FUZZY OBSERVER BASED FLOW CONTROL OF INDUCTION MOTOR PUMP

A.Ruban, R.Senthil kumar, M.Vijayaprabakaran, and C.Kamalahasan
Final year EEE, Saranathan College of Engineering, Venkateswara Nagar, Tiruchirapalli-620012
ruban4647@gmail.com,senthilrajvel912013@gmail.com

Abstract—This work proposes to develop a novel power control unit (PCU) using Texas Instruments microcontroller TMS320F28027 for a fuzzy observer based flow controller of a pump. The proposed fuzzy observer based control unit is very much essential and finds application where the motor shaft is not accessible as in case of a liquid transfer pump. Flow of liquid like transmission of petroleum products and water over a long distance could be controlled by using the closed loop v/f control method based on fuzzy observer approach. This type of electrical flow control provides better energy conservation with smooth control of liquid flow. The unique feature of the proposed PCU doesn't uses any speed sensor for sensing the speed of the pump and hence the flow. Also the proposed PCU founds application for speed control of induction motor where the speed sensing is not feasible by either a contact or a non-contact type speed sensor. The power circuit of the PCU includes a three phase inverter and three phase induction motor, while the control circuit includes a C2000 launch-pad, DAP signal conditioning board, Hall effect Voltage and current sensors and 430BOOST-SHARP96 - Sharp Memory LCD Booster Pack for display of parameters. The proposed PCU will be validated using a 5 kW water pumping station present in the institution.

Keywords— fuzzy observer, v/f control. Pump.

1. INTRODUCTION

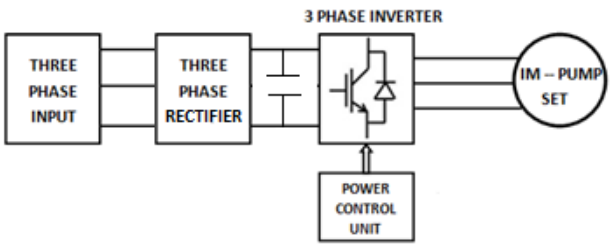
The analysis is made considering the different ratings of VFD used, applications, price and features of the products. It is observed from the analysis, most of the flow controller uses a open loop VFD drive, where speed sensing is not possible and hence the dynamic performance is compromised. The proposed PCU overcomes this issue and intend to provide a closed loop control and enhanced dynamic performance without sensing speed.VFD drives combined with fuzzy logic provide closed loop control of induction motor pump. Fuzzy logic used where ever a system cannot modeled by mathematical analysis.FLC based on fuzzy logic provides a means of converting a linguistic control strategy based on expert knowledge into an automatic control strategy .Using TMS320F28027 the expected pulse can be given to the inverter.

1.1.1Technical Background

The fuzzy logic Controllers are basically put to use when the system is highly non-linear thereby, making the mathematical modeling of the system very arduous. The analytical form of the system is not provided, instead a linguistic form is provided. The precise identification of the system parameters is needed. The system behavior has a vague characteristic under precisely defined conditions. The conditions themselves are vague. The Fuzzy Logic Controller used in this simulation has some drawbacks along with is advantages. But these disadvantages, viz. (i) achievement of only near to exact reference speed. After change in reference speed and (ii) high rise time, can be reduced by refining the membership functions. In this simulation we have taken hybrid of trapezoidal and triangular membership functions for the inputs and triangular membership functions for the output. We can choose Gaussian membership functions for refining the control. Also the membership functions near the zero region can be made narrower and those towards the outside can be made comparatively wider. The tuning of the control will be taken up as the next step for the project. The modified design of the Fuzzy Logic Controller was found to have a decent performance. The steady state error was found to be zero. Whenever the induction machine was loaded the speed of the machine fell, but only to a very little extent. The rise time and the settling time of the system were not affected much, but the peak overshoot of the system was found to have reduced as compared to the earlier design. Hence, this controller can now be used in other applications. But now the system has to be optimized so as to achieve an optimum value for the rise time, settling time and peak overshoot.

