



Power Stability Expert

Research and Application of Digital Generator Protection Based on Fiber Optical Current Transformer(FOCT)

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INTRODUCTION

02

GENERATOR PROTECTION BASED ON FOCT

03

CONCLUSION

- Stator winding **inter-turn short** circuit protection and **branch open** circuit fault is essential for large generator.
- for most of generators, there is **no room** at neutral point for electromagnetic CT on each group of winding.
- New solution has to be explored: **generator protection based on fibre optical current transformer (FOCT).**



01

Fibre Optical Current Transformer

02

Generator Protection Scheme Based on FOCT

03

Operating Time of Differential Protection

04

Sensitivity of Differential Protection

05

Issues Related to frequency

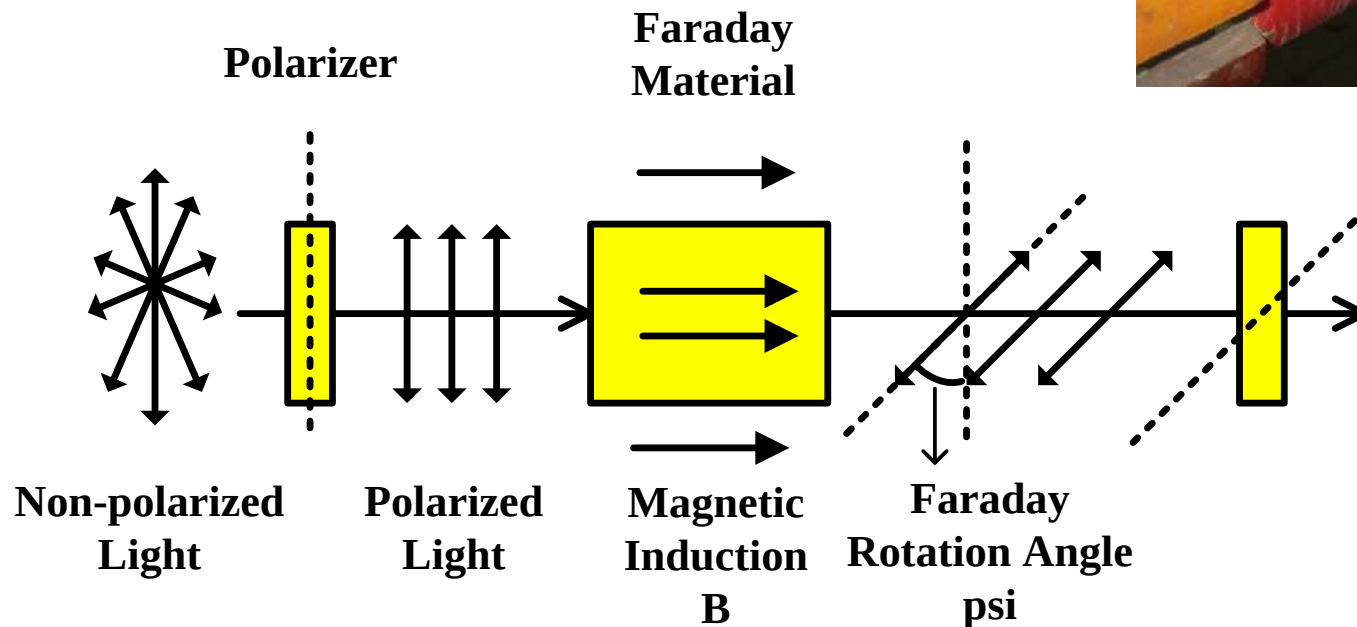
06

Field Practice

1. Fibre Optical Current Transformer



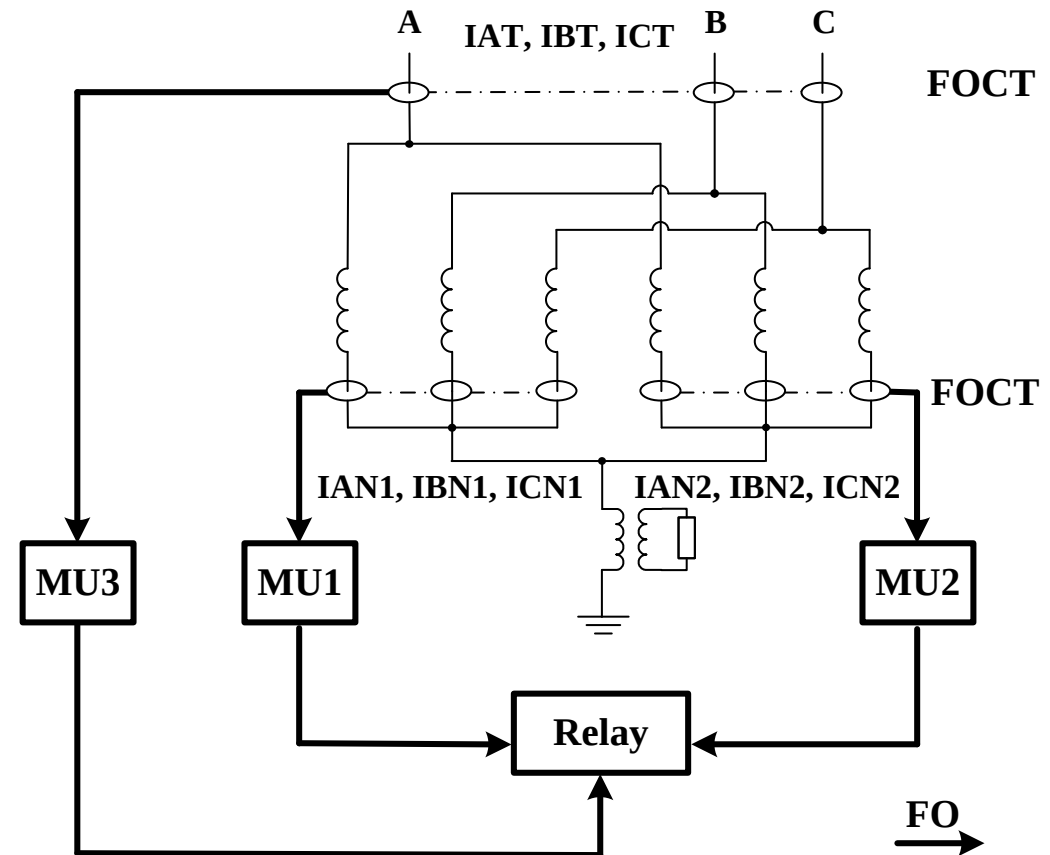
- Faraday magnetic optical effect
- Sensor of FOCT → Fibre optic cable
- Space saving
- Convenient installation



2. Generator Protection Scheme Based on FOCT



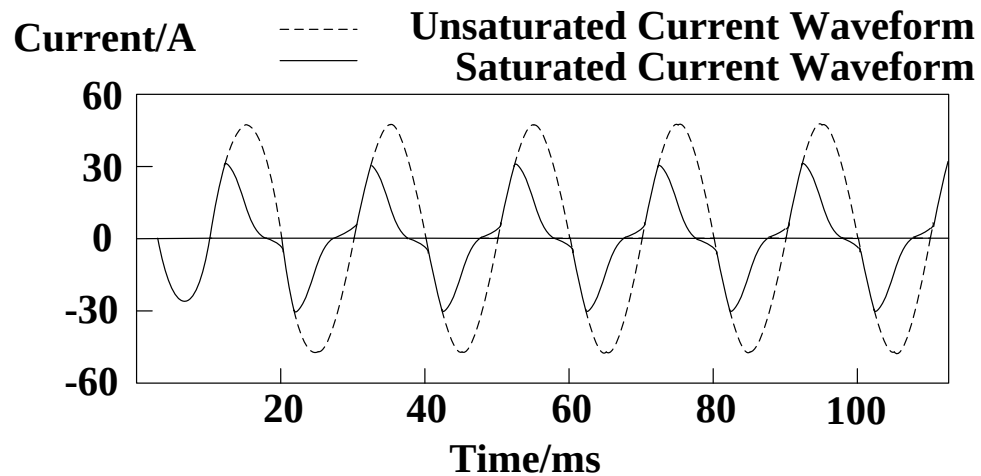
- Multi-differential protection
 - Phase differential protection
 - Partial differential protection
 - Phase-segregated transverse differential protection
 - Unit transverse differential protection
- Stator winding **inter-turn short circuit** fault
- Stator winding **branch open circuit** fault



