Wireless Automation of Multiprocess using Labview[TM]

Multi process, Multi controlling scheme using Labview[TM]

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Abstract: Project focused about the wireless automation of multiple process Using Labview[TM]. The wireless system interface with the PC using DAQ card. According to the process varialble received through DAQ, Labview[TM] generates Controlling controlling signal based on the logic implemented in it. Multi process multi controlling scheme can be implemented so that the user can choose the controlling action as per requirements. The controlling signal is feedbacked using DAQ and transmitted back wireless to control the final control element. In this project we monitor and control tank level wirelessly using Labview[TM] and another process of simple pick and place robot using stepper motor.

I. INTRODUCTION

The experiment is conducted to create a Wireless ,Automated tank level monitoring and controlling using Labview[TM] and control of a Pick and place robot using stepper motor. Water level is measured using discrete sensors [1] and 15 sensors are arranged in the tank to obtain discrete water level. This sensed output is encoded to 4 bit for transmission. Atmel 8051 is used as microcontroller and transmitted through zigbee.The DAQ is used in the receiver side to acquire data from the receiver zigbee and microcontroller. Controlling scheme is implemented in Labview[TM] and Error signal is produced by comparing the set level and present water level
obtained through DAQ. Multipoint controlling scheme, Continuous PID controlling scheme is implemented using labview, that produce controlled output.

The feed backed signal for the tank is transmitted back through DAQ .It is transmitted back to the tank side by zigbee. In the receiver portion Digital to analog converter converted the feedback error signal to voltage output. V-I converter convert the voltage to a current of 4 20ma DC industrial standard. The output from V-I converter fed to the I-P converter that control the pneumatic valve to control the inlet flow to the tank. The system behaves like an automated level controller controlled by the Labview[TM].

In the pick and place robot arm using Labview the proximity sensor attached to the assembly line will detect the presence of an object. The triggering of electromagnet and speed and direction of robot arm is controlled by Labview[TM].

II. EXPERIMENT SETUP AND ZIGBEE

Level sensor[1] is made by switching action of transistors[2]. Taking leads from the base of transistors and fixed it in different height for the different level of the tank. The encoding action is little different than the normal one since in this type more than one transistors turn on at a time. The coding is done in Atmel 8051 and transmitted through zigbee using another microcontroller. In the pick and place robot the robot arm needs to pick the magnetic object from one assembly line to another assembly line by rotating 180^0 in clock wise or anti clock wise. The electromagnet is de energized at the destination position.
The board rate is set as 9600bps. The receiver part also set by 9600bps for synchronization of communication. Zigbee[4] communication is much safer to use in industries. The receiver receives the data only if the PAN of

sender zigbee is configured as the address of the receiver and vice versa. X- CTU software is used for such configuration.

ZigBee[4] is a low-cost, low-power, wireless mesh network standard. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory .The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range.. ZigBee operates in the industrial, scientific and medical (ISM) radio bands; 868 MHz in Europe, 915 MHz in the USA and Australia and 2.4 GHz in most jurisdictions worldwide. Data transmission rates vary from 20 kilobits/second in the 868 MHz frequency band to 250 kilobits/second in the 2.4GHz frequency band. The zigbee protocol structure is given in fig 2.1.

