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DCM-MotionTechnology

electronic encoding for brushed DC motors

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In this paper it is demonstrated that the Int. Pat. Pend. DCM (Detect-Control-Monitor) Motion Technology enables a new electronic encoder design for precise rotation counting in brushed DC motors.

DCM MOTION TECHNOLOGY

The DCM-MotionTechnology is based on the physical behavior of a coil when a current running through it is disconnected ('Law of Induction'). The DCM-MotionTechnology identifies the Back-Fire transient from the *collapsing magnetic field*[1] in the coil when power to the coil is turned off.

The Back-Fire/Kick-Back transient is a short duration event of a temporary excess voltage, which is proven absolutely stable by its nature and is seen as a spark generated between the breaking contact points. This is similar to the spark generated by an ignition coil.

The Kick-Back triggers the modulation of an electronic encoder signal for each of the motor commutations. Thus an N pole motor will encode N signals per rotation.

The information from the Kick-Back can be extracted anywhere on the power wires to the motor. This is performed by a special DCM-Detector.

TEST RIG

A test bench has been developed to verify the DCM-MotionTechnology. The motor that has been tested here is a conventional brushed DC motor (Mabuchi 578, 8 poles, 12V, I_{stall} at 24A). The motor is connected to a power supply and the DCM-Detector is connected to the power wires. The motor drives a mechanical disc brake in order to apply an adjustable mechanical load. An optical detector with an 8 slot encoder is attached to the motor shaft. A simple on/off switch is used to apply and to break the power supply to the motor. The detected signals were recorded using a PC based oscilloscope.

TEST RESULTS

In this test the load was adjusted to 40% of the nominal stall torque of the motor. When the power is turned on the motor accelerates. Then, as the power is turned off the motor is coasting in generator mode, i.e. it is rotated by the inertia of mass of the mechanical brake until reaching a complete standstill.

Fig. 1 shows the *precise count* by the DCM-Detector (in blue) from start to stop. The photo detector (in red) ends with half a count (staying high). If counting on the falling edges the photo detector will miss one count compared with the DCM-Detector.

The DCM-Detector signal moves back/forth a little when compared with the photo detector signal. This is due to the difference between an electromechanical signal and a mechanical signal during acceleration and deceleration.

Fig. 2 shows an enlargement of the signals in Fig. 1 around the time when the power is turned off. The motor under test takes four commutations to 'recognize' that it is now working as a generator (from the vertical dotted black line to the dotted green line). The DCM-Detector counts are moving backwards (to the left) in relation to the photo detected signals until they are approximately centered over the photo detected signals. Changing from generator mode back to motor mode by turning the power on would create a similar transient pattern.

The duration of the DCM-Detector counts adjusts to the physical point in time where the power is turned off thus offering a precise electronic identification of said point in time.

Notably, neither the turn-on nor the turn-off affects the ability of the DCM-Detector to perform absolute counting.

CONCLUSIONS

DCM-MotionTechnology offers a simple and reliable sensor less method of rotation counting for brushed DC motors.

For other sensor-less methods (e.g. ripple counting) the *inrush current*[2] and the resulting high voltage transients would pose a problem in the encoder design. Such transients occur when the motor is turned on/off or when it converts to generator mode forced by a moving mass. On the contrary the performance of the DCM-Motion Technology is unaffected by such transients.

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[1] Other methods (e.g. ripple counting) are detecting the back electromotive force (BEMF)/counter electromotive force as described by the 'Law of Lenz', when power is turned on.

[2] Inrush current or input surge current refers to the maximum, instantaneous input current drawn by an electrical device when first turned on.

