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A Novel Trenchless Detection Technology Based on Transient Electromagnetic Method for Power Poles

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I. Introduction

During the construction of distribution network, base plates, pulling plates, chucks (abbreviated as BPC) and stay wires are supposed to be attached to and buried with the poles in order to keep the poles from descending and tilting. A trenchless detection method is urgently needed to judge if the BPC are set according to construction standard. Transient electromagnetic method (TEM) is a trenchless underground metal detection widely used in the fields of municipal engineering [1], tunnel prediction, [2] and ore layer exploration, etc. But it's not suitable for this application due to its detecting blind zone whose depth ranges from 0 m to 20 m. This paper proposes a novel detection method for the BPC based on exerting external excitations which can solve the problem.

II. Design and Operation Principle

Fig. 1

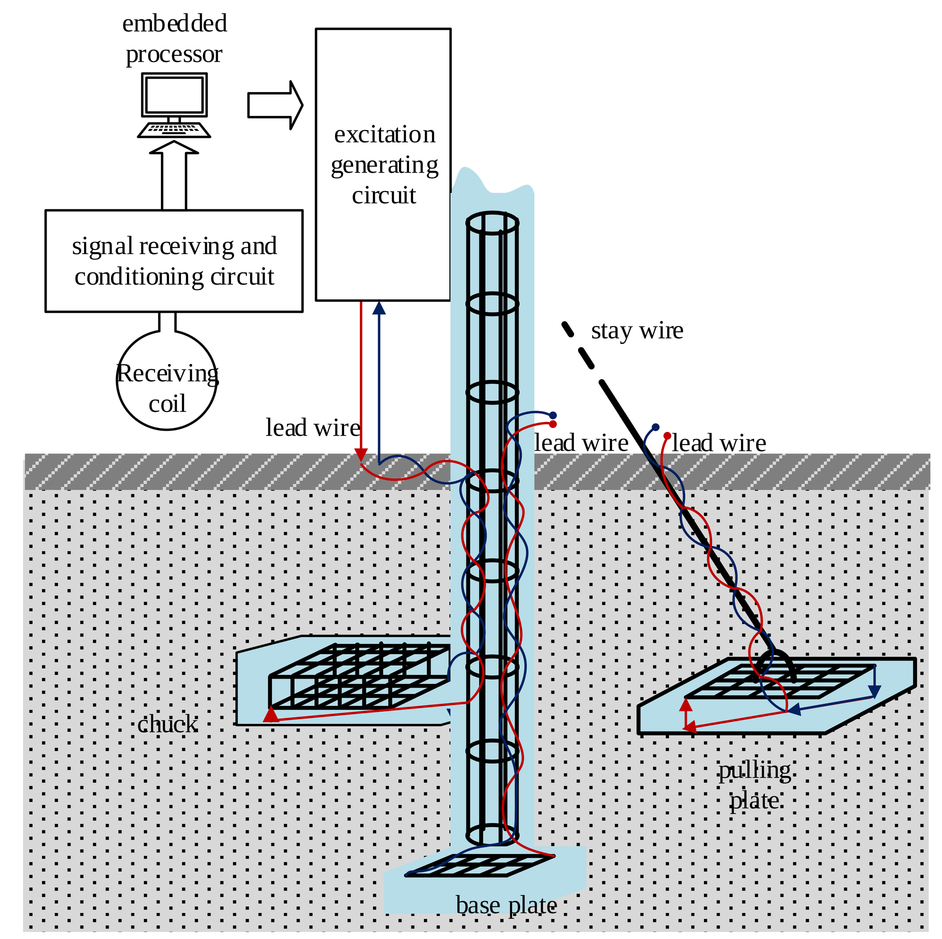


Fig. 2

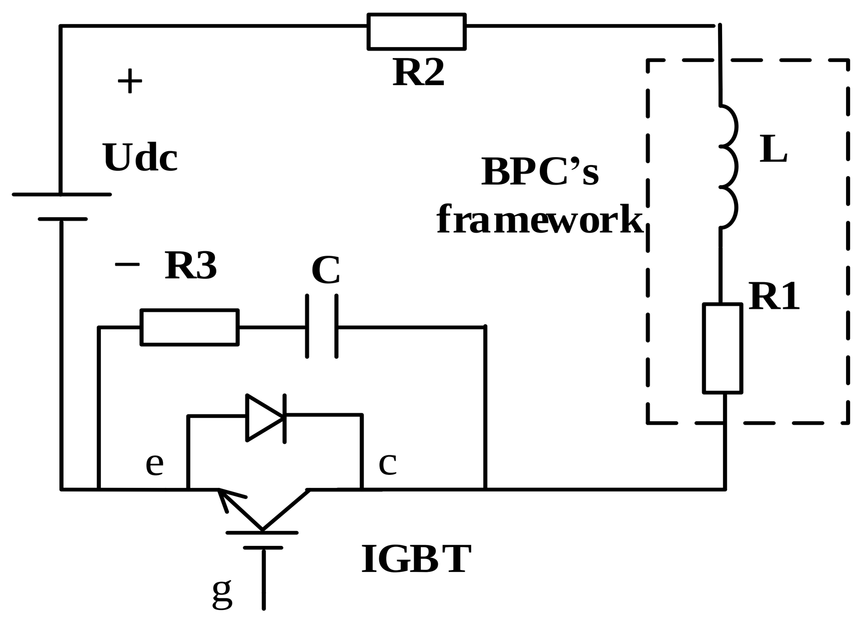