The ZigBee[4]network layer natively supports both star and tree typical networks, and generic mesh networks. Every network must have one coordinator device, tasked with its creation, the control of its parameters and basic maintenance. Within star networks, the coordinator must be the central node. Both trees and meshes allows the use of ZigBee routers to extend communication at the network level. ZigBee buil upon the physical layer and medium access control defined in IEEE standard 802.15.4 (2003 version) for low-rate WPANs. ZigBee nodes can sleep most of the time, average power consumption can be low, resulting in long battery life.
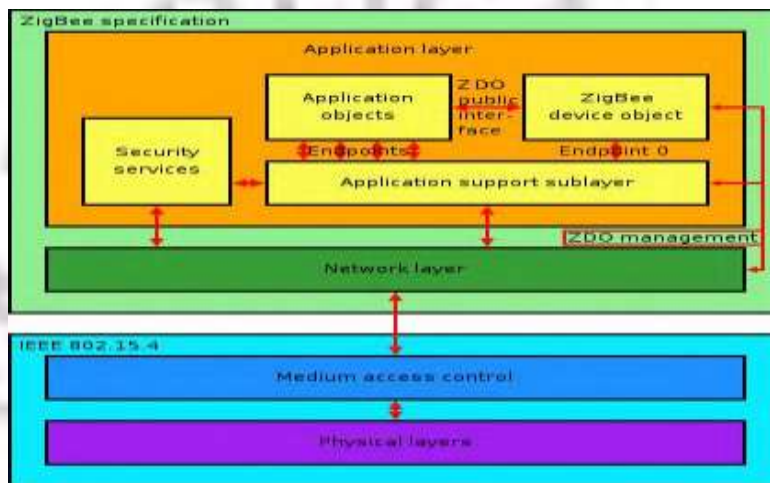

Fig 2.1: Zigbee Protocol Layer

DAQ (Data Acquisition System) is used to interface the external signals with the system in the control room. The signals from the tank side is transmitted wirelessly and received in control room interfaced with the system using DAQ. Similarly the feed backed control signal is taken out to the external world by DAQ.
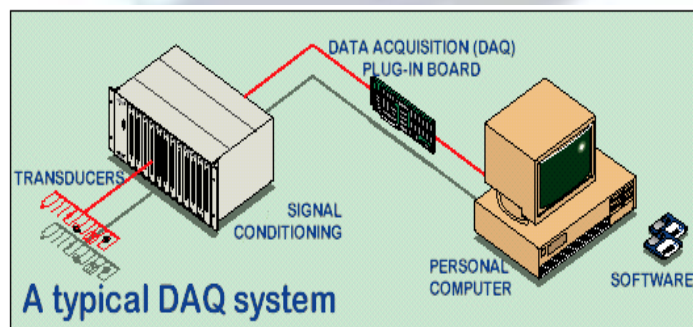

Fig 2.2: A DAQ System

The final control element is the control valve at the inlet, that controls level to maintain in the set value. The feddbacked binary control signal is processed using DAC(Digital to Analog converter),V-I converter (Voltage to Current) and I-P converter (Current to Pressure converter) before giving to the final control element. The control signal obtained is fed through a R-R ladder Digital to Analog converter. The analog voltage applied to a V-I converter to obtain a 4-20ma output which will control the I-P converter and finally the control valve.
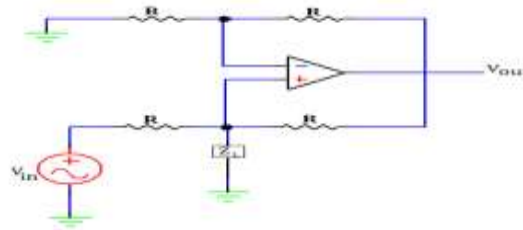
Fig 2.3: V-I converter

DAC converts the 4 bit digital signal to corresponding analog voltage from 0-5V. The V-I converter is much complex design. The V-I converter converts 0-5V analog voltage to 4- 20ma current signal which is the industrial standard. The calibration of the V-I converter needs to be accurate because a current output more than 25ma may cause high pressure output from I-P converter and this may damage the control valve which is pneumatic.

Fig 2.3, shows the circuit diagram of the V-I converter. The main concern in designing a V-I converter is that the output current need to be independent of the load resistance. The input Vin varies from 0-5V and the output current through load Z_L varies from 4-20 ma correspondingly. The arrangement is similar to a wheatstone bridge in which the Load regulation is done by the Vin and Vout.