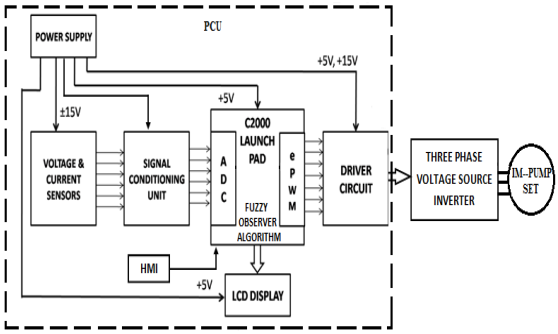
1.1 PROPOSED SOLUTION

Power circuit



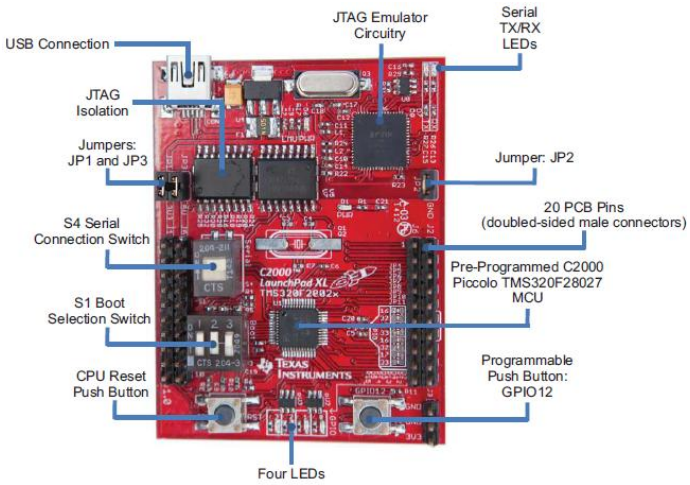
In this block diagram explains power circuit to the inverter. Here three phase input is given to the three phase rectifier. in order to filter the harmonics ,the coupling capacitor is added between rectifier and three phase inverter. Rectifier converts AC input into DC output. This DC source input given to the inverter. Six gate pulse given to the inverter gate terminal from power control unit.

Power Control Unit



This block diagram includes LV25-P voltage sensor and LA25-P current sensor, signal conditioning unit, C2000 launch-pad microcontroller driver circuit, LCD display, three phase inverter. In this, actual speed is measured from combination of sensors ,signal conditioning unit and microcontroller Voltage and current measured by sensors .The measured voltage and current is given to the signal conditioning unit .signal conditioning unit is used for range matching, amplification and used to clamping and clipping .controller input should be positive values, so signal conditioning unit gives positive amplitude of voltage and current to microcontroller. Micro controller having four important sections used. That includes ADC, e-pwm signal, HMI, LCD display. The analog voltage and current value is given to the microcontroller. In this ADC will convert analog values into digital.LCD display used to display the digital values. Voltage sensor- Closed loop (compensated) voltage transducer using the Hall effect ·Insulated plastic case recognized according to UL 94-V0.low thermal drift, high bandwidth, high immunity to external interference. it having galvanic isolation between primary circuit(high voltage)and secondary circuit(electronic circuit).This voltage sensor used to measure up to 600V.current sensor-low temperature drift, optimized response time, current overload capability. This current sensor using the Hall Effect principle and measure up to 25A.signal conditioning unit-In this unit, gain magnitude is set by first two pot and required output adjusted by another two pot. this pots used for clipping and clamping operation.10V supply is given to signal conditioning unit. The input of signal conditioning unit is ac supply. This unit is used to clamp the input to positive values. the maximum value of output is 3.3V.The output of sensors is given to the signal conditioning unit. The output of signal conditioning unit is given to microcontroller. In microcontroller contains ADC section. Enhancement PWM is one of SOC to start the ADC conversion. Actual speed can be estimated by actual voltage and current values. for implementing the fuzzy algorithm, we need a corresponding information from the pump. The linguistic form of speed data of pump configured from expert knowledge .the various speed corresponding to a Voltage and current values tabulated from the experiment. From the tabulated values the expression of speed is derived with a values of voltage and current values. from the professional curve fitting software expression of the speed is derived from voltage and current values.

1.2 MICROCONTROLLER*:*



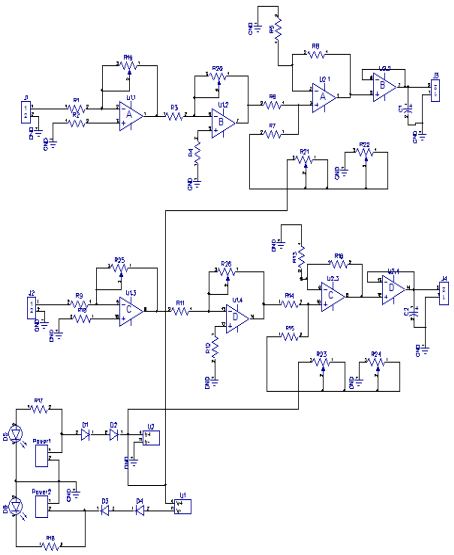
Launchxl-f280x microcontroller used for analog to digital conversion in the fuzzy observer concept. The speed can be displayed using analog to digital conversion. The corresponding rms Voltage and rms current noted. From the current and Voltage sensor data fed to the microcontroller. so microcontroller is very much needed for this specific application.

2. IMPLEMENTATION

2.1 Hardware Implementation

Signal conditioning unit: its implemented using lm324 Ics .This signal conditioning unit having two channel input and output. one channel used for voltage sensor and another channel used for current sensor. first two amplifier used to adjust the gain magnitude and another two amplifier used for clipping and clamping action take place, DC compensating voltage given to the amplifier. pots used to adjust the gain magnitude and output voltage .

