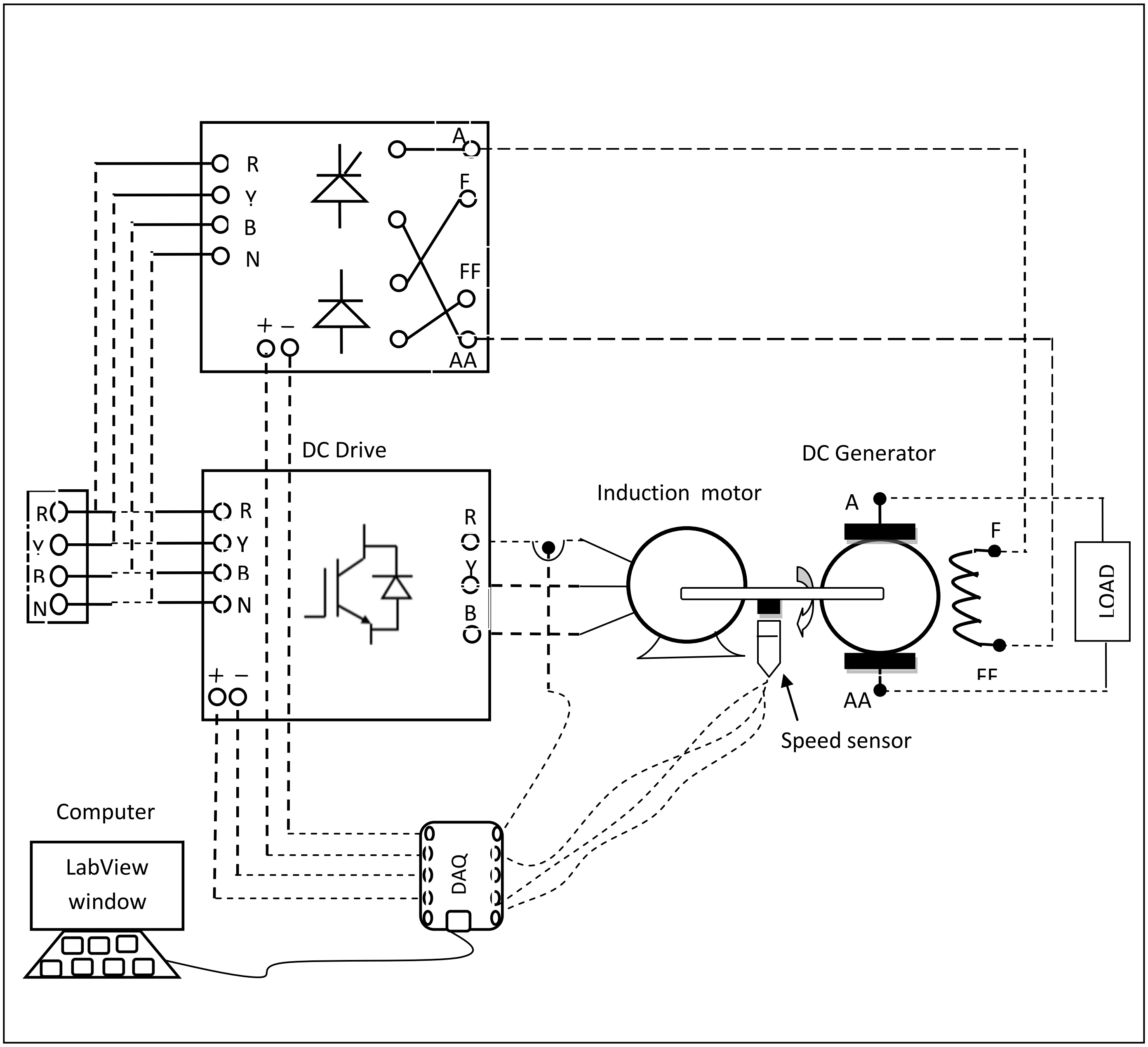
Apparatus:

i. NI LabView Software, DAQ
ii. Control design and simulation tool kit
iii. V/F AC drive
iv. Induction motor
v. current sensor
vi. Proximity Sensor

Specifications:

AC Drive	***Induction motor***
Three phase Inverter: 0-415V AC	*Armature voltage:* 415V AC
	Current: 0.9Amps
	Speed: 1500 RPM
	Power: 0.5 HP

Theory:

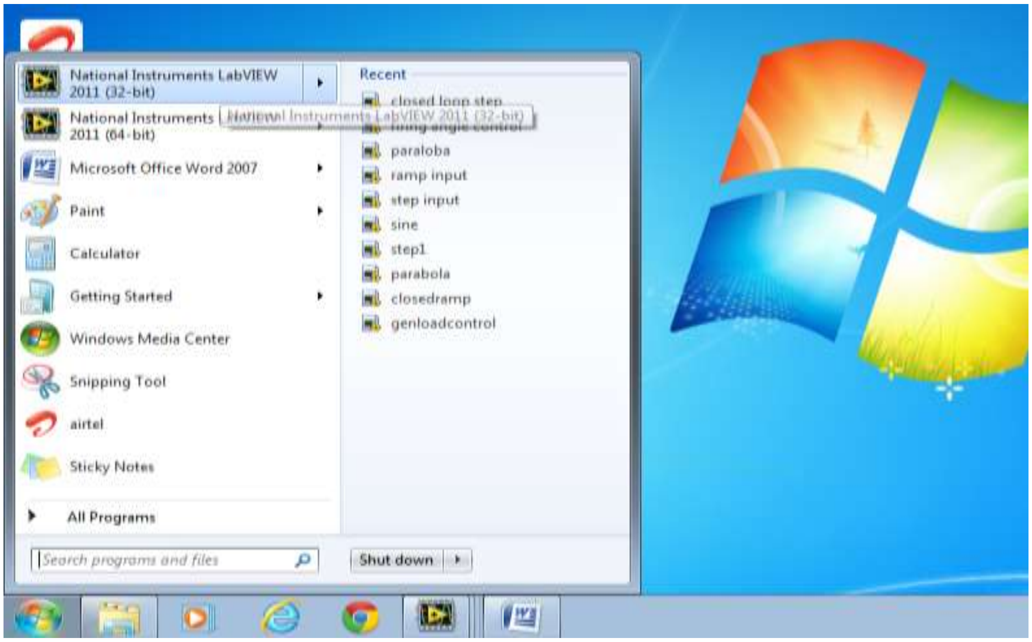


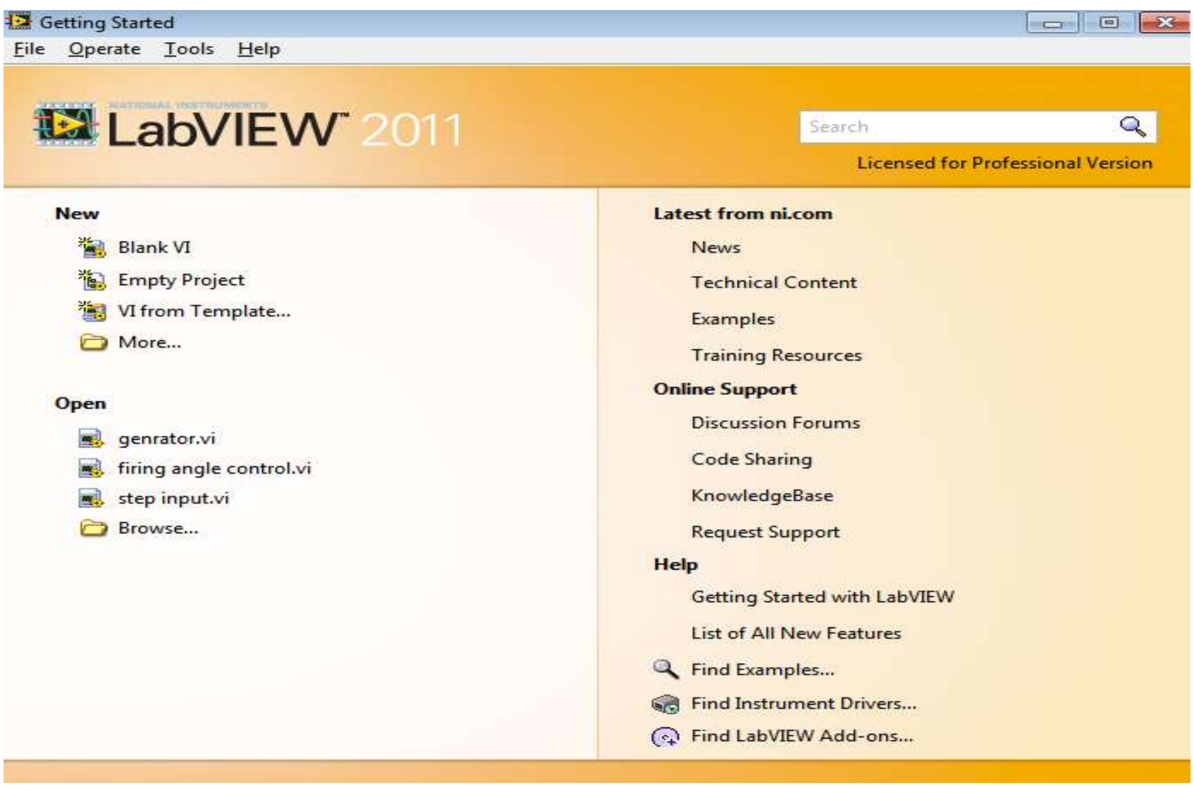
A
R
Y
B
N
F
FF
+ −
AA
DC Drive
DC Generator
Induction motor
R
Y
B
N
R
Y
B
+ −
A
F
LOAD
AA
Speed sensor
Computer
LabView window
DAQ

