Carbon brushes for fractional horsepower motors

Radio interference suppression in commutator motors

As a result of the constantly rising number of radio-receiving devices, radio interference suppression is of great importance for electrical motors in household and industry. Since these devices are primarily equipped with commutator motors, the resulting oscillations cause high frequency harmonic waves, which represent an interfering signal. This interfering signal superimposes and disturbs the wanted signal of radio traffic, radio broadcasting and television.

Consequently legally binding limits were specified. All devices, which generate electromagnetic oscillations within the range of 10 kHz to 300 MHz, need to be approved according to the high frequency law.

The regulations dealing with radio interference comprise broadband frequency spectra, which result from rapidly occurring electrical processes with a repetition rate of at the furthest 10 kHz in connection with mechanical contacts, semiconductors and commutator motors. The resulting radio interferences are frequency-dependent transmitted to receiver devices both via cable and wireless.

The radio interference of the devices powered by electric motors is presently measured in principle in a frequency range of 0.15 to 300 MHz, whereby in Western Europe the values for radio interference voltage and interference output must be kept within the limiting values determined by CISPR (Comitée International Spécial des Perturbations Radioélectriques).

The IEC international special committee for radio interference prepares the CISPR regulations.

These regulations correspond to the following EN-regulation DIN EN 55014-1.

Because of the wavelength, the radio interference voltage is transmitted in the frequency range of 0.15 – 30 MHz mainly via cable (connecting lines). Therefore the radio interference voltage is measured within this range.

Within the range of 30 – 300 MHz the radio interference is caused almost exclusively by interfering radiation. The dimensions of the devices, into which the motors are installed, are an important factor. Two types of measuring methods are used here: on the one hand the actual field intensity measurement by means of a suitable antenna, on the other hand the "clamp measurement" with absorption clamp and radio interference output measurement receivers, a method developed in accordance with the CISPR. This latter method can be performed with relatively small expenditure in regards to instrumentation. The testing laboratory uses the antenna measurement in arbitration cases. Details regarding the methods and limiting values according to the G, N and K levels of radio interference can be found in the aforementioned regulation.

The devices are basically differentiated according to their intended purpose:

a) Household appliances powered by electric motors

b) Hand-held electric power tools

Since the introduction of the artificial mains network with 50 Ω//50 µH + 5 Ω a special modified limiting curve for the interference level N applies to household appliances powered by electric motors.

For hand-held electric power tools, three limiting curves for the interference level N still apply, which are distinguished depending on the rated power consumption of the devices.

The exact limiting curve according to the interference level N applies to the interference suppression of devices with up to 700 W power consumption. The limiting value is 4 dB higher for devices with 700 – 1000 W power consumption. For devices with a power consumption of more than 1000 W a limiting value that is 10 dB higher can be used as a basis.

The radio interference of commutator motors is caused by mechanical and electrical influences, which often can be reduced by relatively simple means. Therefore it is at a later date possible to reduce expensive suppression material.

Electronically speaking it is important to keep the energy content of the interference source to a minimum, which means that the internal resistance of the interference source must be large.

Radio interference suppression in commutator motors

Brush sparking occurs in commutator motors as a result of the commutation process and possible mechanical malfunctions. This leads to high spikes above the segment voltage with a steep edge. It can be proven with Fourier analysis that such a spike can be divided into harmonious sinus oscillations, which reach into the highest of frequencies. The shorter and steeper such a spike is, the further the frequency spectrum extends into the high frequency range.

Phase controls with thyristors or triacs as well as rectification with silicon semiconductors, which are nowadays installed in an increased extent in household appliances and hand-held electric power tools, are an additional source of interference, mainly in the long wave and medium wave range.

The resulting high-frequency oscillations are transmitted as interference voltage via the line cord and as interference field strength and/or interference output through radiation in free space.

When designing the motor, the number of segments and the number of rotor slots should be chosen as high as possible in order to reduce the segment voltage (for 230 V motors e. g. 24 segments and more, if possible). The exciting coils should be arranged as symmetrical as possible and one-sided field tapping for different speeds should be avoided.

To ensure a smooth mechanical carbon brush run and thus reduce radio interference, the following points should be considered:

The residual imbalance of the motor should be as small as possible, e. g. 0.5 – 1.5 gmm, and the axial freedom of motion of the rotor should be restricted as much as possible.

Every effort should be made to avoid any eccentricity of the commutator after the final manufacturing operation, otherwise mechanical excitations will occur periodically on the carbon brushes.

A limiting value of 8 µm should not be exceeded for motors with speed values up to 25000 rpm. For motors with a speed range of 25000 – 35000 rpm a limiting value of < 6 µm applies and a limiting value of < 4 µm applies for motors with a speed values of > 35000 rpm.

The out-of-roundness of the commutator must be kept to a minimum as well. The same limiting values as shown with eccentricity apply for out-of-roundness when distributed over a larger commutator area. Out-of-roundness caused by protruding segments should not exceed a value of 1 – 2 µm, depending on the size of the commutator, otherwise an increase in commutator sparking is to be expected due to the mechanical contact separation.

A commutator surface roughness of $R_Z = 6 - 12$ µm and/or $R_a = 1 - 1.6$ µm is required to improve the running in of the carbon brush and/or to increase its service life.

If the surface roughness is too low, the coefficient of friction will be too high which results in an unsteady brush run.

It should be further mentioned that the clearance between carbon brush and the brush holder affects the carbon brush running behaviour and especially the radio interference. Tolerance guidelines according to the DIN IEC should therefore be observed unconditionally. Please see details to this in brochure 13.34.

The carbon brush material and the carbon brush contact pressure must of course be optimally coordinated with the motor. By using a carbon brush material with an impedance as high as possible, the short-circuit current can be limited and the internal resistance of the interference source can be increased. Additionally it is possible to lower the radio interference during the entire carbon brush lifetime through purposeful impregnations, e. g. with symbol F7, F10, F12, F13, F20, F25, F101, F131 and ZP, and through improvement of the mechanical running properties and therefore better electrical behaviour. Furthermore the range of the measured values is reduced. The impregnations stated here remain stable and effective in their concentration and effectiveness up to the end of the carbon brush service life, coordinated with defined maximum operating temperatures in the devices.

In motors that run unsteadily it is sometimes of advantage for the interference suppression and the lifetime to angle the brush top instead of having the standard design. Such a measure provides a pressure component in the direction of the holder wall in addition to the pressure component perpendicular on the carbon brush. This brings the carbon brush into a defined position and is good for vibration damping.

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13.36e/1000/2008

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