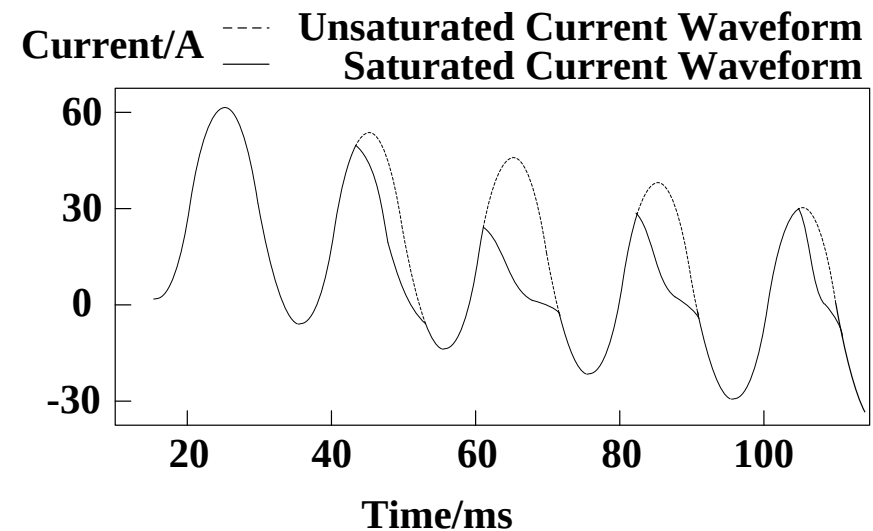
3. Operating Time of Differential Protection



- conventional electromagnetic current transformer
 - CT saturation → CT saturation identification → Prolong operating time
- FOCT
 - No saturation → No saturation identification → shorten operating time