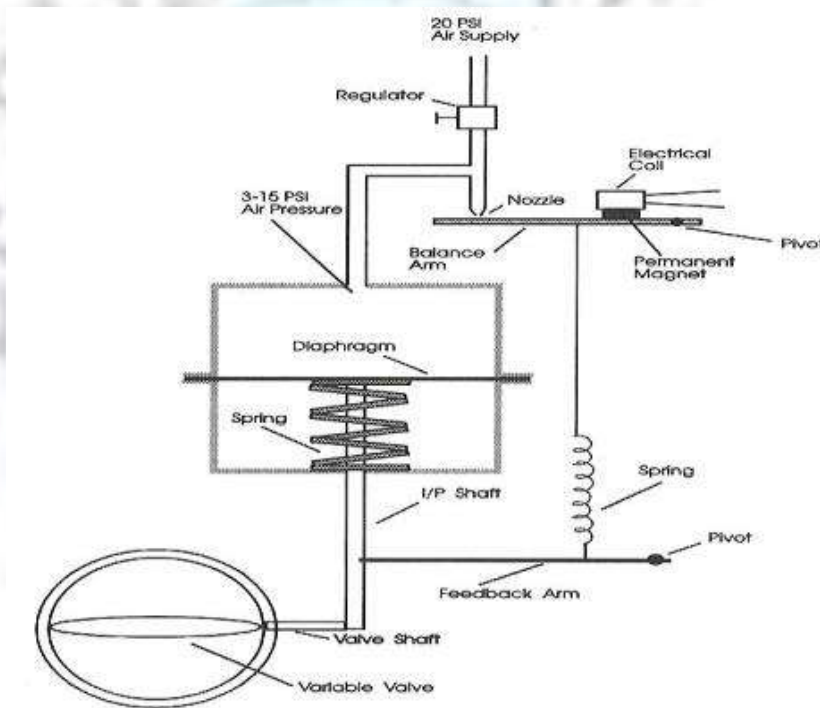**Fig 2.4: I-P converter**

III. CONTROLLING SCHEME USING LABVIEW DAQ

(Data Acquisition System) is used to interface with Labview[TM][6] software. The receiver is attached to DAQ and by DAQ to Labview[TM]. The controlling signal is fed back by the same method through DAQ. Labview[TM] is a highly productive development environment that engineers and scientists use for graphical programming and unprecedented hardware integration to rapidly design and deploy measurement and control systems[3]. Within this flexible platform, engineers scale from design to test and from small to large systems while reusing IP and refining their processes to achieve maximum performance.

In Labview[TM] there are two screens. Block diagram is the algorithm and logical implementation of the particular function. Other screen is Front Panel which is user friendly. The function can be operated by layman using the front panel even the user don't have any knowledge about the algorithm in the block diagram side.

The controlling action implemented is multi position controller. Valve is controlled from 0%-100%,using discrete control levels.0%,25%,50%,75%,100% are the discrete levels in controlling scheme. Multi position controller [3] helps to reduce the error occurring in ON-OFF controllers. The controlling scheme is implemented in IF.. ELSE.. logic. The process provide an option for the user to enter Height of the tank (H) and number of sensor used(n) is used to produce controlling action.. The controlling action can be made to user requirement and the accuracy depends the sensor performance. The continuous controller provides more precise and accurate controlling signal. In this project we use discrete sensors that reduced the flexibility of controlling action to an extent. It is possible to implement multiple controlling and tuning action for a process using wireless and Labview^{TM} interface.

Table 1: Discrete control logic

Error= Present Value-Set value	Percentage of valve closing(%)
Error>2(H/n)	100
2(H/n)>=Error>(H/n)	75
(H/n)>=Error>0	50
0>=Error> -(H/n)	25
-(H/n)>=Error>-2(H/n)	0

In the Pick and place robot arm the proximity sensor and electromagnet is attached to the arm and the purpose of the robotic arm is to pick a magnetic material from the assembly line and place it in another assembly line by rotating 180^0.The proximity sensor sense the magnetic body and transmit it to the system through zigbee. The object is picked up by the electro magnet when passing current through it. A thyristor controlled circuit maintain the current through the coil. The gate voltage of the thyristor is triggered by the feedback signal from the Labview^{TM}. The speed of assembly line need to be set in the proper level so that the arm got enough time to rotate. When the arm rotates 180^0completely remove the current through electromagnet and this will place the object in the other assembly line. The arm is rotated in the opposite direction to get back in the starting position.

