# Sensorless D.C. Motor Control with Predictive Sensig Methode

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***Abstract***: *The conventional motor controls are working speed-, or angle feedback. The proposed solution in this work is used advantageously in this area where the cable network has already built up but there is no possibility to be expanded, or it is money-gobble. At the presented procedure with the D.C. motor control the use of supply voltage added commutations noise. Since the commutation noise amplitude, the frequency, the signal shape and the duty cycle could depend on the speed of the axis and power (torque) of motor, it must be a differential signal conditioning to be used for extraction of speed information. Applying the tunable filter the speed-signal has significantly jitter and time-domain noise. The exact speed of the communication noise can only be determined if the expected value or, at least, the range of it are known. Furthermore if the motor speed voltage characteristics are known, so that control is a function of the expected value can be determined. The microcontroller controls of the motor speed by PWM, further determines the expected value by prediction algorithm and for the prediction an exact D.C. motor model is needed create.*

***Keywords***: *D.C. motor control; prediction; embedded microcontroller; FPAA*

# 1 Introduction

The engineering practice is widely used the applications of various types of brushed D.C. electric motor, such as electrical, mechanical and cheapest means of transducers. In some applications the precise speed control is inevitable and in this case the well-known speed sensor feedback is proposed. In generally optical-, or Hall sensors solutions are used. These solutions are reliable; however, mechanical and electrical treatments are extra costs. In this case it is not negligible for the application of such sensors that it implicates geometric volume growth.

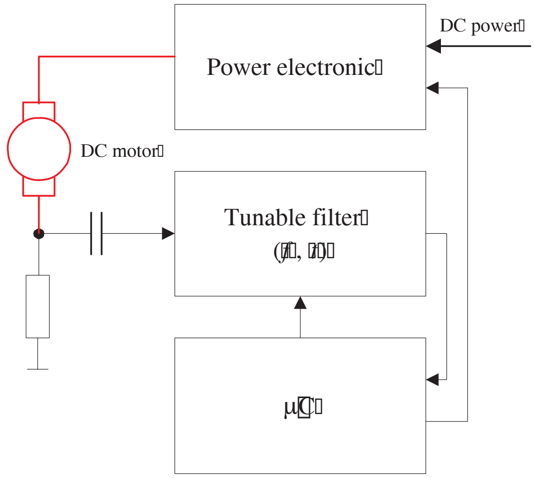


Figure 1
RPM signal mining from the power voltage added commutation noise,
on two wire (red) connect to the D.C. motor

An earlier our work dealt with the power electronic application of microprocessor in different art of abilities of pulse with modulation (PWM) [4], in which a certain specific motor control options [5], the potential application of tunable, reconfigurable filters at cooperation of microcontroller and field programmable analog arrays (FPAA) was described [6]. In this paper a microprocessor used to a special control is presented and applications we have described are a smart sensor less DC motor control PWM method [1].

## 2 Abilities of Angular Speed Sensing at Brushed D.C. Motors

Possibility mentioned in the abstract is leaving to a precise speed detection sensors and regulation, using D.C. motors work combined with the electronic noise (Fig. 1).

This commutation or brush-noise superposes on the power supply output voltage (Figs. 2, 3). We can see the different commutation noise on below, left side graphite-, right side a bronze brush. For exacting of this noise necessaries a serial induction or resistor in power line, a capacitor A.C. coupling for the separating of D.C. component of power voltage and an amplifier [3].
Technological difficulties mean that lot of the form of noise signal, its amplitude, a significant number of pulses depend on the construction and the commutator used in the electric motor. Since the commutation noise amplitude, the frequency,

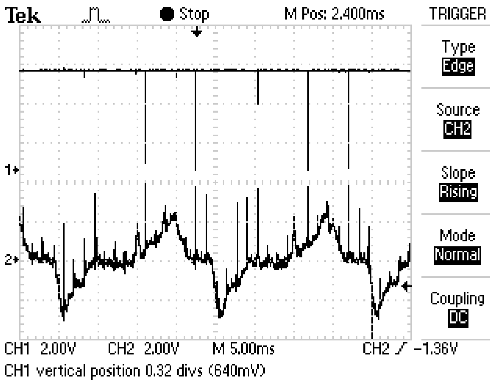


Figure 2

Commutation-noise of two small DC electric motor at bronze-brush,

upper the generated digitalized noise

the signal shape and the duty cycle will very depend as well on the speed of the axis and the power (torque) of motor, it must be differential signal conditioning to use for sensor less D.C. motor control extraction of speed information [2,7] . The production of the digital speed-information from the brush-noise should take into account the characteristics of current electronic motor and the promptly RPM. In Figs. 4-5 different digitalized brush-noise (upper) and their filtered digital angular speed-signal impulses are demonstrated.