(a) Steady-state Saturation

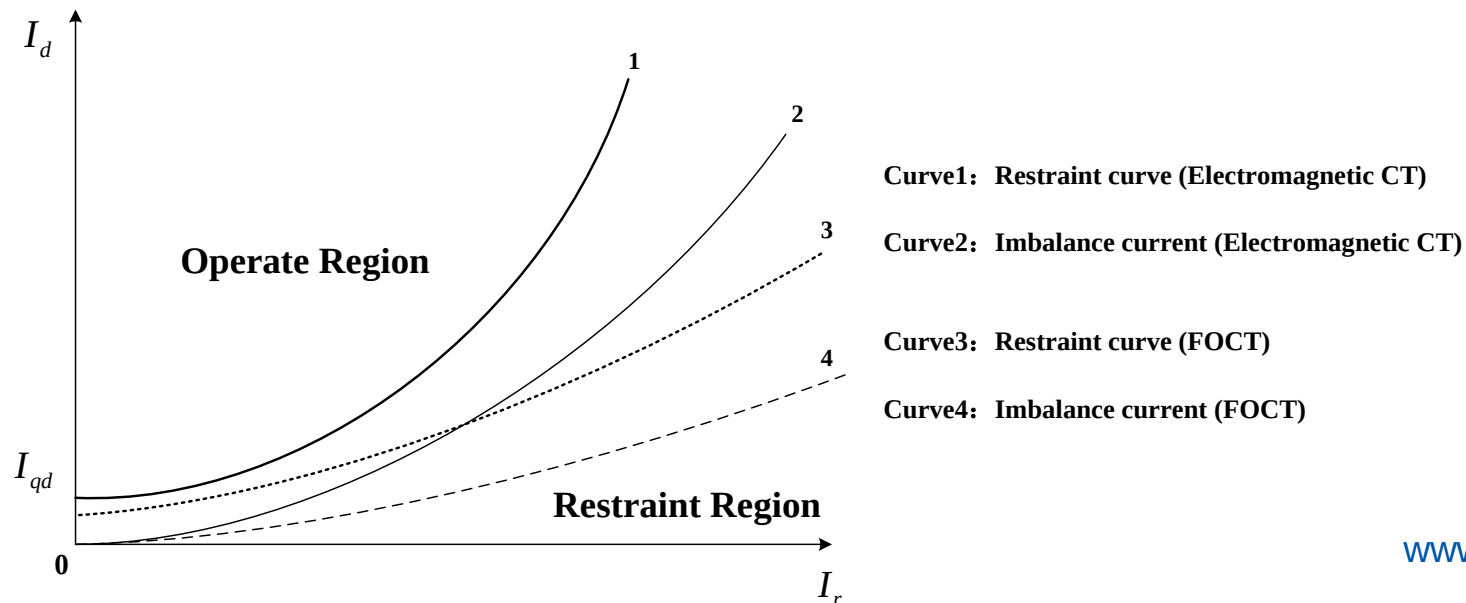


(b) Transient Saturation

4. Sensitivity of Differential Protection



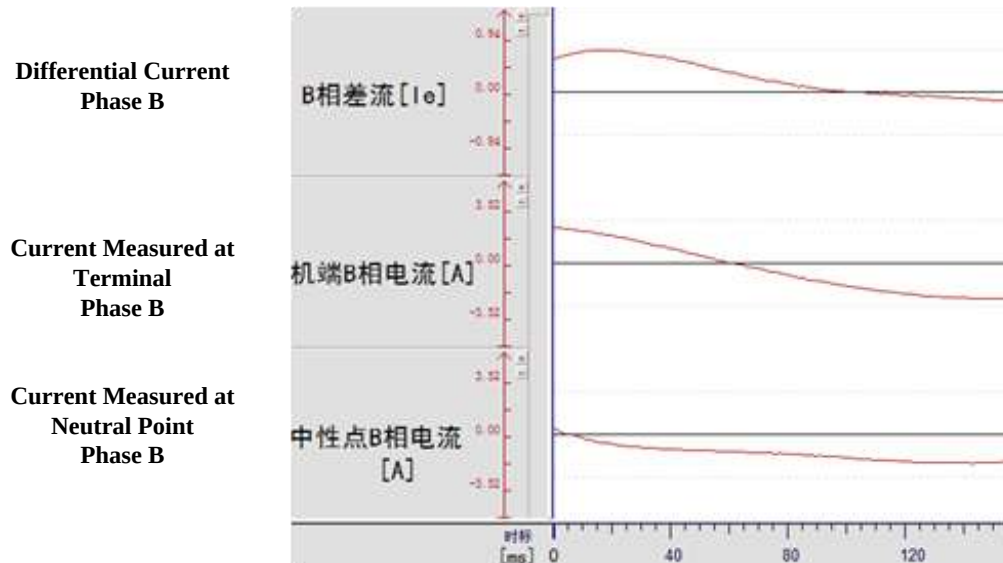
- conventional electromagnetic current transformer
 - Different CT transformation characteristics → High percentage restraint characteristic → Low Sensitivity
- FOCT
 - No saturation and fewer imbalance current → High percentage restraint characteristic → High Sensitivity