IV. OBSERVATIONS

In this project two controlling scheme are implemented one using discrete controlling action and other with continuous PID controller[3]. There is two windows for Labview$^{TM[6]}$ Front panel and block diagram. In fig 4.1 the front panel for discrete level controller is given. Error signal is produced by comparing the present level and setpoint obtained wirelessly. The controlling action required is produced by comparing the Error Output .According to the controlling action DAC(Digital to analog converter),V-I converter convert the digital control signal to current level. I-P converter used to control the control valve and maintain Level according to the error.

The front panel provides the facility to enter the tank height and set point by user. For different Tank we are sending the same digital signal from 0000 to1111.Thre provision to enter the Tank Height by user make the system flexible to use different tanks .For eg:The digital signal 0010 is the signal transmitted from a tank of Height 45 cm then Labview find out the present Height from thr received signal by multiplying the decimal value of each data with (Height of Tank/Number of sensors).Fig 4.2 is The block diagram of the discrete controller that uses many comparators to find out the controlled output and LED's are used to represent digital output from the controller as in Fig:4.1.
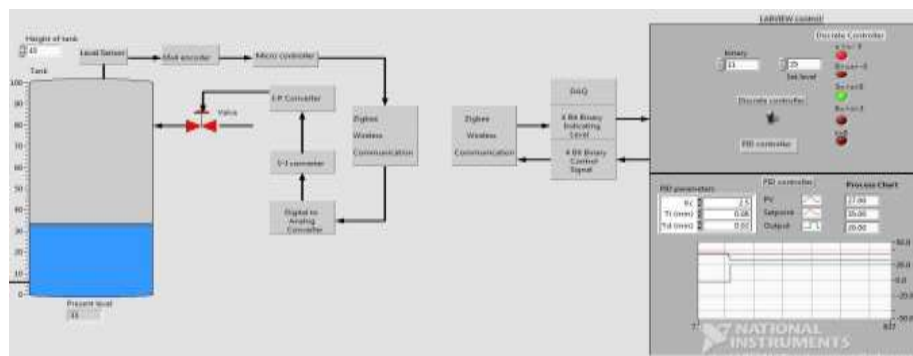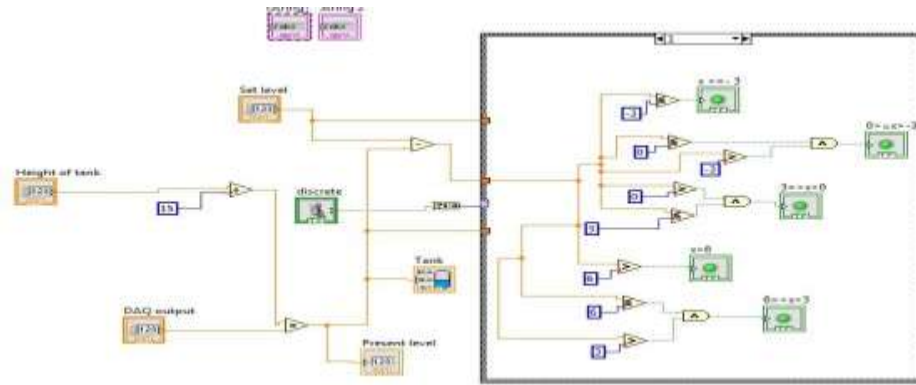