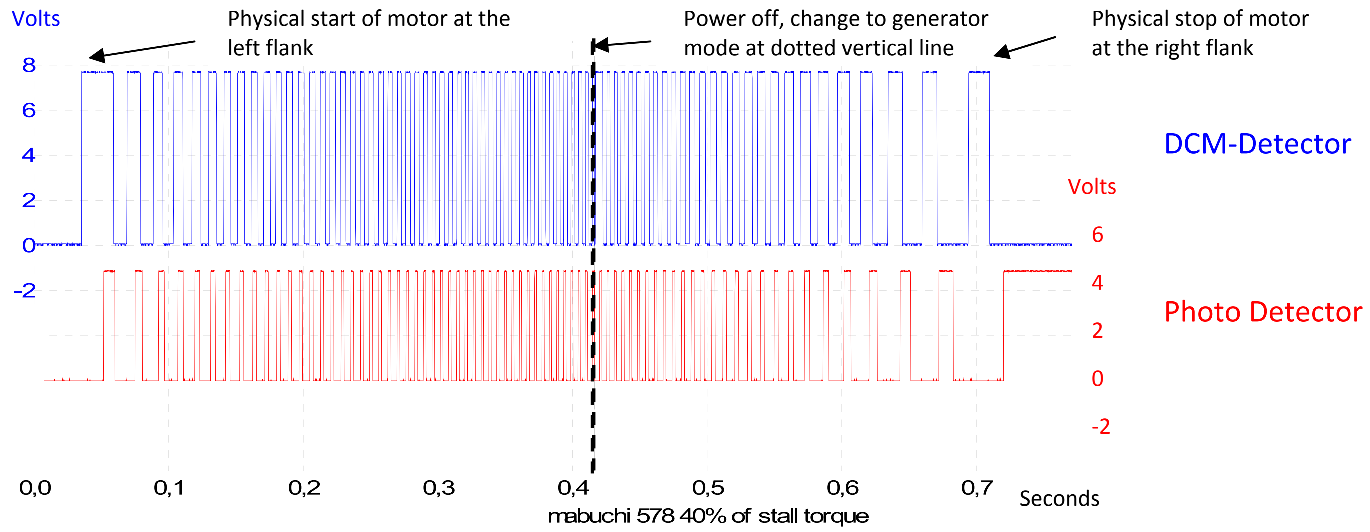

Fig. 1. DCM-Detector counts compared with photo detector counts at 40% of stall torque on a Mabuchi 578 8 pole motor.

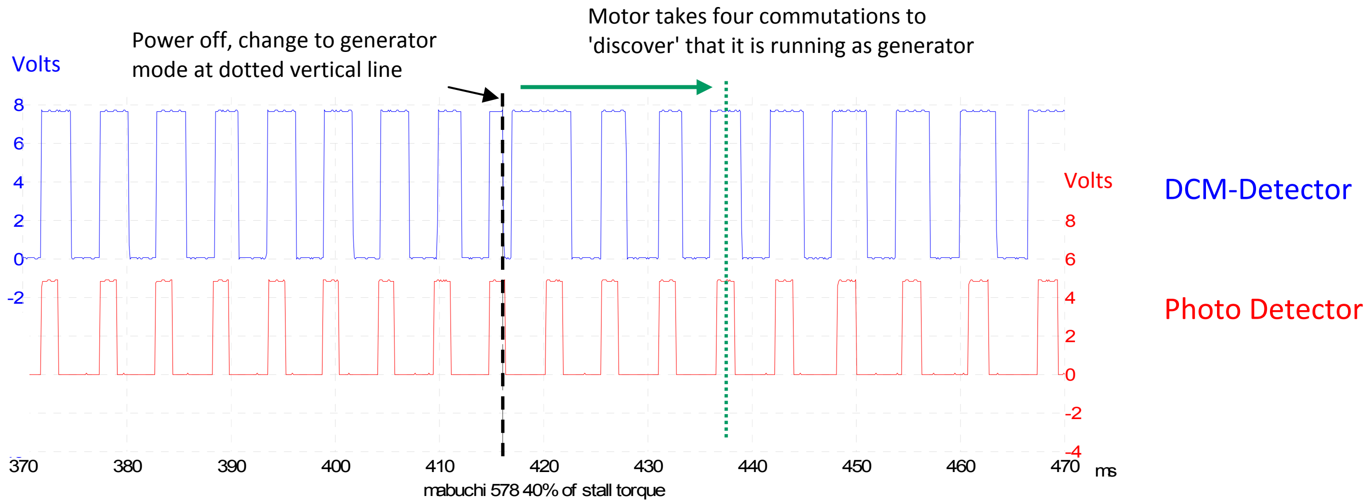

Fig. 2. Details of counts when changing from motor mode to generator mode