

Using a Standalone Digital Signal Processor for Motor Control Applications

Electrical machines are used in many applications today. Control of parameters such as speed and torque is often desired. A control system based on a family of microprocessors named Digital Signal Processors (DSP) does this cost effective and efficiently. These processors specialize in handling certain signal processing, such as *analog to digital conversion* (ADC) and *Pulse Width Modulation* (PWM). They also have the capability of executing multiple tasks simultaneously, allowing for better utilisation of the processor clock cycles.

Even though the DSP is the right choice for the task, many electronic additions must be made in order to get a full system working. Without additional power electronics, no control system would be possible. This conclusion is based on the fact that a given DSP does not have the ability to supply the load with the needed current. This is instead done with a frequency inverter¹ that contains transistors capable of handling high currents and fast switching frequencies. The frequency inverters come in a wide variety of models, handling power consumption from about 750W to 40kW and more. The standardized way of controlling the transistors is by CMOS² level, voltage signals (0-15V) meanwhile a DSP output is [0,3.3] V. An electronic interface between the DSP and the frequency inverter is thereby imperative. Figure 1 visualises the idea behind such a system.

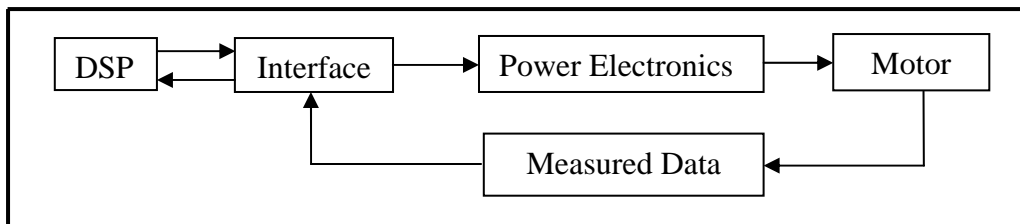


Figure 1: Principal sketch of motor control system

The selected DSP is from the TMS320-family and manufactured by Texas Instruments. This family includes a large number of different DSP configurations. The one used for this project is the TMS320F2812, with a clock speed of 150 MHz and 56 Input/Output-pins. It also features 16 ADC-channels with a conversion speed of 25Mhz and a resolution of 12-bits.

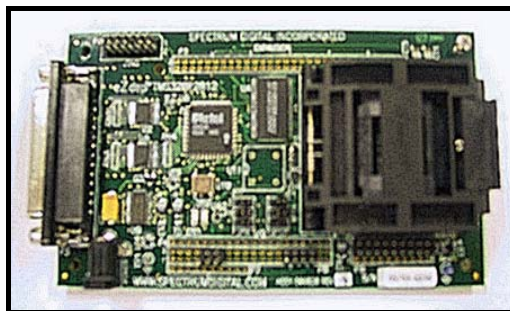


Figure 2: Card that holds the DSP (Block on the right)

¹ Power Electronic device

²Circuits from the *metal oxide semiconductor* family

Controlling Algorithm

In order to enable a complete control system, one also needs to implement program code in the DSP. This is done by using standard C/C++ (and/or Assembler)¹ in a special development environment called Code Composer Studio (CCS). Within CCS, the developer is able to control the execution of the program code and track faulty values in variables.

The implemented controlling algorithm is based on the current lab set-up. Depending on the desired control system, different numbers of parameters need to be taken into consideration. Choosing the optimal type of controller is a completely separate area of research and is not addressed in this project.

Interface card

Once an implemented system is up and running, transformation from DSP signal levels is needed, please refer to

Figure 3. Based on the application that utilizes the interface, different voltage levels may be used. In addition, input levels need to be adjusted in order to fit the DSP input. A universal solution requires different input levels; the gain and the offset must therefore be adjustable.

