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Design and Analysis of Multi-Winding Power Current Transformer for Power Transmission Lines Inspection Robot

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Abstract

Special current transformer (CT) is designed to induct power from the power transmission lines for an inspection robot. Equivalent circuit is used for calculating and modelling the parameters of the current transformer. Air gap analysis is given aiming at adapting dynamic range of bar current, and calculation of the effect of air gap is provided in detail. Ratio change of current transformer is introduced by which the secondary current could be adaptive to the bus current. Simulation results show that dynamic control of length of air gap and turns of the coils could make the current transformer be adaptive to the variable bus current and be more convenient for inducing power for the power transmission lines inspection robot.

Key words: current transformer, induction charging, inspection robot

1. Introduction

In recent years, researchers have been working on designing one kind of mobile robots to partly or fully perform the inspection tasks of power transmission lines[1]~[3]. Most inspection robots are powered by Li battery packs. Due to the limitation of the Li battery capacity, the robot can not work continuously for a long time and requires periodical maintenance. So, continuous long period working ability of robot

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becomes one of the vital difficulties before putting it into practical applications. To solve this problem, on-line power supply system is needed. Several available approaches have been tried on the robot such as laser power supply system, CT power supply system and solar power approach. Merits of laser power supply are the stable supplying of power and could be immune to the effect of bus current change, but due to the limited output power of laser and the low conversion efficiency of photocell, it is not fit for power the robot; solar power system has the same merits as those of laser's but it's performance is strongly effected by weather, and the price of this system is another shortcoming. Current transformer is used to induct power from power transmission lines by most of the researchers in this field. Merits of current transformer are of simple structure, low price, and easy to design, but this approach has its own shortcoming that is surging current in transmission lines. When the bus current is low, the device can not provide enough power for the robot, if the bus current becomes high, the CT would be saturated and heat consumption rises rapidly. Consequently, we must avoid such situations like that the device could not provide enough power for the equipment, or that the device could be destroyed by long time of deep saturation. In this paper, special current transformer will be designed to avoid or eliminate such situations for this application.

Similar work has been done and many means have been tried. In [4], a method to decrease the heat consumption of power supply by controlling the CT ratio is introduced. However, the author provides only two choices of turns of secondary winding, i.e., there are only two separated windings, so the secondary current could only alternate between two dynamic ranges of values. In [5], the author solves the problem of saturation and high heat consumption by introducing an air gap magnetic resistance to the draw-out coils and by matching parameters such as the configuration of the coil, the material of the magnetic core, turn numbers and air gap length. But the equivalent length of magnetic path is not provided by which we could control the permeability value of the current transformer by controlling the length of the air gap dynamically. In this paper, a multi-winding current transformer in introduced aiming at the problems mentioned above, and the experimental results which prove that the designed current transformer could have better performance in inducting power than conventional CT with no variable turns of coils and air gap.

2. Description of the induction unit

The inspection robot is designed for 500KV power transmission lines. In the design of this equipment, factors as insulation property, temperature characteristic and anti-interference ability of both software and hardware are considered, so in this paper, we are not going to talk about these details and we will focus on the design of the power induction equipment, the analysis and design of the current transformer.

Induction unit for power transmission lines inspection robot is equipped on the arm of the robot. Core of current transformer is divided into two semicircles and attached to one arm of the robot. When the robot negotiates with obstacles, the core opens up, moves upward and departs from the transmission line. During the normal inspection operations, the two semicircles will move downward, and close themselves to make a magnetic circuit for induction from the power transmission lines. The power induction unit is shown as Fig.1.

Normal bus bar current on power transmission lines varies between 5 ~ 1000 A, so the induction must be designed to work under this situation. Besides, abnormal situation such as short circuit with high impulse current should be considered to prevent the transformer from being destroyed.