Physica C 494 (2013) 339–343

Contents lists available at SciVerse ScienceDirect

Physica C

journal homepage: www.elsevier.com/locate/physc

Limiting characteristics of the superconducting fault current limiter applied to the neutral line of conventional transformer

I.G. Im, H.S. Choi *, B.I. Jung

Dept. of Electrical Engineering, Chosun University, 309 Pilmun-daero, Dong-gu, Gwang-ju 501-759, Republic of Korea

ARTICLE INFO

Article history:
Received 19 January 2013
Received in revised form 24 April 2013
Accepted 26 April 2013
Available online 13 May 2013

Keywords:
Transformer
Superconducting
Fault current limiter
Quench

ABSTRACT

The increased electricity demands influenced by the recent industrial development make the electric power distribution system more comprehensive, and the risks are high to cause failures to steady state electric line due to the extended range of fault at the time of fault occurrence. Also, the high performance and the high precision electric appliances that sensitive to switching surge and fault current expose vulnerability of reduced life span and increased fault occurrence ratio. Therefore, this thesis analyzed the fault limiting characteristics by the fault types by applying the superconducting fault current limiter to the neutral line of the transformer in order to reduce the fault currents that flow such high performance appliances. A current transformer (CT) that detects the fault current in the simulated power distribution system, a switching control system that is self-developed and a transformer are used in constructing a circuit. When a fault occurs, the initial fault current is restricted by the superconducting fault current limiter and simultaneously detours the fault current by operating the SCR contact of the switching control system through the detection by CT. This thesis analyzed the limiting characteristics of the superconducting fault current limiter that are applied to the neutral line of the transformer by the fault types.

1. Introduction

Discovery of electric energy contributed to the fast development of industry. The electric energy is significant as it does not produce harmful substances, converts effectively into other energies, etc. However, it is being used along with other equipment such as protective relays and circuit breakers due to its high risk. While the electricity demand increases and extends, the circuit breaker still sticks to the conventional methods. Various measures are currently under consideration to solve the fault current problems according the electric power system, and researches and developments are going on the fault current limiter using the superconducting element. The superconducting elements are characterized with zero resistance at critical temperature have no losses in power transmission and distribution lines and have merits that can protect various appliances and devices according to its installation positions. When a fault occurs to the superconducting fault current limiter at the superconducting state, quench occurs when the superconducting element exceeds the critical characteristics. Then, the resistance of the element increases and limits the fault current [1,2]. That is, the application of the superconducting fault current limiter in the electric power system uses the process that the superconducting state transfers to the normal conducting state. This thesis analyzed the characteristics of limiting characteristics of the superconducting fault current limiter by the fault types to limit the fault current generated when a fault occurs by applying the superconducting fault current limiter to commercial transformers and to protect electric appliances and devices.

2. Experimental data

Fig. 1 shows a circuit diagram of the superconducting fault current limiter applied to the neutral line of the 3-phase transformer [3–5]. The experiment uses 240 V as the applying voltage. When the applying voltage flows into through SW-R1, SW-S2, and SW-T1, the current flows on the first coil of the transformer and the voltage is abandoned at the second winding. Table 1 shows the inductance of the 3-phase transformer coils and the turn ratio of the transformer was set at N_P:N_S:N_T = 3:2:1 in order to observe the characteristics of the current that are supplied to the load. The CT was installed to detect the fault current at the second winding and the SCR control system operates the SCR when the fault current was detected. The occurrence of the fault current was simulated using the SW-R2, SW-S2, and SW-T2 switches, and the faults were occurred at a single, double, triple line-to-ground fault and a double, triple line-to-line fault. Table 2 shows the specification of the superconducting element used in the fault current limiter; the superconducting fault current limiter limits the fault current when a fault occurs, the SCR-b of the neutral line

* Corresponding author. Tel.: +82 062 230 7025; fax: +82 062 230 7020.
E-mail addresses: asiligo@gmail.com (I.G. Im), hyosang@chosun.ac.kr (H.S. Choi).

0921-4534/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.physc.2013.04.082