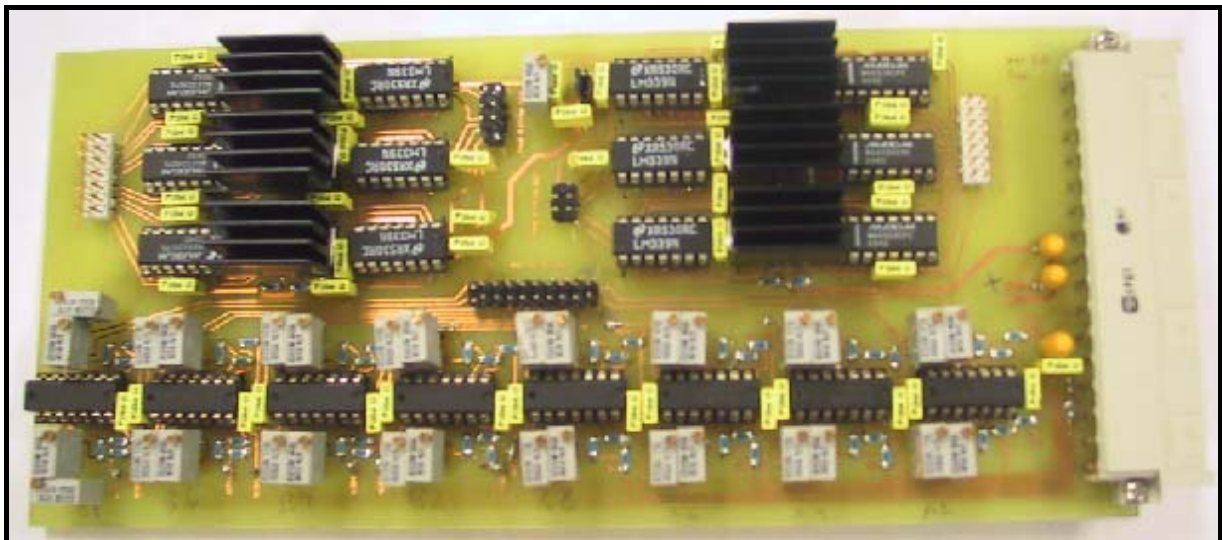


Figure 3: Layout of the interface card

The output uses the Pulse Width Modulation(PWM) principle. This is based on changing the relation between on and off times rather than changing the signal amplitude. Consequently, the connected device is controlled by changing the *Duty cycle* i.e. the active time divided with the total time each cycle.

¹ Computer languages

Real laboratory setup

The given DSP, including the interface, and necessary components were tested in a real motor application. The two motors are connected with the same shaft and must therefore to be controlled simultaneously or individually if only one of the motors is used. Please refer to Figure 4.

Test with this type of equipment reveals the true power of a DSP solution compared to other systems. The selected F2812 can be used in multiple control applications. It is hereby possible to control a small industry or laboratory with only one DSP system.

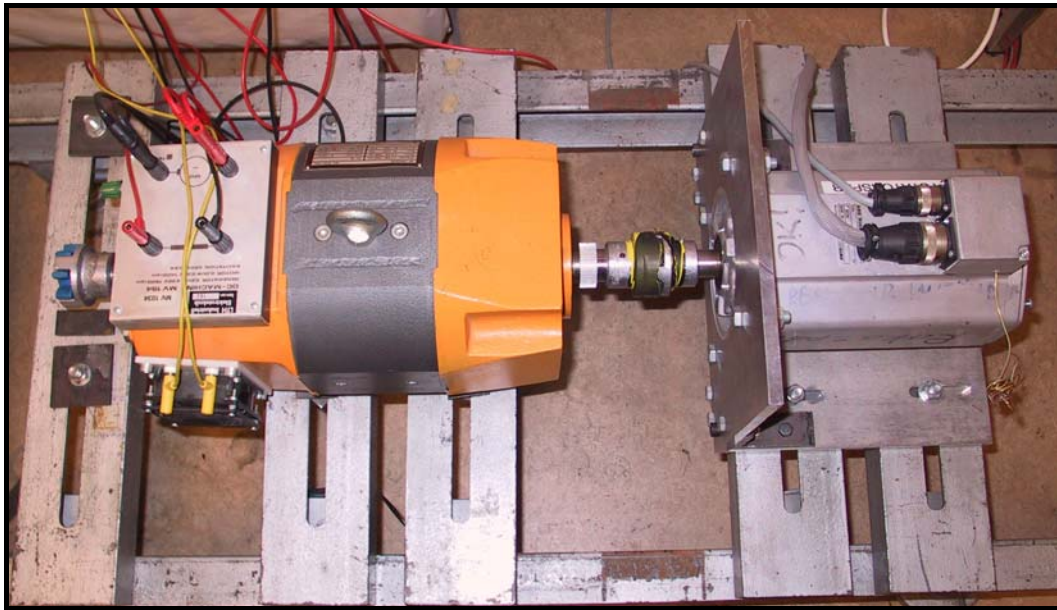


Figure 4: Real test setup

The primary goal for the implemented control system is to enable a replacement system for the present controllers on today's market. The new DSP system should be able to handle a variety of applications; this goal is certainly fulfilled in the final design. The costs for this DSP-based control system are almost entirely related to the development phase. Once the system is up and running, no costs are incurred, truly an advantage over similar systems.

Daniel Martinsson, E-00

Magnus Lind, E-02

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