Digital Signal Processor System for AC Power Drivers

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***Abstract* – DSP (Digital Signal Processor) is the best solution for motor control systems to make possible the development of advanced motor drive systems. The motor control processor calculates the required motor winding voltage magnitude and frequency to operate the motor at the desired speed. A PWM (Pulse Width Modulation) circuit controls the on and off duty cycle of the power inverter switches to vary the magnitude of the motor voltages.**

***Keywords:* DSP, Power Drive, PWM, Controller.**

I. INTRODUCTION

Electric motors are the major components in electric appliances such as refrigerators, washing machines. Controlling the speed of the motor can reduce the total energy consumption of the appliance. The essential hardware in a variable speed AC drive system consists of an input rectifier, a three-phase power inverter and the motor control circuits. An analog to digital converter allows the processor to sample motor feedback signals such as inverter bus voltage and current.

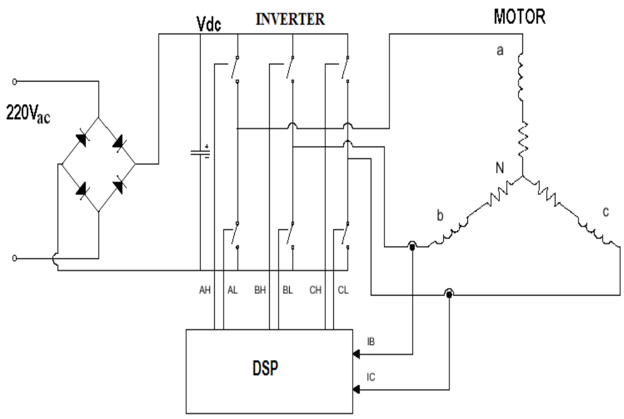

Fig.1. AC power drive system with DSP.

The control law calculates a new rotor position estimate and calculates the PWM duty cycle required applying the required voltage to the motor. The DSP algorithm also performs diagnostic functions, monitoring dc bus-voltage, the motor current and speed.

II. METHOD OF CONTROL AND ADVANCED SOFTWARE SOLUTIONS

Induction motor drive can be solved by using digital signal processors. The most fundamental control of induction motor is provided with Field Oriented Control (FOC) method.

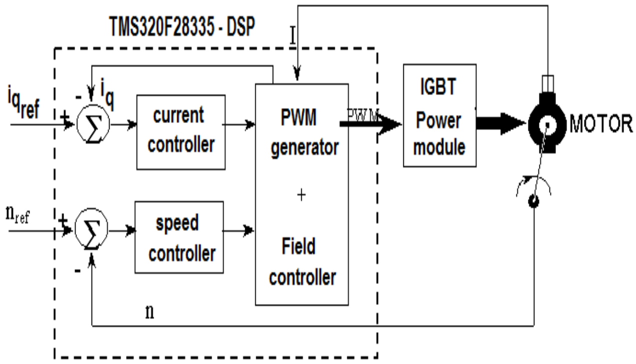

Fig.2. Method of control and inverter for ac drive.

The last occurrence of technological digital signal processor controller with features such as TMS320F28335 produced by Texas Instruments, can implement executable soft in real-time. Benefits drive resides in a robust low-cost and maximum torque. Scheme of Fig.2. contain a power inverter in a typical bridge, with PWM voltage modulated. Current reference ($i_{q_{ref}}$) and speed reference (n_{ref}) are prescribed machine values. Current by two stator phases will measure with two current transducers.

The trend is to introduce specific software (in assembly language) and the processor rule in real time. Do not neglect the theoretical aspects which justify the solution chosen. Practical side, although essential, does not restrict the general applicability. Whenever, a digital signal processor, such as ADMC331 (produced by Analog Device) or TMS320F28335 (produced by Texas Instruments), can theoretically use the software, with same imminent adjustments. Functional adjustments in the hard and soft (assembly language) are minimal.

A. Structure of speed controller of the indirect field oriented controller

With same mathematical transformations and using a proportional integral regulator can effectively and efficiently control the induction motor for adjustment speed. Though the induction motors have a very simple structure, its mathematical model is complex due to the coupling factor between a large number of variables and the non-linearity. The Field Oriented Control (FOC) offers a solution to solve high order equations and achieve an efficient control with high dynamic.