LabVIEW

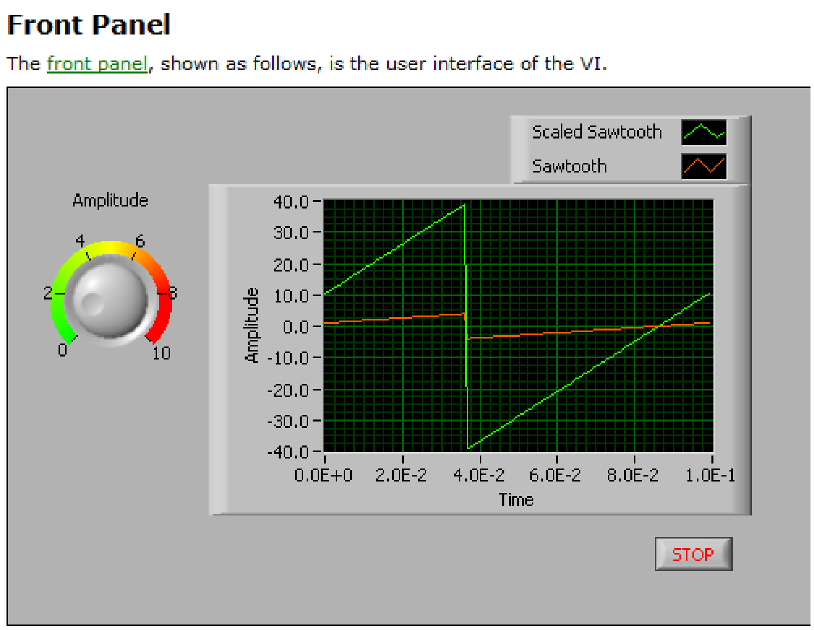
Getting started:

Click on start button on computer, a window opens than click on national instruments LabView and then LabView opens. Click on new VI to new LabView VI.



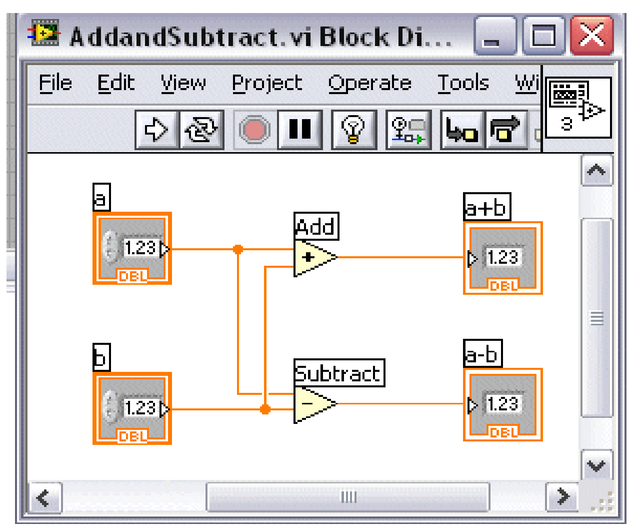


Front Panel:



You build the front panel using controls and indicators, which are the interactive input and output terminals of the VI, respectively. Controls are knobs, push buttons, dials, and other input mechanisms. Indicators are graphs, LEDs, and other output displays. Controls simulate instrument input mechanisms and supply data to the block diagram of the VI. Indicators simulate instrument output mechanisms and display data the block diagram acquires or generates.

Block Diagram:



After you build the front panel, you add code using graphical representations of functions to control the front panel objects. The block diagram contains this graphical source code, also known as G code or block diagram code. Front panel objects appear as terminals on the block diagram.

Terminals

The terminals represent the data type of the control or indicator. You can configure front panel controls or indicators to appear as icon or data type terminals on the block diagram. By default, front panel objects appear as icon terminals. For example, a knob icon terminal, shown as follows, represents a knob on the front panel.

The DBL at the bottom of the terminal represents a data type of double-precision, floating-point numeric. A DBL terminal, shown as follows, represents a double-precision, floating-point numeric control.

Terminals are entry and exit ports that exchange information between the front panel and block diagram. Data you enter into the front panel controls (**a** and **b** in the previous front panel) enter the block diagram through the control terminals. The data then enter the Add and Subtract functions. When the Add and Subtract functions complete their calculations, they produce new data values. The data values flow to the indicator terminals, where they update the front panel indicators (**a+b** and **a-b** in the previous front panel).

Nodes

Nodes are objects on the block diagram that have inputs and/or outputs and perform operations when a VI runs. They are analogous to statements, operators, functions, and subroutines in text-based programming languages. The Add and Subtract functions in the previous block diagram are examples of nodes.

Wires

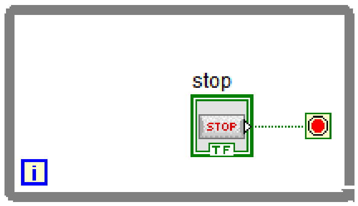
You transfer data among block diagram objects through wires. In the previous block diagram, wires connect the control and indicator terminals to the Add and Subtract functions. Each wire has a single data source, but you can wire it to many VIs and functions that read the data. Wires are different colors, styles, and thicknesses, depending on their data types. A broken wire appears as a dashed black line with a red X in the middle. Broken wires occur for a variety of reasons, such as when you try to wire two objects with incompatible data types.

Structures

Structures, a type of node, are graphical representations of the loops and case statements of text-based programming languages. Use structures on the block diagram to repeat blocks of code and to execute code conditionally or in a specific order.

While Loop

Repeats the sub diagram inside it until the conditional terminal, an input terminal, receives a particular Boolean value. The Boolean value depends on the continuation behavior of the While Loop. Right-click the conditional terminal and select **Stop if True** or **Continue if True** from the shortcut menu. You also can wire an error cluster to the conditional terminal, right-click the terminal, and select **Stop on Error** or **Continue while Error** from the shortcut menu. The While Loop always executes at least once.



