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Sensor less control of FC302 Automation drive using dSPACE

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Abstract: *This paper refers to speed control of the DANFOSS FC-302 Converter Fed Three phase Induction Motor in different modes like through Local Control Panel (LCP), through manual control and through dSPACE. In LCP method, the required speed is achieved by Voltage Vector Control (VVC+) technique. In manual control Mode, the speed control of the Motor is done by varying the the resistance across the control voltage.*

In dSPACE control Method, speed is controlled by Sinusoidal PWM control technique. This control technique allows us to control the speed of the motor without using shaft sensor. The speed can be calculated from the stator voltage and currents. For Real time implementation of Speed control using Sine PWM technique, FC-302 is connected with the dSPACE DS1104 board through the interfacing cards like Interface and Protection Card (IPC3), IPC2dSPACE. The Implementation is done on a 2.2 kW induction motor using dSPACE DS1104 and MATLAB/Simulink.

Key words: *variable frequency drives ,MATLAB/dSPACE; sensor less control ,Induction Motor*

1. Introduction

Since, the AC drives is having more advantages compared to DC drives. In the past it is very difficult to use AC drives but present researches in power electronics developed in such a way that speed control is made very easy .There are so many methods to control the speed of AC motors, here we are implementing V/F control method. The main advantage of V/F control is, the stator flux constant which is necessary condition for below base speeds. Sometimes, it is also called scalar control.

FC-302 refers to frequency converter 302 and it is developed by DANFOSS company. In the frequency converter firstly three phase supply is given to the three phase diode bridge rectifier set and this set converts to DC. later DC link will be present where the voltage across this must be constant. To make it constant, FC series is having brake resistor set. Next it is connected to a voltage source inverter which is having IGBT's as switches. Switch Mode Power Supply (SMPS) drives the IGBT's in the inverter.10V and 24V DC supply is given to the SMPS.

By generating switching pulses using sinusoidal pulse width modulation with MATLAB simulink and building the model in DSPACE 1104, we can get switching pulses to the real time world. We can get the pulses through slave DSP in RTI 1104. The Slave DSP is connected to the IPC2DSPACE interface card. Through optical fiber cable we can connect IPC3 and IPC2DSPACE. The J5 connector of IPC3 is connected to the DANFOSS FC-302 through a 44 pin male connector. So by varying offset in the DSPACE, we can control the width of the pulse which in-turn controls the speed of the motor. Digitalization can be implemented by using this method.

2. Block Diagram

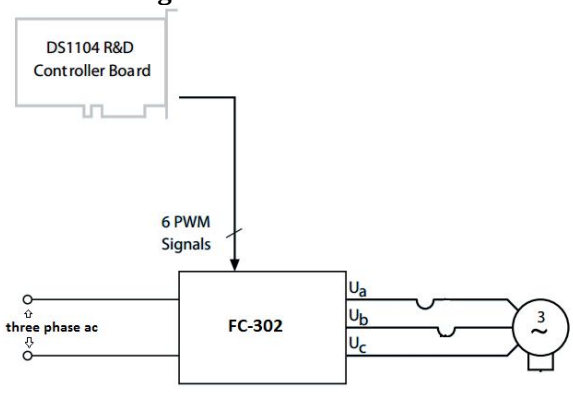

Fig. 1. Block Diagram

The internal architecture of the FC-302 can be shown in the following diagram.

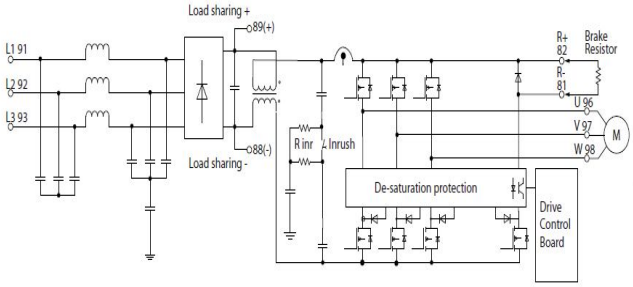

Fig. 2.Internal Architecture of FC-302

The name plate details of the motor using are:

Table 1

RATED	VALUE
Voltage	400V(delta connected)
Power	2.20Kw
Frequency	50 Hz
Current	5.3A
Speed	1420 RPM

3. Motor Control Principle

The control principle used to drive switches in voltage source inverter is Voltage Vector Control Plus (VVC+).This control method is used for the system with open loop configuration (without feedback taking from the sensor). VVC+ will improve the stability when the system with constant load application.