The entire algorithm of the field oriented control is in a one subrutine. Waiting loop can be modified from the user interface. DSP (Digital Signal Processor) with a role of controller is used to generate rectangular signals necessary for electronic power module. It is programmed to generate symmetrical PWM signals to the frequency of 10 kHz. For this purpose is use TIMER1 as register for the time base. Sampling period (T) is 100µs.

B. Measuring currents

Control structure with the indirect Field Oriented Control (FOC) requires two currents as inputs. Is used current transducer whose output is a voltage, Fig.3. Measured values must be rearranged in an acceptable domain.

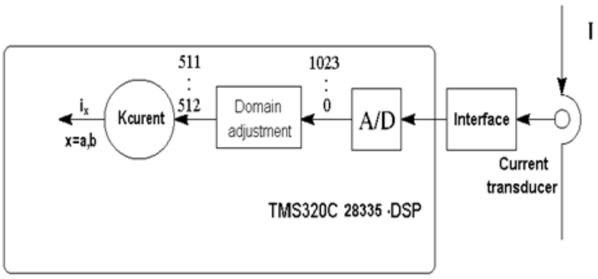

Fig. 3. Measuring current and scaling it.

The signal output may be either polarity. It should be translated (Fig.4.) by the analog interface in the classical (0-5V). One converter Analog / Digital module (inside in DSP) will read positive and negative values.

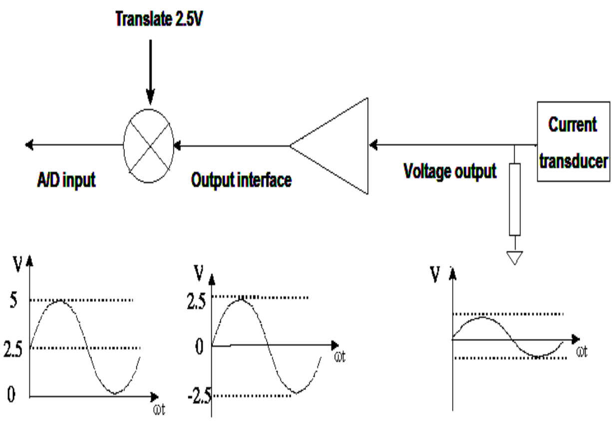

Fig.4. Current measurement interface.

Phase currents are measured using the Analog/Digital converter. There are two channels of measurement and management software in real time.

C. Speed Measurement

To measure speed rotors provides 1,000 pulses for maximum speed. The output of two sensors A and B are connected to DSP - controller.

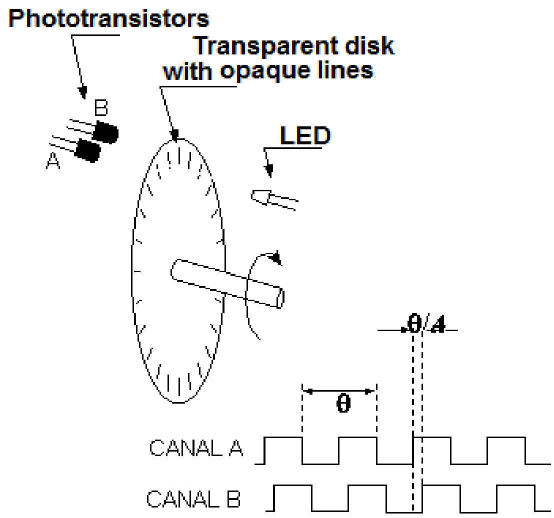

Fig. 5. Speed measurement using optical sensors.

The system defines the time for counting. At each sampling value is stored in the variable named „encincr" Fig.6. Counting impulses is achieved by a program written in assembly language. The program will bring to the counting interrupt-requests from PWM signals.

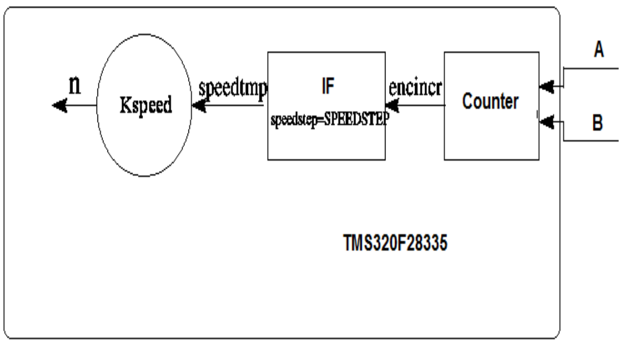

Fig. 6. Speed measurement.