5. Issues Related to frequency



- conventional electromagnetic current transformer
 - Frequency $< 5\text{Hz}$ $\rightarrow$ CT saturation $\rightarrow$ Differential current is no expected $\rightarrow$ Low operating performance
- FOCT
 - Transform DC and AC $\rightarrow$ Better performance for wider frequency range



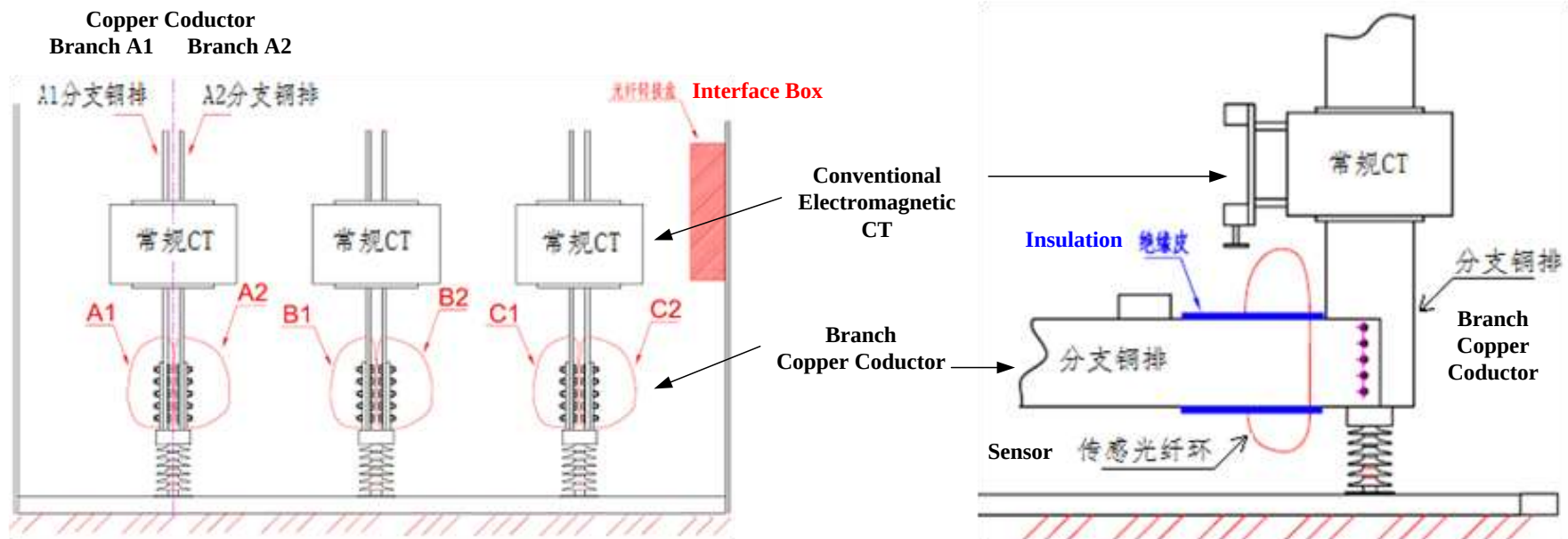
Frequency (Hz)	Injected Current (A)	Measured Value by FOCT (A)
3Hz	60.0	60.13
50Hz	60.0	60.12

Performance of **FOCT**

Secondary Current Waveform of **Electromagnetic CT** at **3Hz**

6. Field Practice

- Shahe Pump-storage Power Plant, China
 - 50MW generator, two stator winding branches
- Others
 - 300MW steam turbine generator, 600MW hydro turbine generator



- FOCT's sensor can be wound on conductor in any shape in a narrow space.
- Facilitate optimization of generator protection scheme against stator winding inter-turn short circuit fault and branch open circuit fault.
- Improve the performance of differential protection in operating time and sensitivity.
- No saturation, Good low-frequency response.

Thanks for Your Attention!

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