The VVC+ can be implemented into modes.

1) Stator Flux Asynchronous Vector Modulation (SFAVM).

2) 60 Asynchronous vector Modulation (60AVM)

1) SFAVM: This method is used for low speed applications. It will give better stability for low speed. The maximum 87% of the output voltage we can get for a given input voltage.

2)60AVM: This method is suitable for high speed applications. By using this method efficiency will improve at rated output. In this method every switch is in on for 60 deg and in off for 60 deg. So for 120 deg no switching is going to present. Hence switching losses is reduced. This switching pattern will allow the system to apply rated voltage.

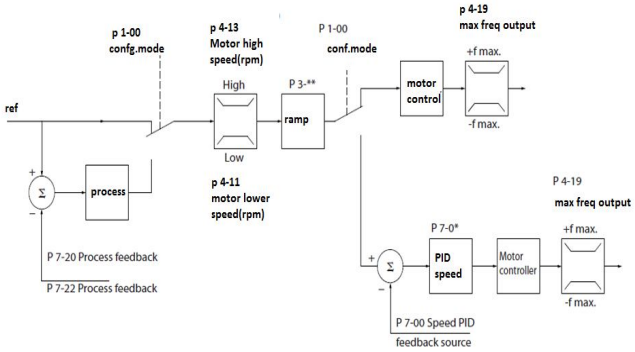

Fig.3. Control structure for VVC+

4. Speed Control Modes in FC-302

I) Control through Local Control Panel (LCP).

ii) Control through potentiometer.

iii) Control through dSpace.

The snapshot of the complete setup is given below.

Fig 4 .FC-302 set up

I) Control through LCP:

By switching LCP into hand on mode and by giving Required speed in the LCP with arrows.

Fig.5 Local control panel

ii) Control through potentiometer

By switching the LCP into auto on mode and by connecting the potentiometer at 53, 55 of 1 kohm .By varying the potentiometer we can control the speed of the motor.

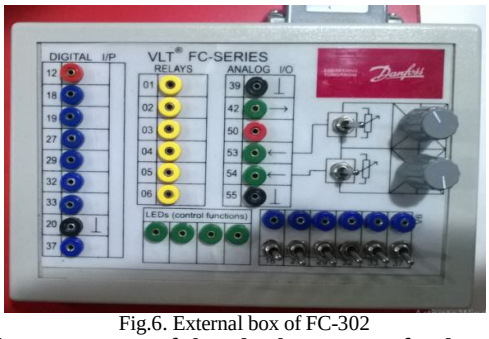

Fig.6. External box of FC-302

The characteristics of the plot between ref voltage and speed are linear. These characteristics are shown in the below figure.

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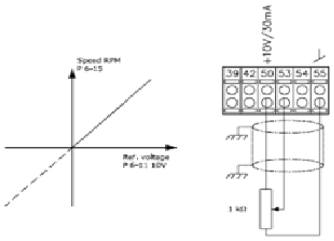

Fig.7. Characteristics for POT mode

The results for potentiometer mode are given below:

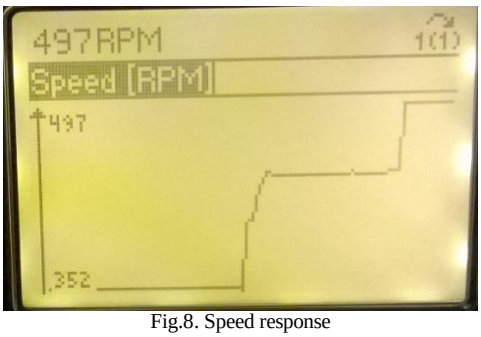

Fig.8. Speed response

Fig.9. Frequency response

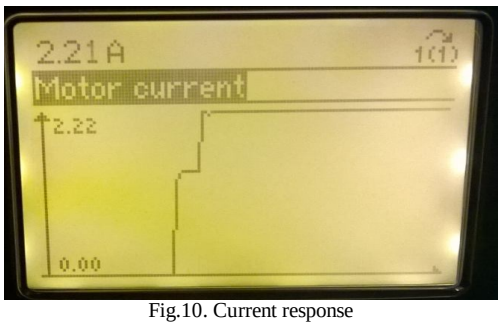

Fig.10. Current response

5. Introduction to dSPACE

DSPACE DS1104 provides access to implement your control models in Real - time hardware. The rti blocks in the dSpace are designed in such a way that to specify the real time applications. In DS 1104, the units are ADC, DAC, BIT I/O, INC, Serial Interface.