It defines a function object to set the time-unit for a conversion "SpeedStep". If the two are equal, then counting the number of impulses. With function object "speedtmp", the speed (n) can be calculated.

III. PWM IMPLEMENTATION AND EXPERIMENTAL RESULTS

It is the most effective way to generate six types of rectangular waveform required the block of power. Space vector modulation requires as input: the reference voltages $v_{S\alpha ref}$, $v_{S\beta ref}$, supply voltage as a parameter and continues to provide three output PWM waveforms.

The program, to generate Symmetric PWM impulses, is run by the signal processor in real time. Executable object code is in good condition for a wide range of DSP controllers.

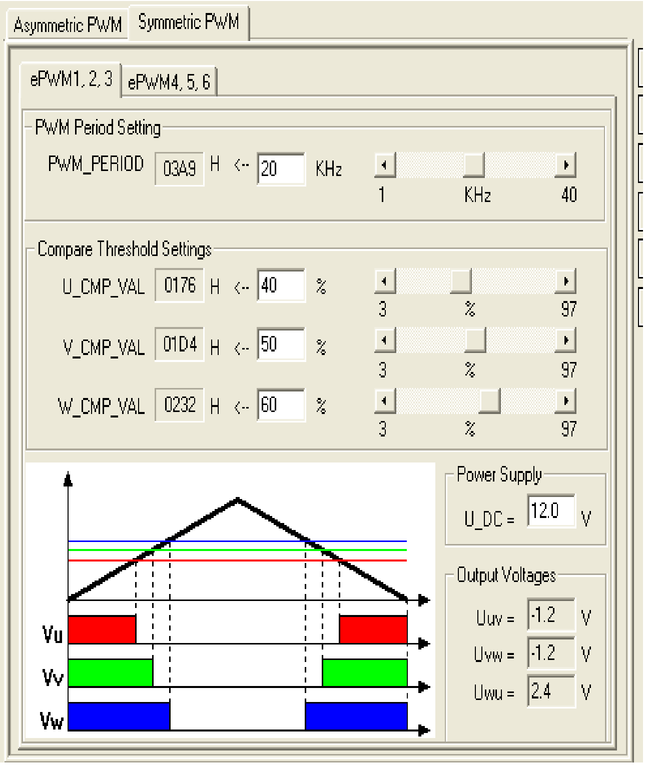

Fig. 7. Generating PWM impulses, with values calculated by MCWIN software.

The development system has a soft MCWIN. Generating PWM impulses are fixed properly according to the parameters set.

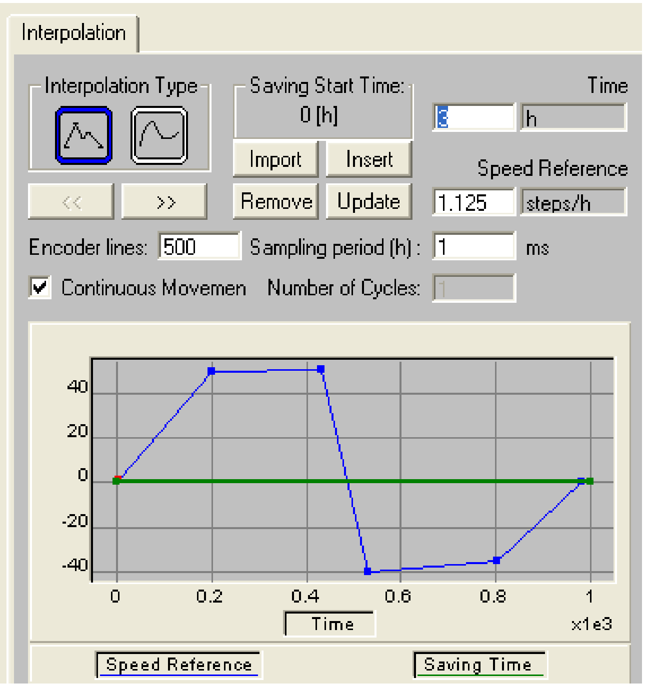

Fig. 8. Fixing profile variation speed (n_{ref}) and the type of interpolation for adjustment.