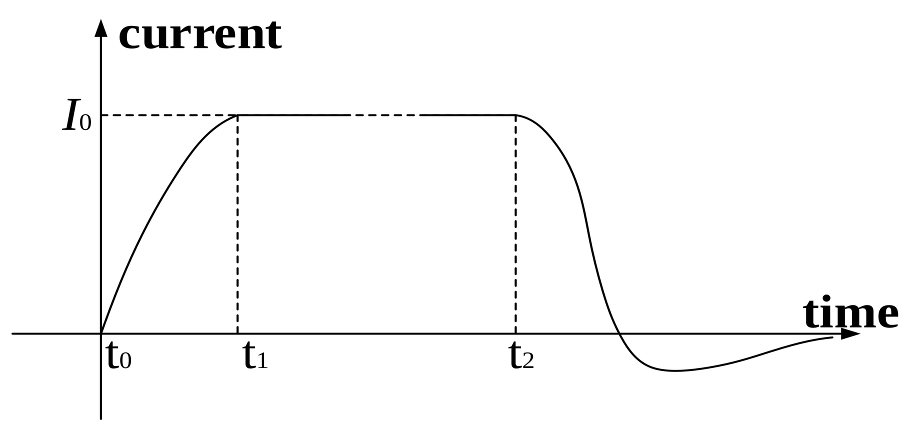


Fig. 3



As shown in Fig. 1, the system is composed of excitation generating circuit, receiving coil, signal receiving and conditioning circuit, embedded processor, and lead wires for the BPC. The lead wires are buried in advance during construction and used as terminals for exerting excitations. The topology of the signal generating circuit is shown in Fig. 2, the excitation current's waveform is shown in Fig. 3.

1) Depth evaluation

Peak value of the receiving coil's signal is used as the criteria for judging the BPC's depth. Assume the coil is in square shape, and its side length is l, the same as the length of the BPC's diagonal line. The excitation current in the BPC's framework is i. The depth of the BPC is d. Turns of the coil is N. The relationship of the receiving signal's voltage Ur and the framework's depth d is shown in equation (1).

$$U_r = \frac{N\mu_0}{4\pi}\bullet\frac{di}{dt}\left[-2l\bullet ar\sinh\left(\frac{2l}{l+2d}\right)+2l\bullet ar\sinh\left(\frac{2l}{2d-l}\right)\right] + \frac{N\mu_0}{4\pi}\bullet\frac{di}{dt}\left[\sqrt{5l^2+4dl+4d^2}-\sqrt{5l^2-4dl+4d^2}-2l\right] \quad (1)$$

