

Improving reliability: redundant stepper motor

Introduction

In some applications, the proper operation of the motor needs to be guaranteed whatever failure may happen to the system. This is popular in the aerospace and medical domains where a little failure of the motor may cause intolerable human and material damages.

Therefore, the solution used to satisfy those requirements often proposes a redundant stepper motor which consists of adding some kind of back-up motor and electronics or magnetic components that can replace the original parts in case of failure.

The goal of this application note is then to explain what a redundant stepper motor is, how it operates and when it is appropriate to use it.

Principle of a redundant stepper motor

The idea is to ensure that the application will continue to run even if the motor and its electronics fail. Several options can be imagined depending on the criticality of the application and the redundant component can be different:

1. The electronics only (back up of the driver, the controller, etc.)

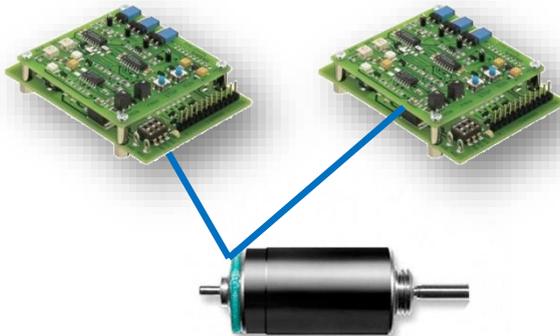


Figure 1 : Back up of the electronics.

2. The motor and the electronics (second motor that can replace the defective one in case of failure)

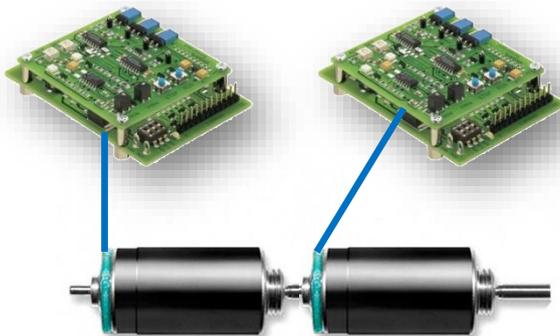


Figure 2 : Back up of the electronics and the motor.

3. A component of the motor (usually the windings) and the electronics

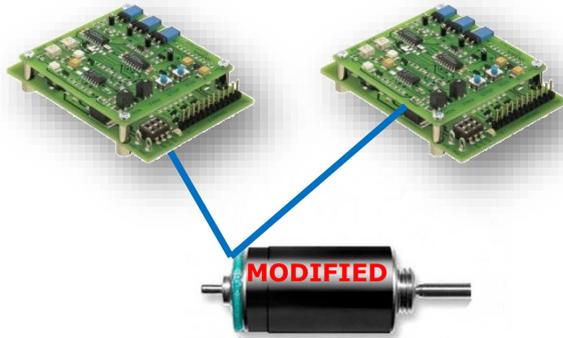


Figure 3 : Modified motor design and electronics back up.

4. A combination of those 3 options

Of course, the choice of the option is also depending on its cost, option 2 can be much more expensive than option 1 for instance.

Option 1 and 2 are simple to realize, the only need is to design a system with a second electronic or motor that will replace the defective part and pursue the operation. Option 3 is more complex because it asks for a redesign of the motor from the manufacturer but it is a good solution if the available space is critical.

PRECiStep® redundant stepper motors

FAULHABER PRECISTEP SA has investigated different ways to propose redundant stepper motor depending on the motor technology (AM and DM technologies¹).

AM technology

With AM stepper motors technology (AM0820, AM1020, AM1524 and AM2224(R3)). The concept is to double the windings for each phase which means that one phase contains then 2 windings instead of 1. To do so, the stator of the motor has to be modified so that 2 back up windings (A2 and B2) can be placed, as shown in Figure 4, which may result in a longer motor. The disadvantage of this solution is that if A1 fails, it could damage A2 too because the original and back up windings are in close contact each other.

Though possible, its implementation would be very costly.

DM technology

With DM stepper motors technology (DM0620, DM1220), the concept is to split the 4 coils which normally constitutes 2 phases into 4 independent coils which 4 independent phases (2 motors). To do so, the connection of the phases is done differently. In this solution, the windings are all independent from each other and therefore the failure of one winding won't affect the operation of another one. This modification is easy to implement.

¹ Please refer to the « Stepper motor basics » application notes for more information about those technologies.

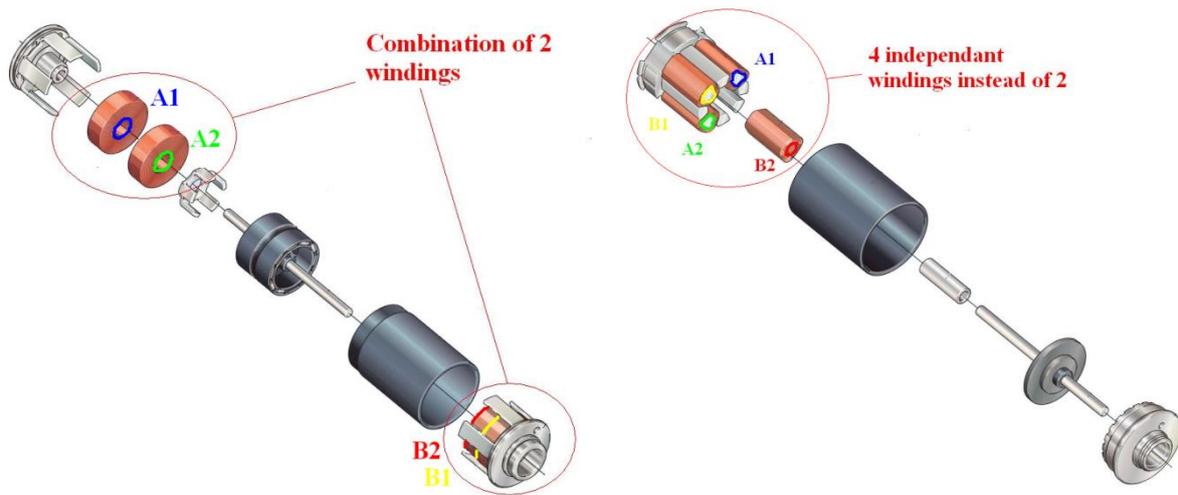


Figure 4 : Schematic of the backup of the windings in the AM (left) and DM (right) stepper motor technology.

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