Using the ac power converter software MCWIN and software extensions in assembly language was obtained a field oriented control - in which the reference speed profile is chosen from the desired operation (Fig.8.). Constants are fixed values for the proportional integral "PI" regulators.

Speed reference appears in Fig.8. It was fixed the current value of the current " i_{s_q} " in the calculations. There is an approach with fast response speed compared to actual prescribed speed profile.

The electrical values calculated by the program are moved to DSP:

$$i_{s_q} = -\sin(\rho)\times i_a - \sin\left(\rho - \frac{2\pi}{3}\right)\times ib = i_{q\,Re\,f}$$

- $i_{q\,Re\,f}$ is calculated for the dynamic evolution;

- i_a and i_b currents are measured on the measuring channels A/D;

- ρ is estimated from measurements of dynamic speed n.

Representation is for the expression of i_q current of space vector.

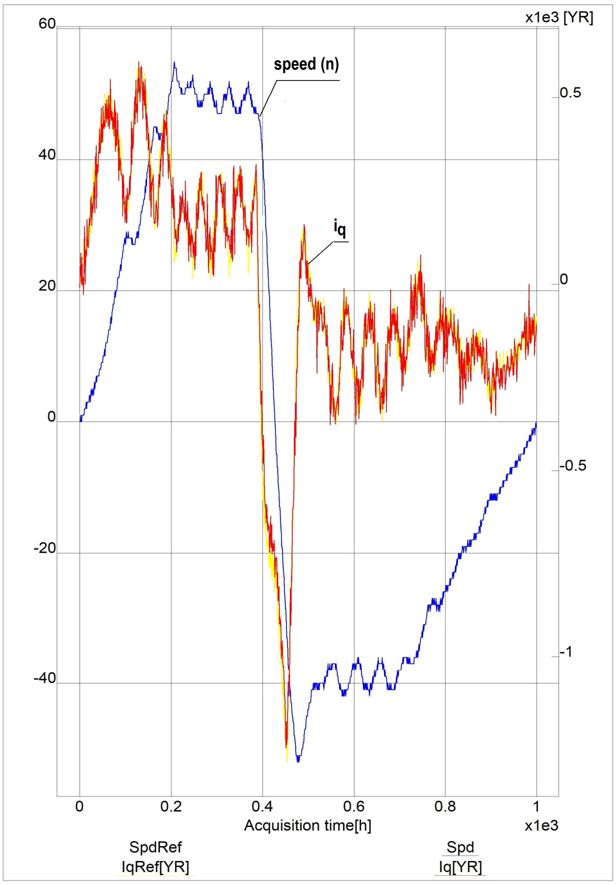

Fig. 9. DSP - controller - electrical measures, i_q current space vector and dynamic speed n.

Compared with the reference values set in a power ac motor, actual values are obtained close (Fig. 8. and Fig.

9.). The domain error of the real values is dependent by regulators used for adjustment of speed and current. Proportional Integral regulators are. Constants k_p and k_i were chosen after adjustment strategies.

Data transfer to computer is done on a PC serial interface RS 232. The electronics board with signal processor works in real time. Data are saved in the memory of its own "System Development" and is transmitted in packet sequencing on a relatively slow serial interface (11500 bits/s). Observing instant is great for the definition of a particular setting, after that process will take place continuously in most applications.

IV. CONCLUSIONS

Developed software is created in assembly language for DSP. The objectives are focused on the electronic structure of the management of interactive ac power operation. It used high-level software MCWIN with graphic interface for power ac motors. PWM modulation is used. The ensemble of the two programs provides effective control in a domain setting.

The DSP power drives becoming complex application with fast hardware. The solution of such a system is justified by the measured values that are close to those of reference. The system has safety subroutines and a very good reliability. It works in real-time for power electronics devices and for any industrial applications.

A high level software has functional predefined bloks for fields of interest; industrial electronics is a possibility. Considerations regarding the practical implementation of the proposed solution and some experimental results are also given.

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