2) BPC's condition evaluation

The condition of the BPC can be evaluated by measuring the electrical parameters of its framework. By acquiring the static value of the voltage and current of the BPC's framework from t1 to t2, the resistor of the framework can be calculated. And the inductance of the framework can be derived as equation (2).

$$L_1 = \frac{\int_{t_0}^{t_1} u_1 dt - R1\int_{t_0}^{t_1} i dt}{i(t_1)-i(t_0)} \quad (2)$$

III. Experiments

Fig. 4

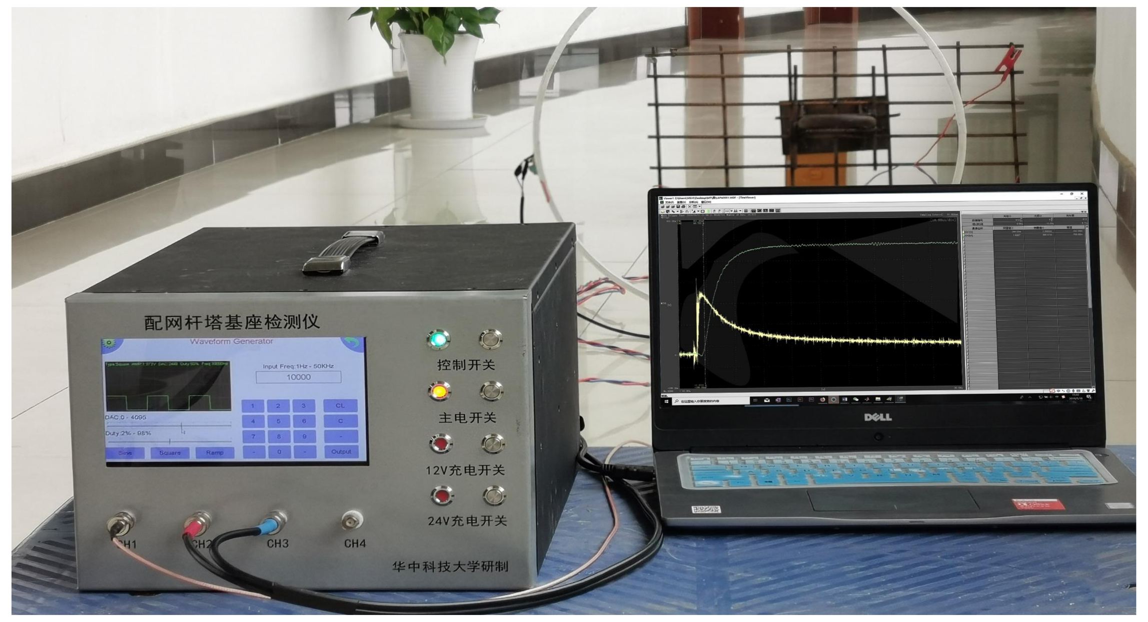
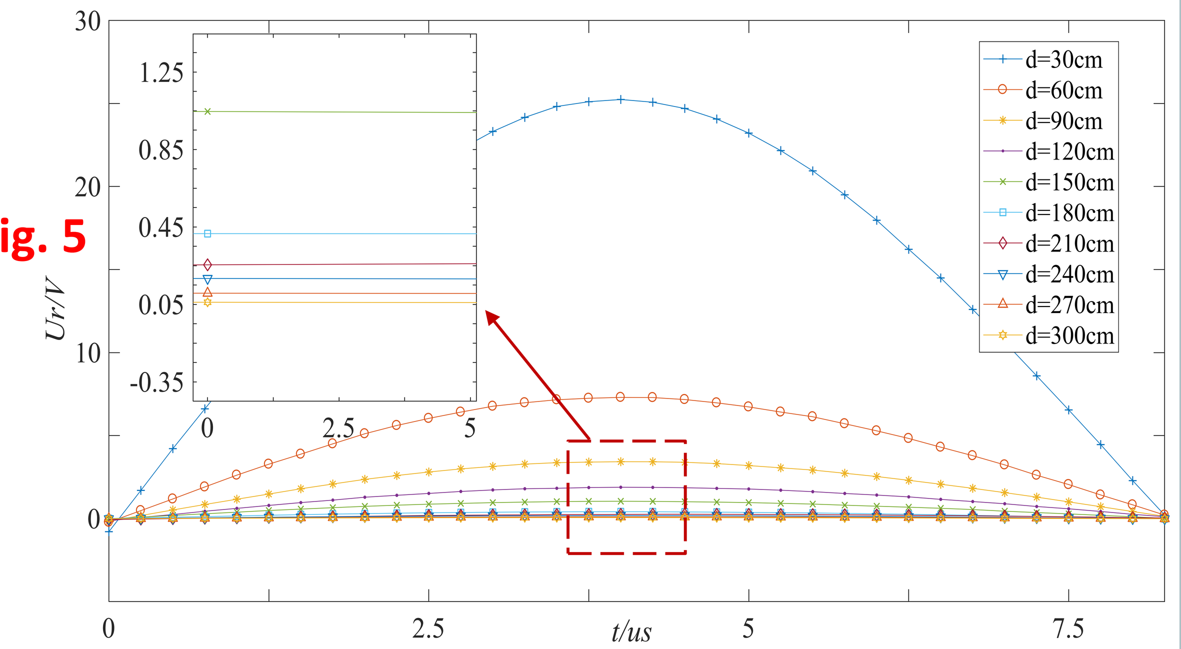


