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A Novel Technique for Fault and Lifetime Self-Diagnosis of Closed Transition Transfer Switch using Dual Lines

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This paper proposes a dual-line closed transition transfer switch (CTTS) and a technique for fault and lifetime self-diagnosis. The proposed system consists of the dual-line CTTS, a closed transition operator, active and inactive channel inspectors that extract the switch characteristics, and a self-diagnosis block for fault and lifetime of the switch using the characteristics. The system controller coordinates the inspection and diagnosis based on a schedule.

The proposed dual-line CTTS has an active channel connecting one input and output, and an inactive channel which has no connection. There are parallel main and sub switches in each phase and they constitute the dual lines, which can be used selectively. The switch characteristics in the active channel are obtained by detecting current variation in each line because the current flows in the channel. Whereas, those in the inactive channel are obtained by detecting voltage variation in each line because there is no current flow.

The inspection procedure of the active channel is as follows. The two switches in each dual-line phase are turned on or off according to the defined sequence. At this time, the inspection does not affect the fundamental operation of the CTTS because at least one switch should maintain the connection. The current signals of the two lines may change according the combination of the switch condition. Thus, the health information of the switches such as the operation speed and current division level between the two lines is obtained from the current signals. However, it is difficult to detect the current variation effectively because the current signal is AC type. For this reason, the current signal is transformed to the useful DC type signal by the axis transformation with the phase information. It was verified that the current variation was detected so fast and precisely with this method.

Meanwhile, the inspection procedure of the inactive channel is as follows. Because every phases in the channel share the output with the active channel, the voltage of any phase in the active channel can be transferred to the inactive channel when the corresponding switch turns on. The operation speed characteristics are obtained by detecting the voltage variation. At this time, the cross voltage sensing method is used, which measures phase voltages of the inactive channel based on the neutral line voltage of not the inactive channel but the active channel. Similarly, the voltage signal is also transformed to the useful DC type.

The closed transition operator consists of two synchronous reference frame phase-locked loops (PLL) finding the phase of each channel, a synchronization detector, and a switch sub-controller. The phase information of each channel is obtained by the PLLs based on the Clarke and Park transformation. The two phases are considered to be synchronous when the difference is less than 5 degrees. By the transition command, the CTTS changes the input source at the synchronized point through one or two cycles of overlap period.

The proposed dual-line CTTS and self-diagnosis were verified by the PSIM simulator. The closed transition was successful although the frequencies of the two sources were different. The current and voltage were transformed to the DC type signals precisely during the inspection. Consequently, the signal variation was detected fast so the switch characteristics and even fault problem were detected fast as well. Therefore, the self-diagnosis was verified to be effective during the operation of the CTTS.

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