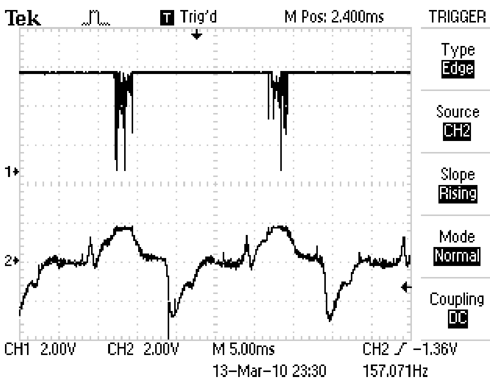


Figure 3

Commutation-noise of two small DC electric motor at graphite-brush,

upper the generated digitalized noise

# 3 Accurate Determination of Motor's RPM by Using the Adaptive Model

The motor of the PWM signal duty factor will be subject to some kind of speed ($\omega$) and torque ($N$) and rotate to be given. The arrangements ($\omega$) or ($N$) are necessary to be optimized. The relationships between the two parameters are well known as follows

$$N = N_s - \frac{\omega N_s}{\omega_n}, \tag{1}$$

$$\omega = \frac{(N_s - N)\omega_n}{N_s}, \tag{2}$$

where $\omega_n$ is maximal angular speed at $N$=0 and $N_s$ is maximal torque at start at $\omega$=0.

The electric power can be written according to the angular speed ($P_\omega$) or torque ($P_N$), as in the next functions are shown

$$P(\omega) = N_s\omega - \frac{N_s}{\omega_n}\omega^2, \tag{3}$$

$$P(N) = \omega_n N - \omega_n N_s N^2. \tag{4}$$

Both equations can arranged according to the parameters, ($\omega$, $N$) being important for our control. These only depend on one hand the electric power, $U_{motor}$ = **f**($PWM$). and other hand on the $U_{motor}^2/R_{motor}$. The duty cycle of PWM signal is generated by microcontroller or their algorithm.

The estimated angular-speed can be calculated. The latter is very beneficial, because well known that in this range which will be a noisy RPM-signal, so the best signal quality can be produced [9].

Simplifying we know the expected value of this, we can precisely defined it, actually the help of predictions can be determining the expected signal-value. The proposed microprocessor program is shown in Fig. 6. In figure "Predefined characteristics" can be seen a block which contains any tables of necessaries voltage of motor and for example the got RPM. The block of "Calculate of characteristic" basically means linearity interpolation between two predefined values [10].