Fig 4.1: Front panel

Fig 4.2: Block diagram of discrete controller

The discrete and PID switch can be set by the user according to his wishes. In the discrete controller the controlling action is given as per the table which is already given .The DAQ output is the decimal value of the binary signal that transmitted from the process side. Here in the figure it is 11 and the present level is obtained by (Height of the tank/ no of leads) x DAQ output, ie 33 as shown in the tank in Fig 4.1.The present value of level is compared with the set level and according to error signal the controller output is produced. The output of controller is transmitted back using DAQ and final control element is controlled using the feed backed value. In this eg. only 5 discrete output level so the feedback signal is also 5 in number which produce only discrete control of control valve ie 0,25,50,75,100 % of valve action only. Thus the discrete controller produces its controlling action.
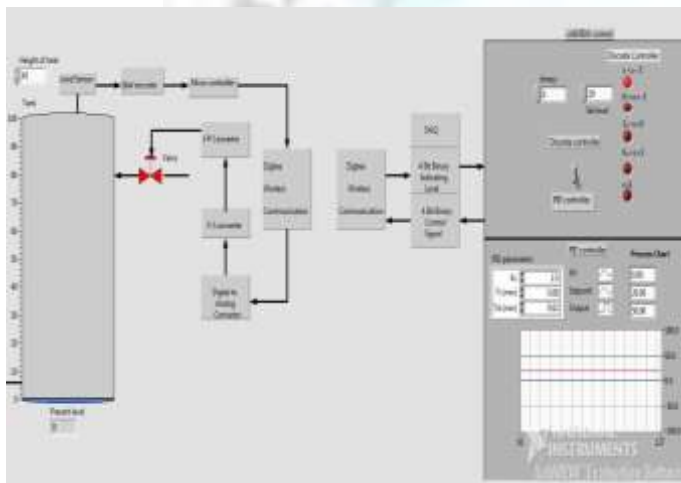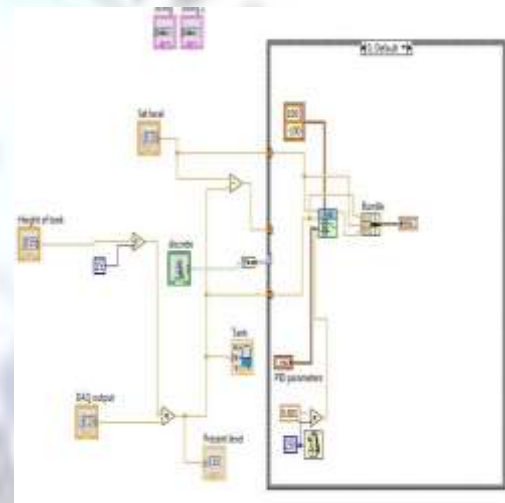

Fig 4.3: Front panel   **Fig 4.4: Block diagram of PID controller**

In the PID controlling scheme the manual switch changed to PID controller and this stops the discrete controlling action. The PID parameters ate obtained after calculating the transfer function of the process using Simulink Or open loop tunning in Labview[TM] is sufficient to provide the PID parameters[3].Kc is the proportional gain and Ti,Td indicate the Integral and Differential time respectively. In Fig4.3 by observing the graph the present value is 0 and set level is 20 so the output is positive and maximum 50.
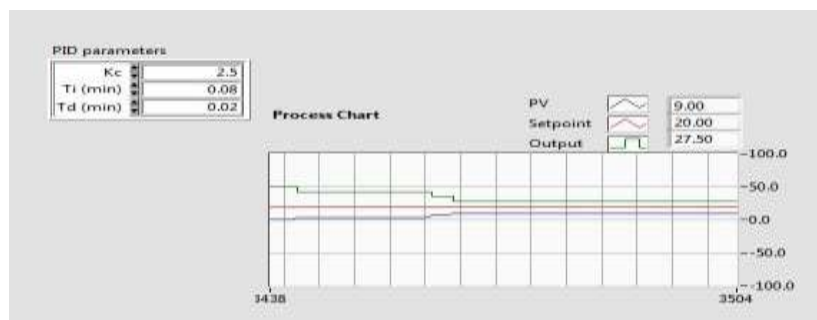

Fig 4.5: Output graph-output is positive

In the Fig 4.5 when comparing with Fig 6,the present level is increased from 0 to 9 and the controller output decreased from 50 to 27.50 as shown in Fig 4.5.This indicates when present level increases we need to close the fully opened inlet control valve (ie output is maximum) gradually which produce a continuous control action. The control valve is maintained at 50% when error is zero. When error is negative we need to open the valve and when error is positive the valve should be closed gradually. The 4-20 ma current is converted to 3-15psi to control the pneumatic valve which is air to open type.50% open refer to 12ma current which is produced V-I converter and the voltage input at the Tank side is the feedbacked controller output.

In the Fig:4.3 the present level is zero ie, error is negative maximum or output is positive maximum so this feedbacked a binary value of 1111 and which is converted to analog by DAC(Digital to Analog converter) at the receiver. V-I produce maximum output 20ma and I-P (current to pressure converter) produce 15 psi which open the air to open valve from 50% to 100% initially.