The iteration (**i**) terminal provides the current loop iteration count, which is zero for the first iteration. If iteration count exceeds 2,147,483,647, or 2^{31}-1, the iteration terminal remains at 2,147,483,647 for all further iterations. If you need to keep count of more than 2,147,483,647 iterations, you can use shift registers with a greater integer range.

If you select a While Loop on the Execution Control Express VIs and Structures palette and place it on the block diagram, a stop button also appears on the block diagram and is wired to the conditional terminal. If you select a While Loop on the Structures palette and place it on the block diagram, a stop button does not appear.

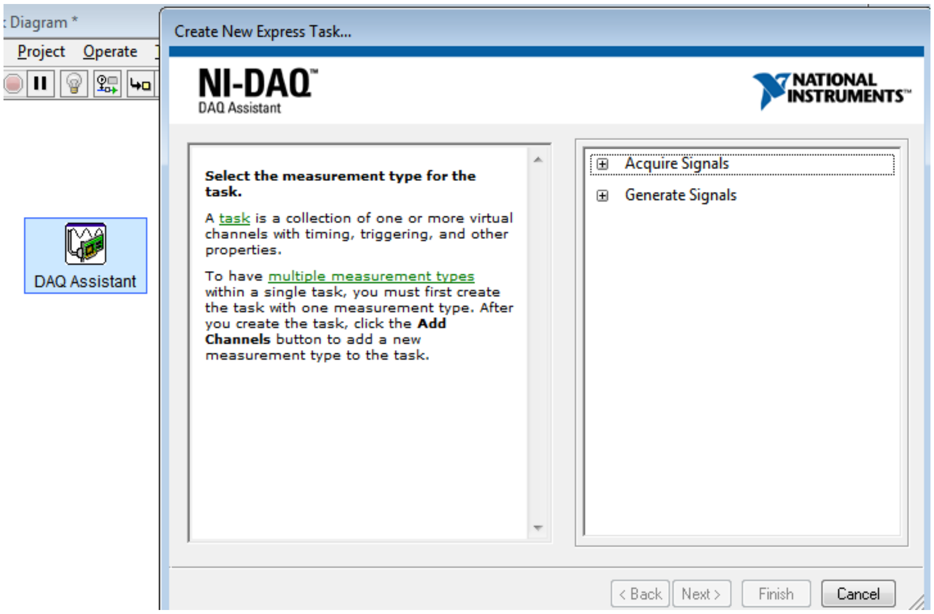
DAQ

1. Launch the DAQ Assistant Express VI

You can launch the DAQ Assistant in several ways. Complete the following steps to launch the DAQ Assistant by placing the DAQ Assistant Express VI on the block diagram in LabVIEW.

1. Open a blank VI in LabVIEW.
2. Place the DAQ Assistant Express VI on the block diagram.

The DAQ Assistant launches, starting with the **Create New** dialog box.



2. Create the Task

In the **Create New Express Task** dialog box of the DAQ Assistant, complete the following steps to create a task to measure voltage from the DAQ device.

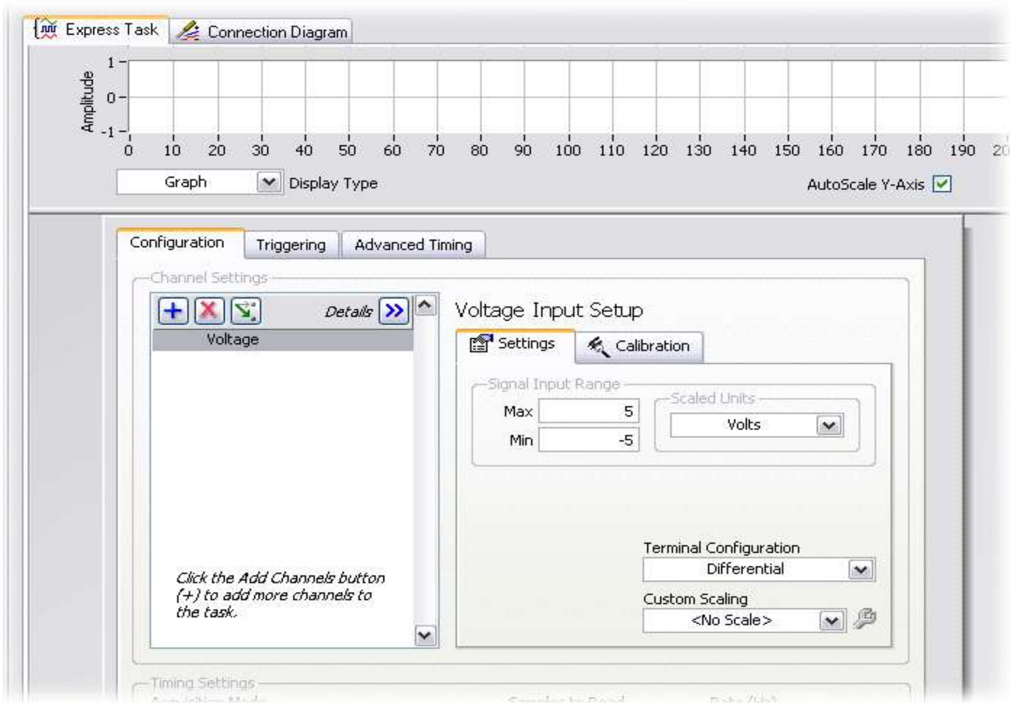
1. Select **Acquire Signals**.
2. Select **Analog Input** for the I/O type.
3. Select **Voltage** for the measurement to perform.
4. In **Supported Physical Channels**, select the physical channel on the DAQ device to which you connected the voltage signal.
5. Click **Finish**.

