The Study of the Practical Application of Busbar Automatic Transfer Switch

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Abstract. Busbar automatic transfer switch, which is abbreviated to BATS, is a normal automatic safety device in power system. However, many dispatchers do not have sufficient understanding of this device. When fault happens, these dispatchers could hardly judge whether the BATS acts correctly. This paper proposes the frequently asked questions about BATS and the solving approaches to make sure the stable operation of the power grid.

1. Introduction
To meet the needs of open-loop of electromagnetic loop network, the designers of the substations always use single power supply. This mode would significantly reduce the supply reliability. Experience over the past years has proved that many substations lose power in this single-mode. The success rate of BATS is traditionally so high that, no matter for substation or power plant, it could significantly increase the supply reliability of them. Hence, it is important to study on the principle and the action method of the BATS. The study plays an important role in power grid fault handling.

2. The Basic Requirements and Types of BATS

2.1. Basic Requirements of BATS
• After the power supply is lost, the BATS would permit the breaker of the back-up power supply to act only once.
• The back-up power supply should be locked when the voltage does not decrease incredibly, and the working power supply should be shutdown when the voltage decreases to almost zero.
• When the fault is on the bus, in order to insulate the faulted bus, the BATS should be locked.
• As long as the voltage decreases to almost zero and is not recovered after a set time, no matter for what reason, the BATS should act. The only exception is the fuse burn-out of the voltage transformer.

2.2. Three Types of BATS

2.2.1. BATS for Incoming Circuit Line
As is shown in Fig.1, this type of BATS is correlated to three breakers, which are Breaker 121, Breaker 122 and Breaker 120. For the 110kV substation in Fig.1, the Breaker 122 is in the ON position, and the Breaker 121 is as the back-up one. After the action of BATS, the operating mode is totally different, as is shown in Fig.2. The Breaker 122 opens and then the Breaker 121 closes.

2.2.2. BATS for Section Breaker
As is shown in Fig.3, this type of BATS is also correlated to these three breakers. When the fault happens on Line 121, the distance protection on the other side of Line 121 acts, then the BATS on this side acts. The status of the breakers is as shown in Fig.4. The process is similar to the process in 1.2.1, Breaker 121 opens first and the Breaker 120 closes then.
2.2.3. **BATS for Transformer**

As is shown in Fig. 5, Transformer #1 is as the back-up transformer. When the fault happens, the status of the breakers and transformers is as shown in Fig. 6.

![Figure 5. Status of Breakers when BATS of Transformer.](image1)

![Figure 6. Status of Breakers when BATS Acts.](image2)

### 3. Case Analysis

The YanXi substation is the wiring method of Single bus segment, the transformer is the breakdown operation, and busbar automatic is the segmented mode.

#### 3.1. Normal Action of BATS

The operating mode of Yanqi Substation is as shown in Fig. 7. Its 110kV bus operating mode is single-bus with two section. Its transformer operating mode is independent operation. Its BATS is for section breaker.

When permanent fault happens on Line Huaiyan1152, the dispatchers would get the alarm information as shown in Fig. 7. Briefly, for Substation Huaide, which is on the other side of Line Huaiyan1152, first the line protection acts and the breaker opens, then the re-closing acts but fails, and the breaker opens again. Finally, the breaker of Line Huaiyan1152 in Substation Huaide opens. For Substation Yanqi, Line Huaiyan1152 satisfies the action condition of BATS, which is voltage zero and current zero. Hence, for Substation Yanqi, Breaker 1152 opens and Breaker 1112 closes. The alarm information about the breakers is shown in Fig. 8.

![Figure 7. Breaker Action Information of Substation Yanqi.](image3)
This case shows how BATS of Substation Yanqi acts normally when permanent line fault happens on Line Huaiyan1152. The distance protection II of the Substation Huade acts and the breaker opens. Then the re-closing device acts, while the fault is still on the line, and the breaker opens again. The line satisfies the action condition of BATS, and then the BATS on this side acts correctly and there is no load loss.

3.2. Abnormal Action of BATS

Here is another case about BATS action. In this case, the BATS acts correctly, but it would be better if Breaker 1112, which is the 110kV section breaker in Substation Yueya, does not follow the order made by BATS. The operating mode of Substation Yueya is as follows. Line Qingyue takes the load of Substation Yueya, with section breaker closed. Line Siyue is as the back-up incoming line. The transformers are in independent operation.

While the permanent fault happens on 110kV Bus I of Substation Yueya, the operating mode after that is as shown in Fig.9. The alarm information and the information about the status of breakers is shown in Fig.10.
Because there is no bus protection in Substation Yueya, when the fault is on 110kV Bus I, the line protection on Line Qingyue in Substation Qingchen would act. Even though Substation Qingchen is not shown in Fig.10, it is clear that the substation is on the other side of Substation Yueya. Similar to the case described above, the re-closing of Line Qingyue would act but fail, and finally the breaker of Line Qingyue in Substation Qingchen opens again. It satisfies the action condition of BATS in Substation Yueya, Breaker 1151 in Substation Yueya opens, and Breaker 1112, which is the section breaker in Substation Yueya closes. However, as the fault is on 110kV Bus I, the over-current protection of the section breaker would act and the breaker would open again. Eventually, the fault is isolated.

4. Key Skills of BATS

4.1. 110kV BATS should be blocked after the transformer differential protection acts
The transformer differential protection acts when the fault is in the transformer. If the 110kV BATS acts, the fault would not be isolated. The transformer would be impacted for the second time, even though the section breaker would open again after the BATS acts.

4.2. 110kV BATS should be blocked after the back-up protection of the line on the other side acts
The back-up protection of the line acts when the fault is on the 110kV bus. If the 110kV BATS acts, the fault would not be isolated. The bus and even the substation would be impacted for the second time, like the phenomenon in Case 2.

4.3. The setting time of the capacitor, re-closing, and BATS
According to the cases shown above, the setting time of BATS is the longest. Then that of re-closing, and then that of the capacitor. According to the alarm information, it is obviously that when fault happens, the voltage turns to zero immediately, and the voltage protection of the capacitor acts. After that, the re-closing acts. If the fault is not a permanent one, the re-closing would success and the breaker would close. If it is a permanent fault, the BATS would act then.

4.4. Over current protection of the section breaker would act when the BATS acts abnormally
As is shown in Case 2, when the fault is on the bus and the BATS acts, the over current protection of
the section breaker would act to isolate the fault.

4.5. The protection of the line on the other side is not the only protection to isolate the fault on the bus

As is shown in Case 2, the protection of the line on the other side acts when the fault is on the 110kV bus. However, even if this protection rejects to act, the back-up protection of the transformer would act to isolate the fault. The reason why it does not act in Case 2 is that its setting time is longer than the protection of the line on the other side. When the fault happens on the bus, the protection of the line on the other side acts first. Only if it fails to isolate the fault, the back-up protection of the transformer would act.

5. Conclusion
BATS is one sort of automatic. This paper introduce the principles and the types of BATS. Meanwhile, it provides two typical cases to show how BATS acts when fault happens. By introducing the cases, this paper concludes the key skill items of BATS.

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