In DS1104, 8 ADC ports and 8 DAC ports are there. BIT I/O is a 37 pin male port. Slave DSP is 37 pin female ports. Here we are connecting the Slave DSP to the IPC2dSpace.

6. Introduction to Interface cards

Interface and Protection Card (IPC3):

Main features of IPC3 are:

1) Provides control over the IGBTs on the FC-302 inverter.
2) Protects for over-current and short circuit on output.
3) Protects dc-link against over voltages.
4) Dead time selection.
5) Protection against over frequencies.
6) Status signals are available via LEDS.

UP, VP, WP is inputs for the PWM signals of each output phase. EN is the input for enabling the gate signals towards the FC-302 drive. RST is the input for resetting the IPC3 interface card in case of a TRIP. BR is the input for the DC chopper to control the DC-link currents through the "R+" and "R-". TRIP is the output signal from the IPC3 to trip the circuit. The µC will limit the initial charging of the DC-link capacitors.

For safety purpose it is having 1 ms minimum pulse filter on the acquired EN signal. CPLD implements the protection for IPC3.

Surface layout of IPC3:-

Fig.10. Surface layout of IPC3

CPLD will trip the IPC3 for :

1) Current > 250% of rated drive.
2) Dc link voltage > 870V.
3) Switching frequency >13.5KHz.

Through J5 pin in the IPC3 which is a 44 pin connector we can connect IPC3 with FC-302.

IPC2dSpace:

It is an interface card which connects the IPC3and Dspace 1104.at a time we can connect two IPC3 cards to this interface card.

Fig .11: Snapshot of IPC2dSpace

7.Control through dSpace

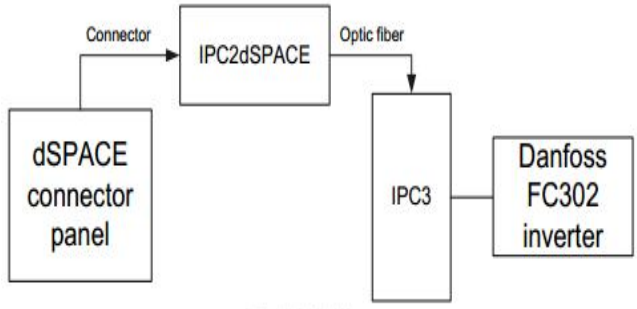

Fig .12 .Block diagram to connect FC- 302 & dSPACE controller board.

IPC2dSpace is connected directly to the Slave DSP of DS1104. Through optical fiber we can connect IPC3 and IPC2dSpace .The J5 connector of IPC3 is connected to the FC-302. The SIMULINK diagram is shown in below.

So by changing the offset, the pulse width is going to change which in-turn drives the inverter. Ultimately we can control the speed of the motor.

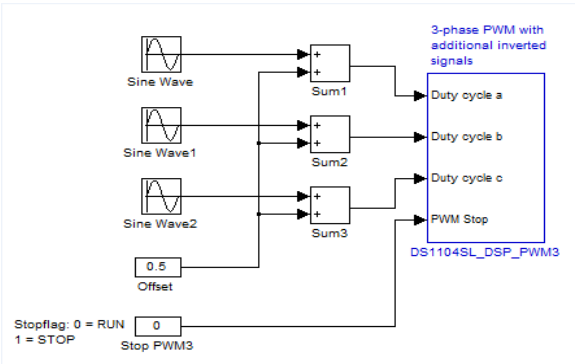

Fig 13. Simulink diagram for SPWM pulse through dSPACE.

8. Conclusion

The Real time implementation of Sine PWM control of the FC-302 converter fed three phase induction motor using MATLAB/dSPACE is analyzed and speed of the induction motor is controlled via LCP, external potentiometer and the results are displayed. Generation of SPWM pulse using dSpace also discussed and displayed in the above sections. Interfacing of FC-302 and DSPACE is also discussed.

9. Acknowledgement

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