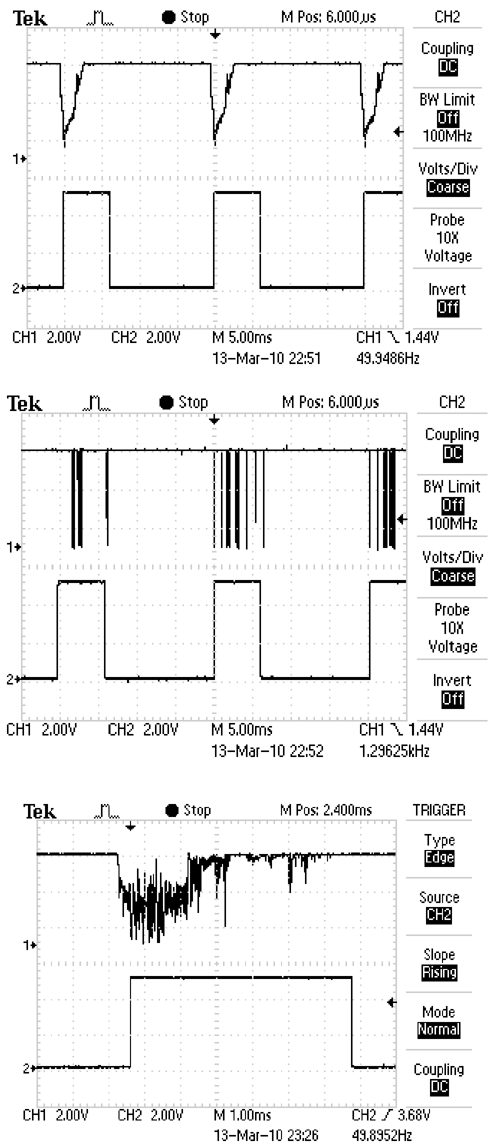


Figure 4

Three different brush-noise and their generated digital impulses at $f_{LP}$=40*kHz* type filter

# 4 Using of Proposed Arrangements

In Fig. 7 a brush-signal source at bidirectional D.C. motor driver circuit can be seen [8]. We get a current signal altogether added brush-noise from the bridge resistor ($R_9$, $R_{19}$) in common sources of FET's [11].

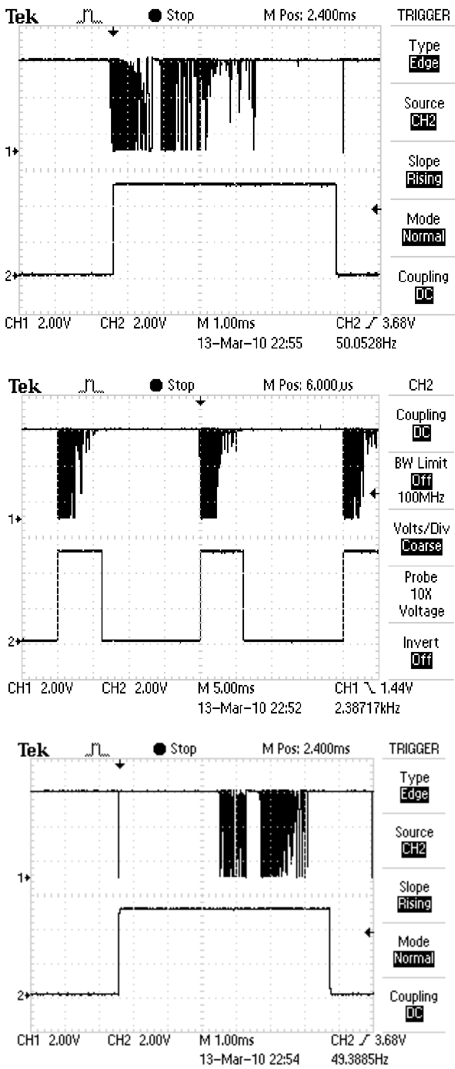


Figure 5

Three different brush-noise and their generated digital impulses at $f_{LP}=8kHz$ type filter

This arrangement is able to reconfiguration of low pass filter according to the generated duty cycle of PWM.

In Fig. 8 is shown a realized sensor less D.C. motor control in an industrial embedded microprocessor card and testing of an experimental machine.

## Conclusions

The proposed procedure can be used advantageously in all places where D.C. motor propulsion equipment, if we can not or do not want to used sensors in application. In such cases, that the application is subject to the microprocessor has enough resources to run the filter and prediction algorithm. Resource-friendly solution for all is, when the signal and the expected speed are smarted and detailed in a table.