Fig. 5



The experiment platform is shown in Fig. 4. Changing the depth of BPC, the receiving coil's voltage is shown in Fig. 5. The relationship between the voltage's peak value *Ur* and the depth *d* is shown in Fig. 6, which is approximately exponential and fits well with the theoretical *Ur-d* graph.

Fig. 7 shows the graph of the BPC framework's voltage and current during t0 and t1. Take the average value through multiple calculations, its resistance calculated from the experiment data is R1′=1.677 mohms, its inductance calculated by equation (2) from the experiment data is L1′=0.9673 uH. As reference, its resistance measured by HIOKI RM3548 RESISTANCE METER is 1.608 mohms, its inductance measured by HIOKI IM3536 LCR METER is 1.0324 uH, which are basically consistent with the calculated values.

Fig. 6

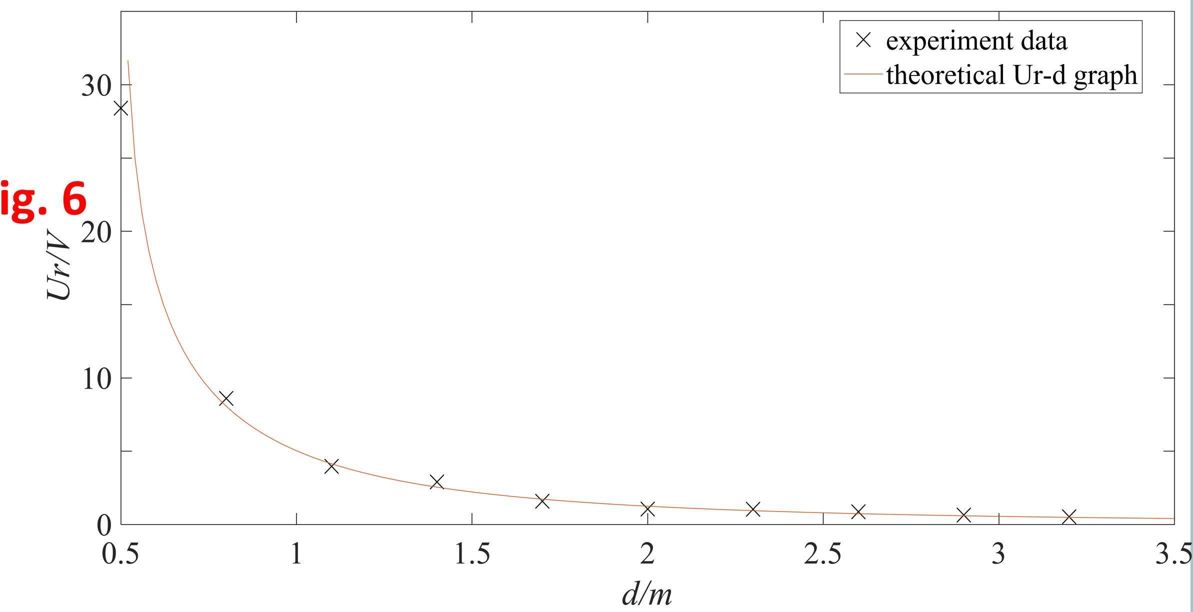
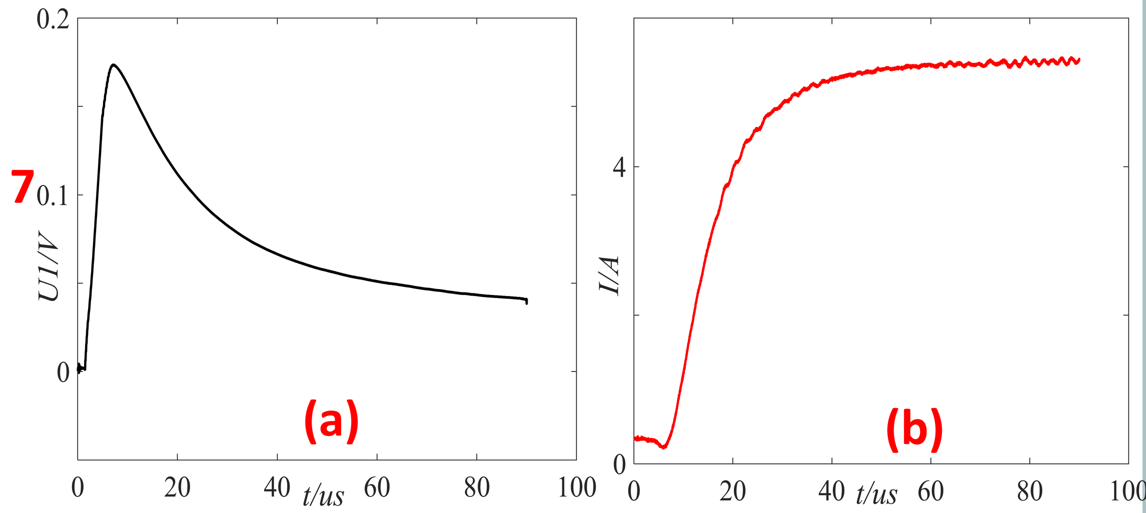


Fig. 7



IV. Conclusion

The relationship between the voltage's peak value U and the depth d is consistent with the theory, thus by storing the receiving signal data of a standard BPC in a database, we can judge if the tested BPC's buried depth meets the installation standard. The resistance and inductance calculated from the experiment data is acceptable and can be used as criteria for evaluating the status of the BPC's structure.

References

[1] Melwaly M, El-Qady G, Massoud U, El-Kenawy A, Matsushima J, Al-AArifiN. 2010. Integrated geoelectrical survey for groundwater and shallow subsurface evaluation: case study at Siliyin spring EI-Fayoum, Egypt[J]. International Journal of Earth Sciences, 99(6): 1437-1436.
[2] Xue G, Yan Y, Li X, Di Q. 2007. Transient electromagnetic S-inversion in tunnel prediction[J]. Geophysical Research Letters, 34(18): L187403.