3. Configure the Task

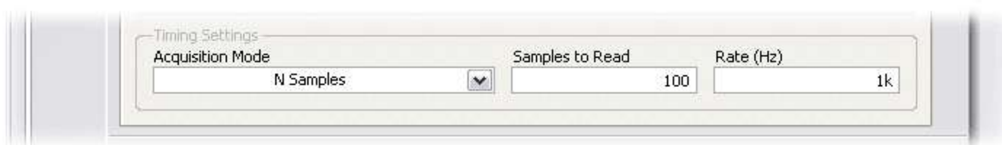
After you create a task, you can configure channel-specific settings such as custom scaling, input range, and terminal configuration. You also can configure task-specific settings such as timing and triggering.

To configure the voltage measurement task, complete the following steps.

1. Specify the input range. You can use the default values.
2. Select the terminal configuration you used to connect the signal.

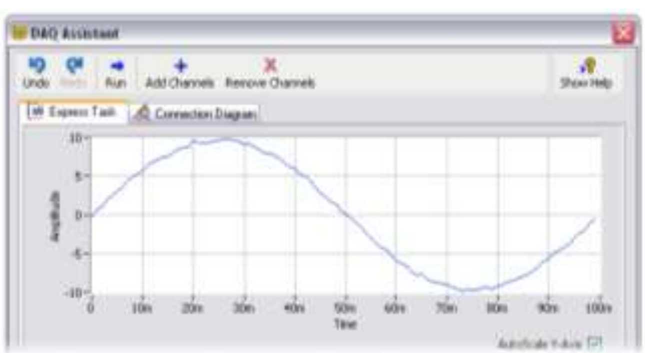


3. Under **Timing Settings**, select **N Samples** as the **Acquisition Mode**. Enter 100.00 for **Samples To Read**, and enter 1000.00 for **Rate (Hz)**, as shown in the following figure



4. Test the Task

You can view data acquired in the DAQ Assistant to test the task and signal connection. Click **Run** to test the task. Data acquired appears in the graph. Verify that you are acquiring expected data and that you connected the signal properly. If necessary, modify any settings and run your task again.

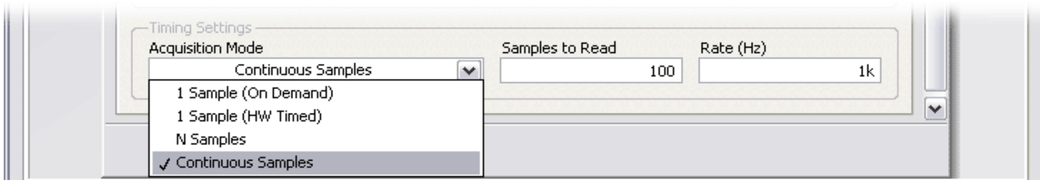


5. Edit the Task

If you want to make changes to your task later, you can open the task using the DAQ Assistant Express VI in LabVIEW.

Complete the following steps to edit the voltage task to acquire data continuously:

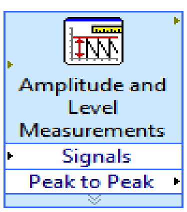
1. Double-click the DAQ Assistant Express VI on the block diagram in LabVIEW.
2. When the DAQ Assistant launches, select **Continuous Samples** for the Acquisition Mode.