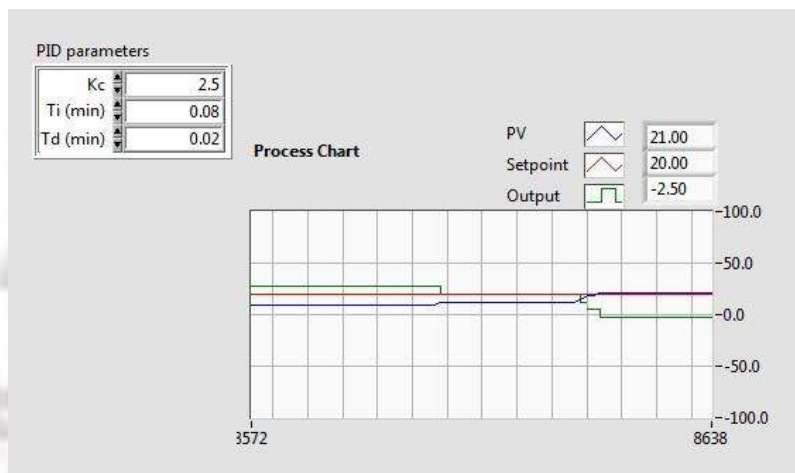When present level increased the controller output decreases and valve closes gradually.

Fig 4.6: Output graph-Output is zero

Fig 4.6 shows the decrease of output to zero when the present level and set level are same. This transmitted back a binary of 0111 which corresponding to 12ma ie 50% valve opening in the tank side. The level is maintained now. The outlet control valve of tank is connected to the process or the varying load. If the process needs small amount of water i.e. load is small, this causing an increase of water level. Now the error is positive and valve need to be closed from the 50% position to lower values so as to maintain the level according to load.
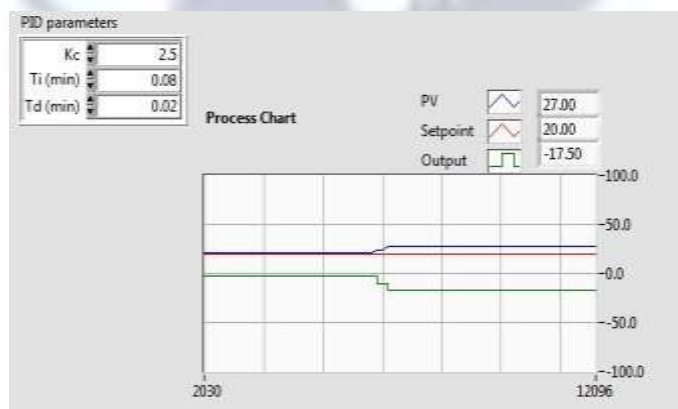

Fig 4.7 : Output graph –Output is negative

In Fig 4.7 the output is negative due to decreased load. So the control valve needs to be closed from 50% to a value lesser than it according to the transmitted signal from 0001 to 0111. Since we use 4 bit transmission 16 positions of valve control is possible from 0%-100%.This can be further increased to a pure continuous controller if the number of bits of the transmitted back signal is increased. Fig 4.8 shows the controller action which again maintain the process level to the setlevel after the load variation.
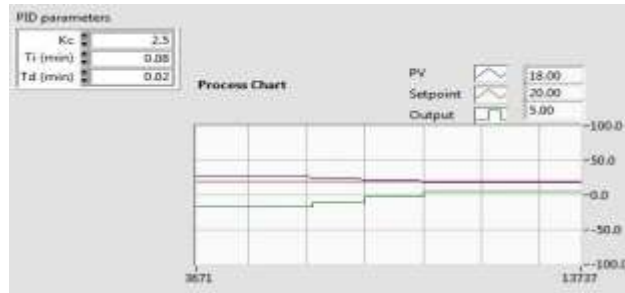
Fig : 4.8 Output graph: Load variation compensated

