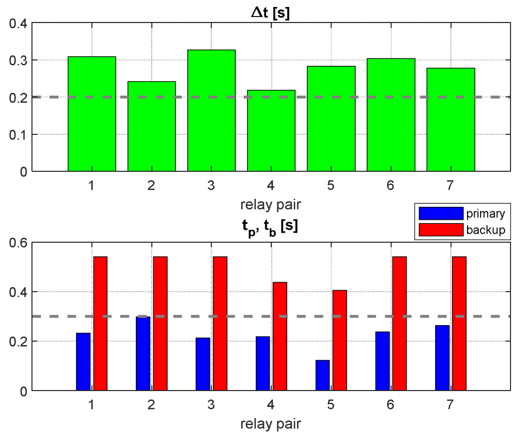

Fig. 9. Δt_r values and operating times – case B.

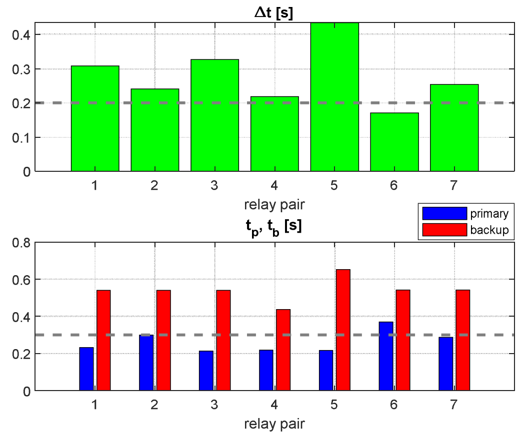

Fig. 10. Δt_r values and operating times – case C.

Case B: The OCRs setting, as well as Δt_r values and operating times were determined using constant WTG impedance. The results are shown in Fig. 9. Selectivity is achieved, as well as required operating times of primary OCRs.

Case C: The OCRs setting were determined using constant WTG impedance, which is typically used. However, Δt_r values and operating times were determined using non-linear WTG impedance. The results are shown in Fig. 10. Selectivity is questionable, since $\Delta t_6 < CTI_6$. Furthermore, the operating time of R_{32} is higher than 300 ms.

5. Conclusion

The proposed short-circuit impedance model for WTG is based on mean short-circuit current magnitudes, combining the type 3 and type 4 WTGs. Note that the proposed model is given only for the comparison with the constant impedance-based model, which is typically used for timing coordination of OCRs operation. Next, a fundamental 6-bus radial network topology was considered with an additional WTG. The timing coordination of OCRs was performed using the DE algorithm. The obtained results show that when using the constant impedance-based WTG model, the short-circuit currents were overestimated within the range between 26% and 44%. Consequently, the operation of OCRs might be affected when using this model for timing coordination. It is shown that the sensitivity of OCRs might be reduced, whereas the selectivity might also be questionable. Further work should evaluate the impact of WTG models on OCRs operation for more complex topologies, like e.g. IEEE 14-bus network.

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