2.2 Schematic for SCB:



Voltage sensor: LV25-P voltage sensor used to sense up to 600V.voltage is measured between measuring point. Conversion ratio is 2500:1000.voltage between 100ohm resistors measured. Current sensor: LA25-p current sensor used to sense up to 25A.current is measured.

3. SOFTWARE IMPLEMENTATION

3.1 Professional curve fitting software:

The experiment is conducted in a 5kw, 3phase induction motor. The motor is loaded continuously; the RMS value of current is noted. The corresponding voltage and speed is noted. Using the professional curve fitting software these values are tabulated. From this the speed in terms of voltage and current expression is obtained. The expression is,

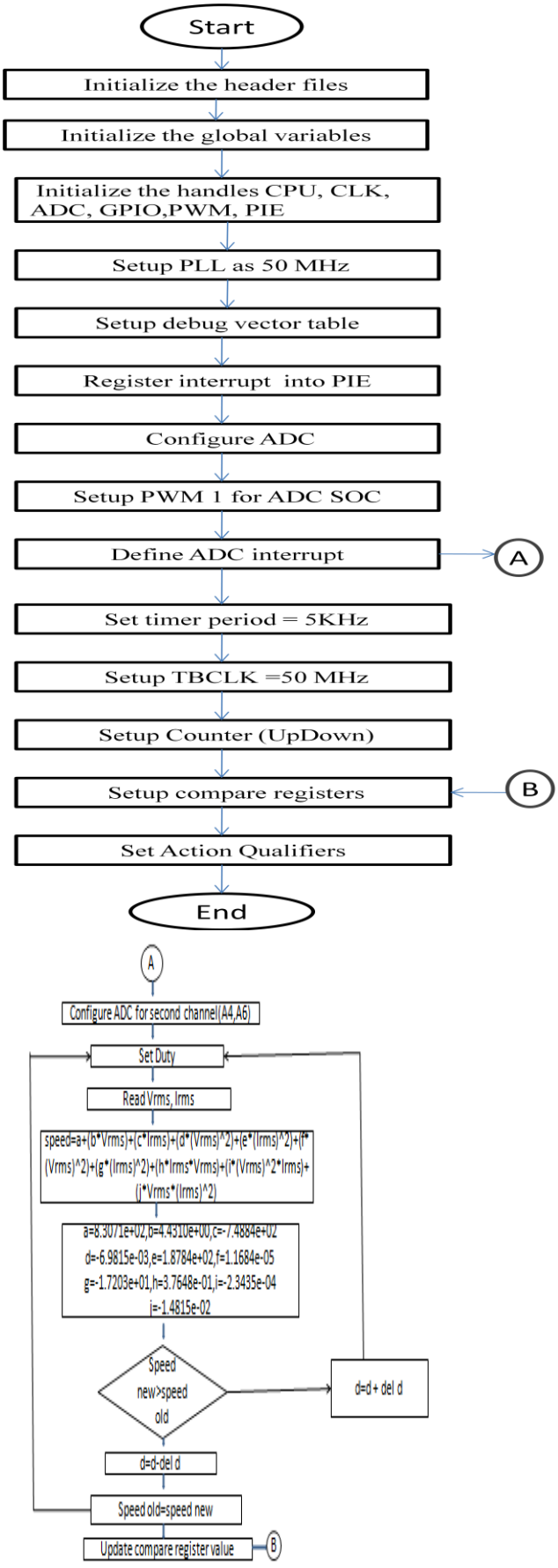
$Y=a+bx_1+cx_2+dx_12+cx_2^2+fx_1^2+gx_2^2+hx_1x_2+ix_1^2x_2+jx_1x_2^2$

Y-speed, x_1-rms voltage, x_2-rms current. Here,
a=8.3071e+02, b=4.4310e+00, c=-7.4884e+02,
d=-6.9815e-03, e=1.8784e+02, f=1.1684e-05,
g=-1.7203e+01, h=3.7648e-01, i=-2.3435e-04,
j=-1.4815e-02