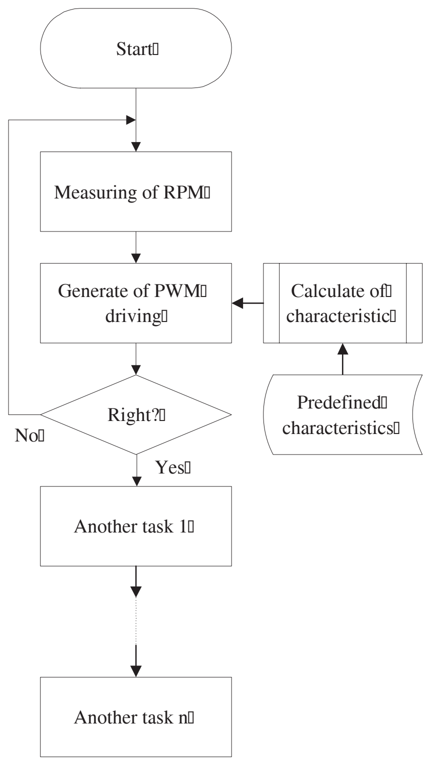


Figure 6

Addition of the prediction microprocessor program

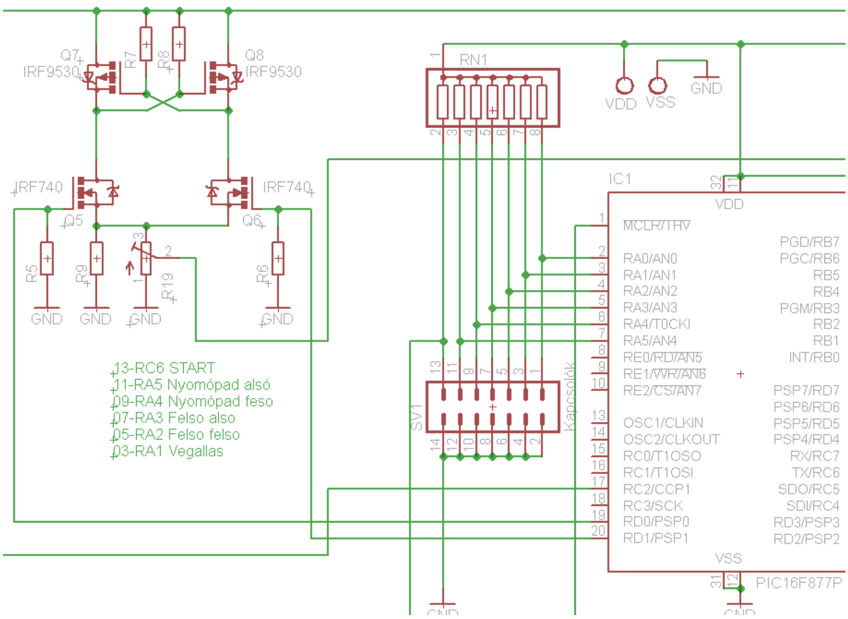


Figure 7

A part of PWM driver bridge with power FET's and PIC16F887 microcontroller

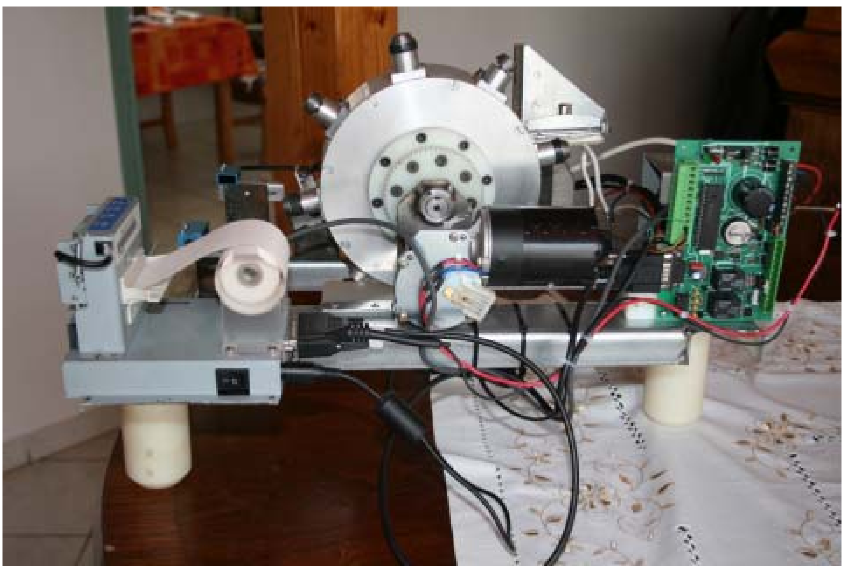

Figure 8

The realized circuit in work at a commercial counter machine

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