In the Pick and place robot the stepper motor[5] is controlled by the Labview[TM]. When the proximity sensor attached to the arm detect the presence of the magnetic body in the assembly line with in a distance, the sensor output is transmitted to the control room and the electromagnet is turned ON by the Labview[TM]. The Labview[TM] also give the electrical pulses for the stepper motor with stepangle 7.50.Total of 24 steps complete 180^0 rotation. The electromagnet is reenergized by the Labview[TM] after 24 stepangles[5].
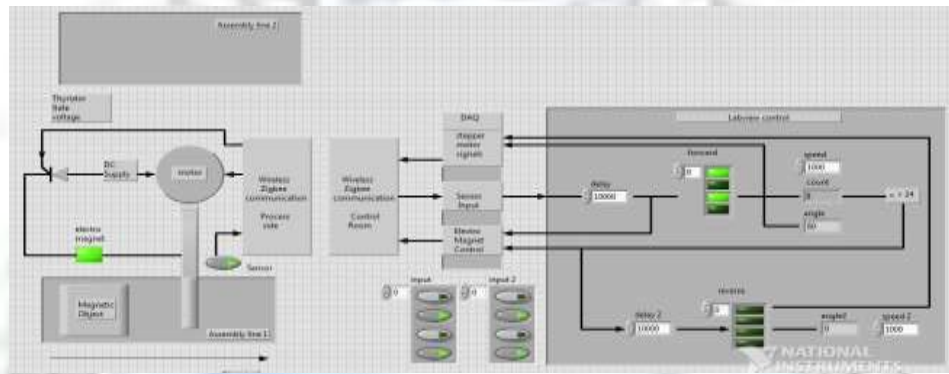

Fig : 4.9 Front panel of the robot arm control

In the Fig 4.9, the proximity sensor output is high and the electromagnet is turned on. The speed and delay of the loop need to be adjusted with the speed of assembly line so that the robot arm rotate only after the trigger obtained to the electromagnet from the control room. The electromagnet is turned on until the angle reaches 180^0.The input pulses are for the stepper motor control each shift in the pulse produces corresponding step angle the shift in the input pulse is visible in the forward LEDs. Delay of 10000ms makes the arm to wait for the time so that electromagnet needs to get back the trigger from the control room with in that time. The stepangle is the angle rotated by the motor in a single trigger. In this project we are using motor with stepangle 7.5^o.In Fig 12 total of 8 such triggering occurred make the stepper motor to move angle 60°
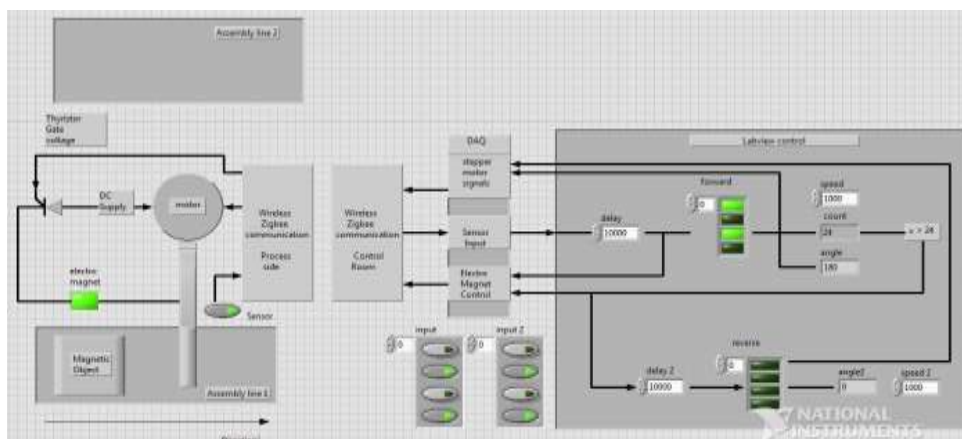