3.1 Code composer studio 5.5

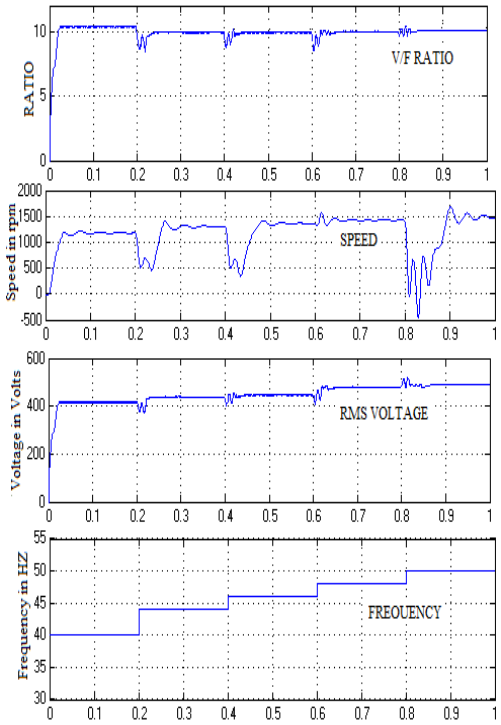
This software is used to display the speed using the Vrms and Irms values.TMS28027 microcontroller used. This is very much used for analyzing the data. From this software we write a coding. In this coding Vrms and Irms for the motor values converted into digital form by using ADC in the microcontroller. By using this Vrms,Irms values corresponding speed is obtained by using the speed expression into that.

4. FLOW CHART FOR ADC

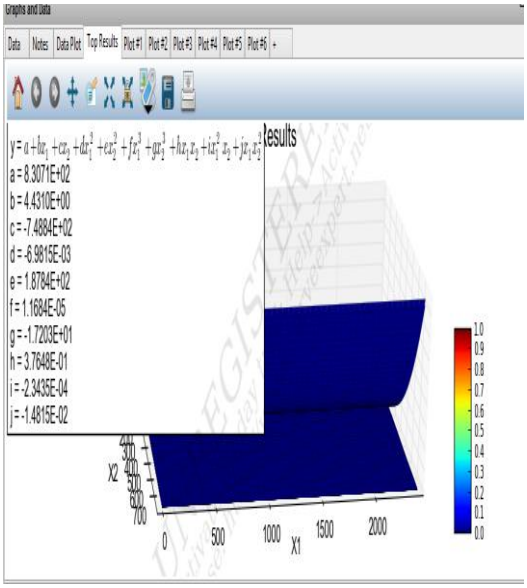


4. RESULTS

In this fuzzy observer based flow controller, it is observed that speed of the induction motor pump mostly equal to the actual speed. The speed changed relatively change in the Voltage and Current.

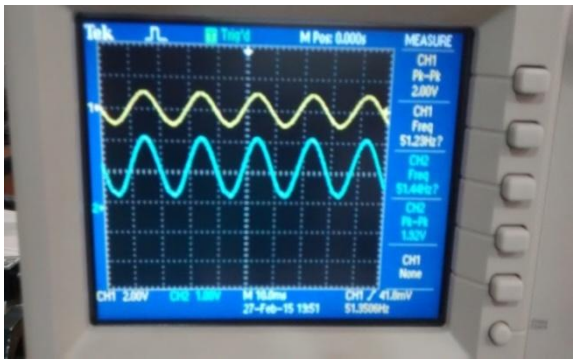


Curve fitting software output graph:



Signal conditioning output:

In this signal conditioning unit up to 2.45V output is pure sinusoidal and positive peak. Above that input voltage output is clipped.



5. CONCLUSIONS

The proposed project develop a low cost IM-Pump set using 1.Fuzzy observer based closed loop v/f control (enhance the dynamic response) 2.The problems associated with the speed sensing is overcome by using the fuzzy observer (without contact or non contact type sensors).The PCU for the proposed system constructed using the low cost TMS320F28027 processor. The prototype once developed has a clear potential for getting converted to a product with all the features mentioned above. A well defined methodology adopted for development cycle that will ensure a prototype confirming to its performance specification.

REFERENCES

[1] Jamoussi K et al," Robust fuzzy sliding mode observer for sensor less field oriented control of induction motor". 6th International Multi-Conference on Systems Signals and Devices, 2009. SSD '09, 23-26 March 2009,pp.1-7.

[2] Benharir, N.; Zerikat, M et al,"Design and Analysis of a New Fuzzy Sliding Mode Observer for Speed Sensorless Control of Induction Motor Drive". International Review of Electrical Engineering;Sep/Oct2012, Vol. 7 Issue 5, p5557

[3] Xiao-Jun Ma et al,"Analysis And Design Of Fuzzy Controller And Fuzzy Observer" . IEEE Transactions on Fuzzy Systems ,Vol:6 , Issue: 1,Feb 1998,pp.41-51.

[4] Yimin Li,"Indirect adaptive fuzzy observer and controller design based on interval type-2 T–S fuzzy model", Applied Mathematical Modelling,vol.36.issue:4, April 2012, PP 1558–1569

[5] Oudghiri M," Lateral vehicle velocity estimation using fuzzy sliding mode observer". Mediterranean Conference on Control & Automation, 2007. MED '07, 27-29 June 2007,pp.1-6

[6] Xiaogang Feng et al,"Fuzzy-controlled DC drive system with load observer". 4th International Workshop on Advanced Motion Control, 1996 18-21 Mar 1996,pp354-358.