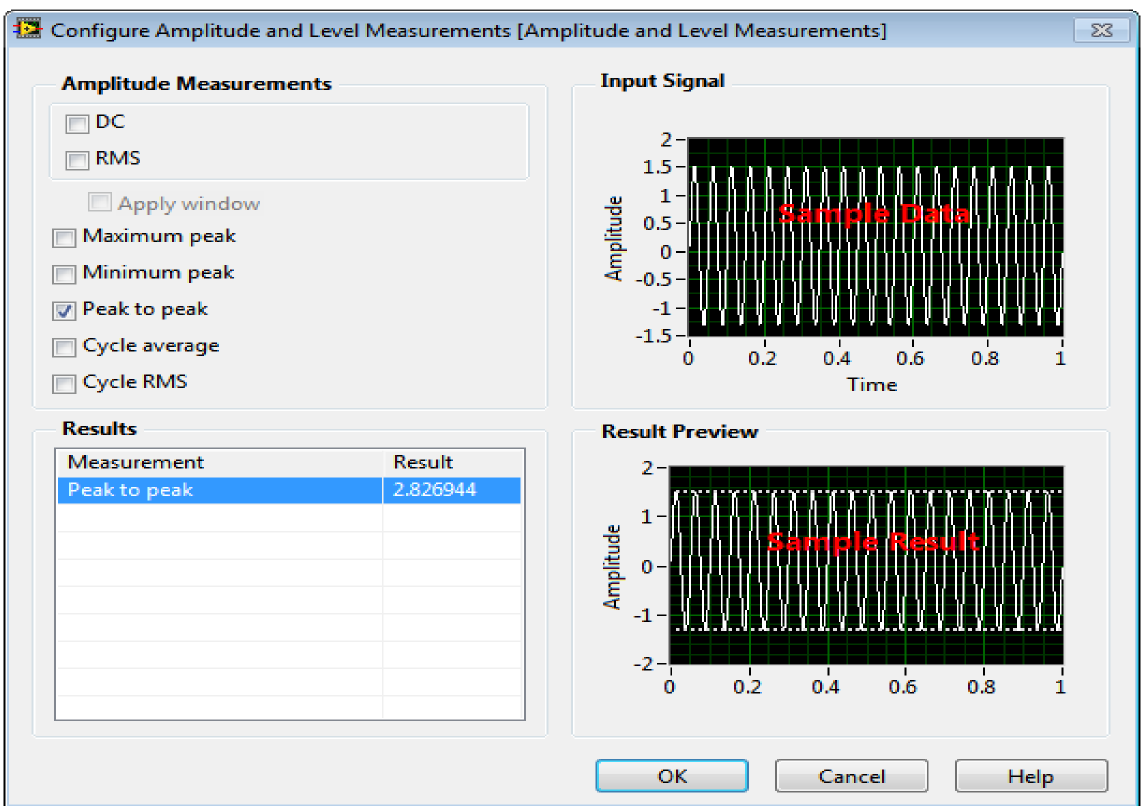


3. Click **OK**.
4. Save the VI as MyVoltageTask.vi.

Amplitude and level measurement:

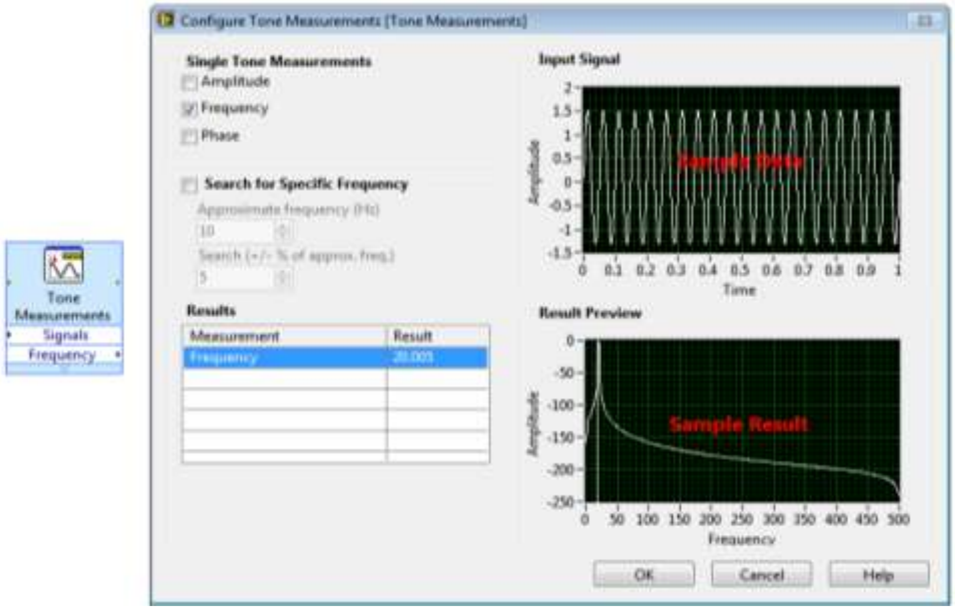
It used to measure the amplitude like peak value, RMS, DC, peak to peak values of input signal. In our lab we are using peak to peak value.





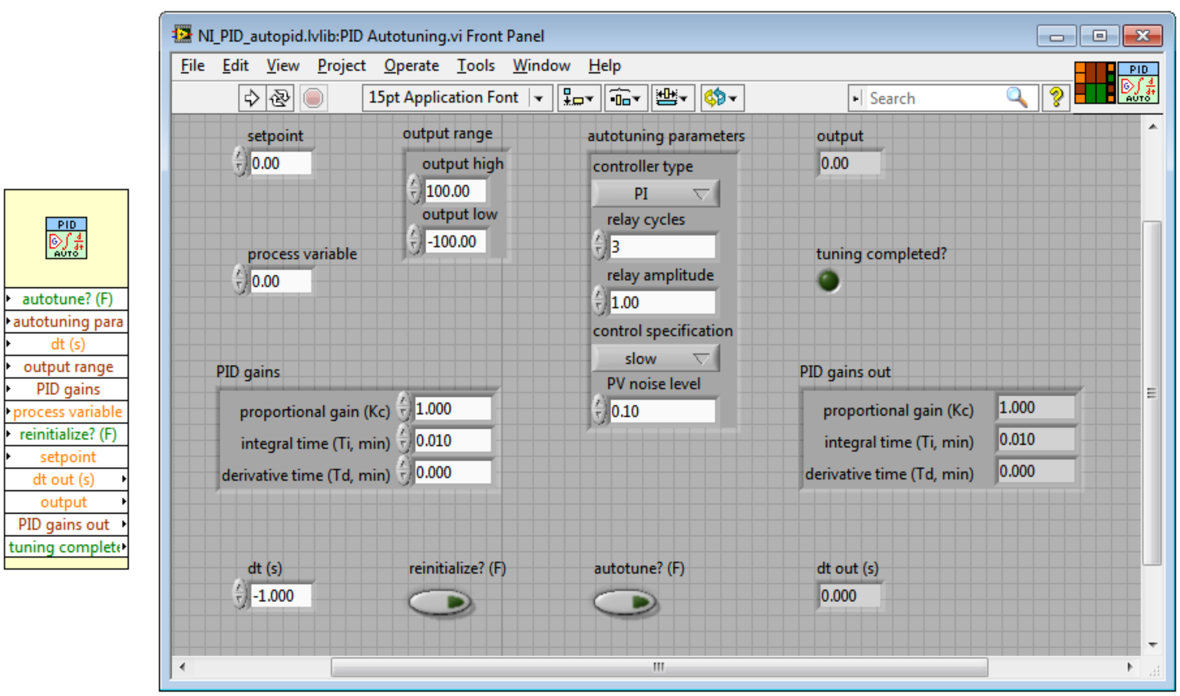
Tone Measurements:

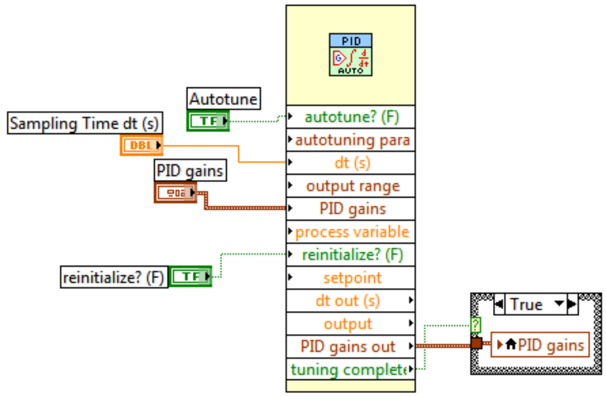
This block is used for measure amplitude, frequency and phase of input signal. In our lab we are measuring frequency of input signal.



PID Auto tuning VI

PID auto tune VI is used for setting P,I,D gains automatically.





autotuning parameters specifies various parameters used for the autotuning process. You can select these values manually in the Autotuning Wizard.

controller type specifies which parameters to return as the output of the tuning process.

0	**PID**—Specifies to return the proportional, integral, and derivative parameters.
1	**PI**—(Default) Specifies to return the proportional and integral parameters.
2	**P**—Specifies to return only the proportional parameters.

relay cycles specifies the number of setpoint relay cycles to use to determine the ultimate gain and period. More cycles result in more accurate parameter estimation; however, slower systems might require more time for numerous cycles.

relay amplitude specifies the amplitude of the setpoint relay action. The setpoint relay is between *setpoint* – *relay amplitude* and *setpoint* + *relay amplitude*.

control specification specifies the desired response performance of the PID parameters determined by the autotuning process.

0	**normal**—Specifies a normal response performance.
1	**fast**—Specifies a fast response performance. Faster response generally results in a smaller rise time.
2	**slow**—(Default) Specifies a slow response performance. Slower response generally results in less overshoot.

PV noise level specifies an estimation of the noise level of the process variable. This value is used as the hysteresis for the setpoint relay action.

output range specifies the range to which to coerce the control output. The default range is -100 to 100, which corresponds to values specified in terms of percentage of full scale. You can change this range to something that is appropriate for your control system. For example, you can relate engineering units to engineering units instead of percentage to percentage. This VI implements integrator anti-windup when the controller output is saturated at the specified minimum or maximum values.

output high specifies the maximum value of the controller output. The default is 100.

output low specifies the minimum value of the controller output. The default is -100.

setpoint specifies the setpoint value, or desired value, of the process variable being controlled.

process variable specifies the measured value of the process variable being controlled. This value is equal to the feedback value of the feedback control loop.

PID gains specifies the proportional gain, integral time, and derivative time parameters of the controller.

proportional gain (Kc) specifies the proportional gain of the controller. The default is 1. In the equation that defines the PID controller, K_c represents the proportional gain.

integral time (Ti, min) specifies the integral time in minutes. The default is 0.01.

derivative time (Td, min) specifies the derivative time in minutes. The default is 0.

dt (s) specifies the loop-cycle time, or interval in seconds, at which this VI is called. If **dt (s)** is less than or equal to zero, this VI calculates the time since it was last called using an internal timer with 1 ms resolution. If **dt (s)** must be less than 1 ms, specify the value explicitly. The default is -1.

reinitialize? specifies whether to reinitialize the internal parameters, such as the integrated error, of the controller. Set **reinitialize?** to TRUE if your application must stop and restart the control loop without restarting the entire application. The default is FALSE.

autotune? starts the autotuning procedure and invokes the Autotuning Wizard, when TRUE. Wire this input from a Boolean control with latched mechanical action and a default value of FALSE.

output returns the control output of the PID algorithm that is applied to the controlled process. If this VI receives an invalid input, **output** returns NaN.