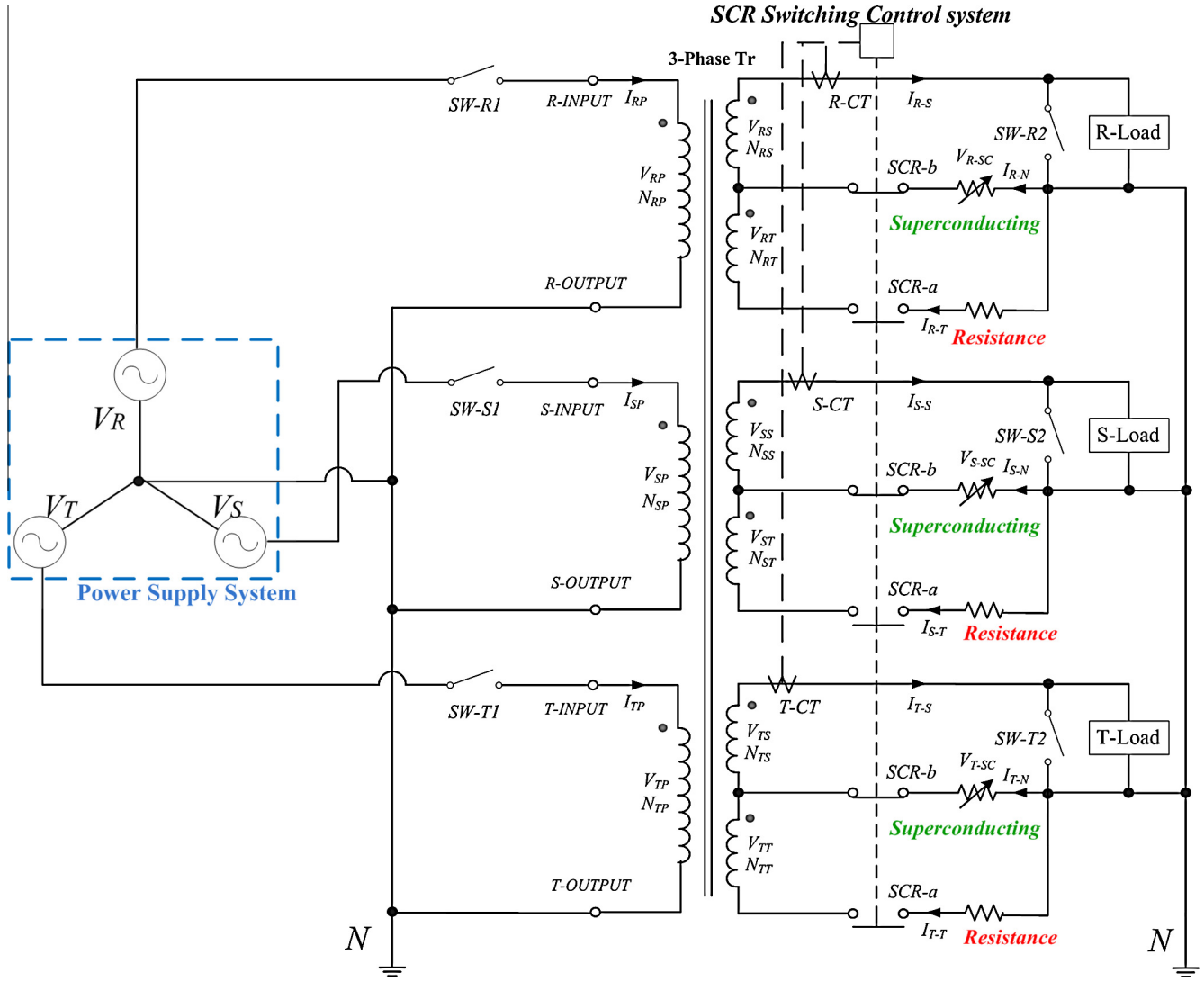

Fig. 1. It shows a circuit diagram of the superconducting fault current limiter applied to the neutral line of the three-phase transformer.

Table 1
It shows the inductance of the 3-phase transformer coils.

Coil	R-phase inductance (mH)	S-phase inductance (mH)	T-phase inductance (mH)
Primary	6.02	7.73	4.90
Secondary	4.01	5.12	3.26
Third	2.00	2.55	1.63

Table 2
Specification of the superconducting element (YBCO thin film).

Parameter	Value	Unit
Diameter	25.4	mm
Width of a line	2	mm
Length	540	mm
YBCO thickness	0.3	μm
Au thickness	0.1–0.2	μm
Critical current	20	A
Resistance	28	Ω

simultaneously turns off, the SCR-a of the third winding turns on, and the fault current is limited by the normal conducting fault current limiter. The fault cycle was set at 5 cycles and the fault limiting characteristics of the superconducting fault current limiter was analyzed. The principle of current limitation was shown in Refs. [6,7].

2.1. Experimental results and discussion

When the faults with 5 cycle occurred by applying 240 V, the limiting characteristics of the superconducting fault current limiter was analyzed by the fault types. Fig. 2 shows the limiting characteristics of the superconducting fault current limiter by the fault types. Fig. 2a shows the limiting characteristics of the superconducting fault current limiter when a single line-to-ground fault. The normal state current was measured at 2.93 A. The fault current rose after the fault occurred and limited at 42.03 A due to quench of the superconducting element, and the switching operation of SCR made the fault current detoured and limited at 8.68 A. Fig. 2b shows the limiting characteristics of the superconducting fault current limiter when a double line-to-ground fault occurs. The steady state currents was measured as 2.91 A at R-phase and