Fig 4.10: Front panel of the robot arm control

In the Fig 4.10, when the angle of rotation reaches 180^0, the electromagnet is turned off by the Labview^{TM} through DAQ. The signal feedbacked from the Labview^{TM} is transmitted back to the arm using Zigbee. The electrical pulses are also transmitted from Labview^{TM} to the arm side by zigbee and DAQ.
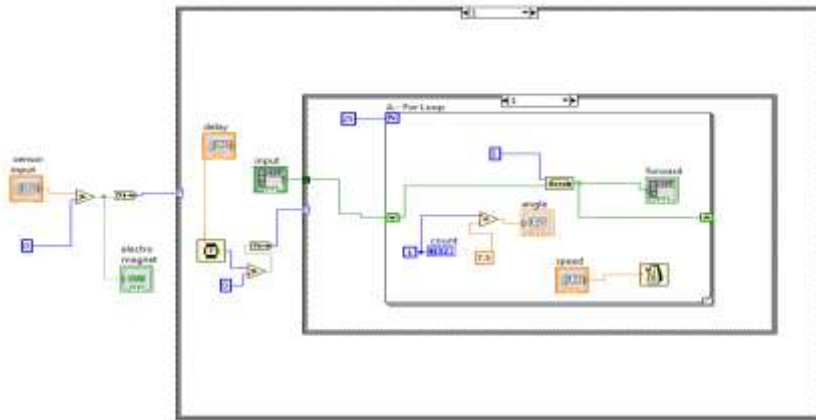

Fig 4.11: The block diagram of the robot arm

In Fig 4.11, The sensor is replaced by the DAQ assistant when connected to a DAQ installed system. The sensor value which is obtained by the proximity sensor in the arm is compared and check whether it is true or false state. Labview^{TM} collect the sensor value through DAQ and send back the signal to turn on the electro magnet through DAQ again. If the sensor value is true then the stepper motor needs to rotate in the forward direction after the delay. The loop is created in Case structure. Forloop is used for looping and the count of 25 is given so the loop terminates after 24 looping. The forward LEDs replaced by the DAQ assistant when connected to DAQ enabled system and the pulses are transmitted to the stepper motor side by zigbee.
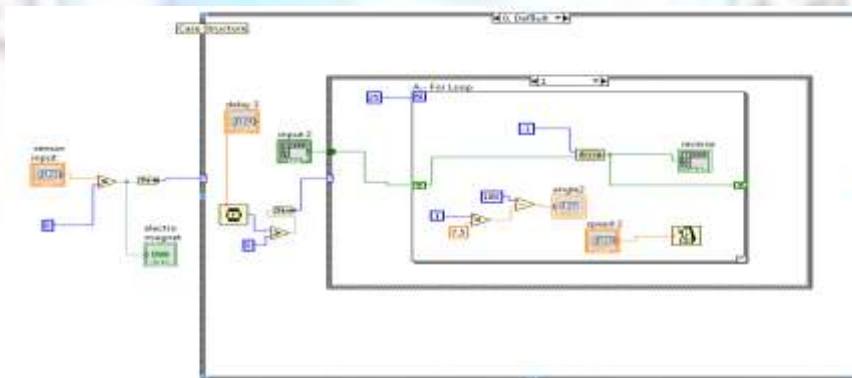

Fig 4.12: Block diagram of robot arm reverse rotation

In Fig 4.12, When the arm reaches the destination after rotating 180^0, We need to bring back the arm to the starting position by rotating in the reverse direction. The status of the electromagnet at this time is OFF. The arm rotates in the reverse direction and the angle reduces from 180^0 to 0^0. The angle reaches 0^0 means the initial position of the arm and the process is repeated for another body. Thus the Multi process system with a process of level control and Pick and place process is implemented with multi controlling scheme. The level controller can be worked in discrete and continuous PID mode.

V . FUTURE SCOPE

The future scope of this project is the fully automated inexpensive method for the industries. The zigbee module can be multiplexed to use TDMA technology and can transmit different controlling signal using the single zigbee itself which will reduce the cost again. Industrial data transmission needs to be secured and safe which is possible using zigbee. Multiple controllers for a single process gave user to choose the exact controlling action needed and maximum efficiency.

Data Acquisition system is costly but when compared with the cost and difficulties of other wired system the wireless method using Labview^{TM} is much safer and inexpensive. Cloud computing is the new technology which can be incorporated with this system so that It will not require to install Licensed version of the software in all computer, Instead different systems in affirm can login to an online platform(cloud) and can use the same software.

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