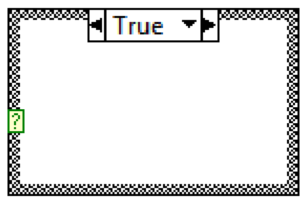
tuning completed? indicates completion of the autotuning process. You can use this output to determine when to update the **PID gains**.

PID gains out returns the updated PID gain parameters upon completion of the autotuning process. Normal output values are identical to the values in the **PID gains** input.

- **proportional gain (Kc)** returns the proportional gain of the controller.
- **integral time (Ti, min)** returns the integral time in minutes.
- **derivative time (Td, min)** returns the derivative time in minutes.

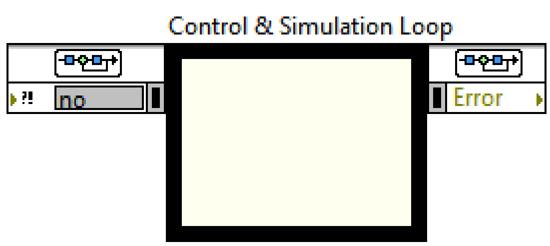
dt out (s) returns the actual time interval in seconds. **dt out (s)** returns either the value of **dt (s)** or the computed interval if you set **dt (s)** to -1.

Case Structure:



Has one or more subdiagrams, or cases, exactly one of which executes when the structure executes. The value wired to the selector terminal determines which case to execute and can be Boolean, string, integer, enumerated type, or error cluster. Right-click the structure border to add or delete cases. Use the Labeling tool to enter value(s) in the case selector label and configure the value(s) handled by each case.

Control & Simulation Loop

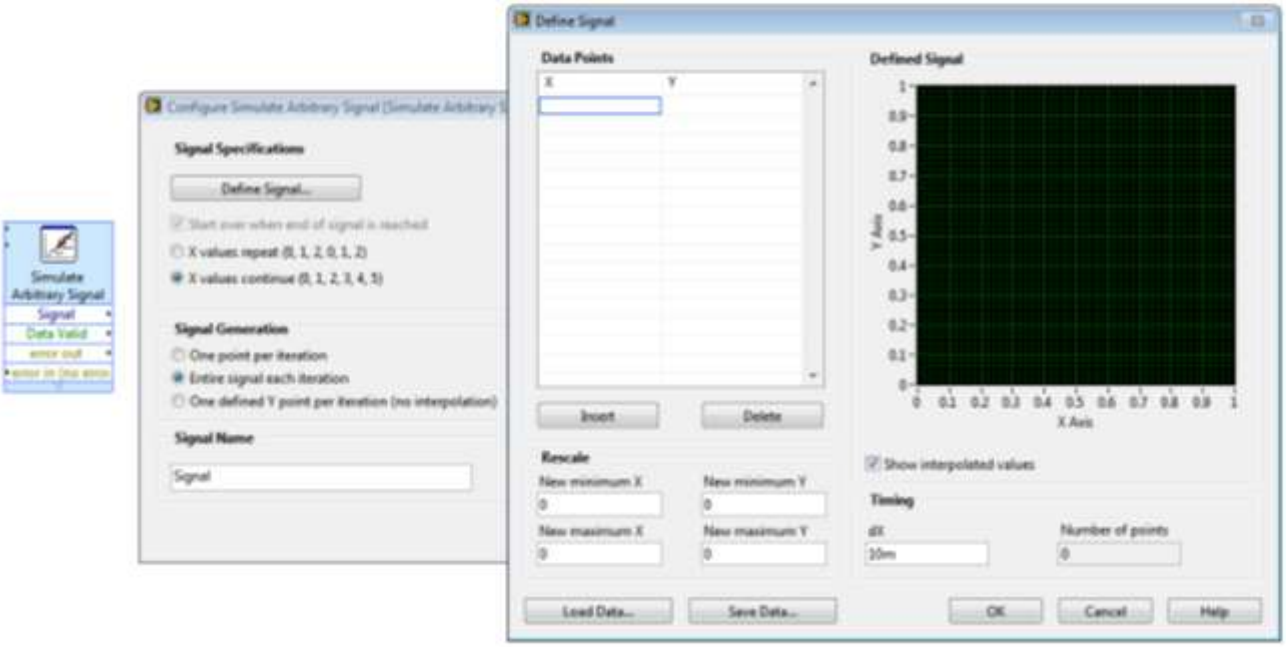


The Control & Simulation Loop has an Input Node and an Output Node. Use the Input Node to configure simulation parameters programmatically. You also can configure these parameters interactively using the Configure Simulation Parameters dialog box. Access this dialog box by double-clicking the Input Node or by right-clicking the border and selecting **Configure Simulation Parameters** from the shortcut menu.

The Control & Simulation Loop has an **Error** input on the Input Node and an **Error** output on the Output Node. These error terminals send error information through the simulation diagram. If the **Error** input detects an error, the simulation diagram returns the error information in the **Error** output and does not execute the simulation. If an error occurs while the Control & Simulation Loop is executing, the simulation stops running and returns the error information in the **Error** output.

Simulate arbitrary Signal:

It is used for generating any arbitrary signal, in our lab we are generating step, ramp, and parabolic signals. Those can be generated by giving x,y values depending on what signal we need to generate.



Write to measurement file:

It is used for writing data to LVM file, which can be opened in excel file in order to draw plots from obtained data.