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Transient Operation Algorithm of CVCF Inverter-based Micro-grid System

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1. Introduction

- In the operation of CVCF inverter-based MG system, phenomenon of energy sinking can be occurred when the total output power of RES is greater than total customer loads in off-grid MG system.

- The voltage of the battery system in CVCF inverter to form MG system can rapidly increase depending on the SOC condition, and then blackout in the entire MG system might be occurred due to the shut-down of CVCF inverter.

- This paper presents transient operation algorithm based on 3 operation modes, in order to prevent the shut-down of CVCF inverter with the energy sinking phenomenon in advance.

2. Transient operation algorithm of CVCF MG system

- Non-critical transient operation mode : SOC and voltage of battery system can not exceed operation limit of SOC and operation maximum voltage.

- Critical transient operation mode : SOC and voltage of battery system exceed operation limit of SOC and operation maximum voltage.

- Restoration operation mode : Curtail appropriate amount of PV system ($P_{PV-curt}(t)$), and the MG system restores to normal operation mode.


Fig. 1. Transient operation algorithm of CVCF inverter-based MG system

3. Modeling of CVCF inverter-based MG system Using PSCAD/EMTDC

- The entire modeling of a 30 kW CVCF inverter-based MG system, which is composed of 30kW CVCF inverter, 20 kWh Li-ion battery, 20 kW PV system and 30 kW customer loads, in order to maintain CVCF operation.

Fig. 2. Modeling of entire MG system

4. Case studies

- In order to confirm the usefulness of the proposed algorithm for the transient operation in a CVCF inverter-based MG system, this paper assumes the configuration of 30kW CVCF inverter-based MG system.

Table 1. Simulation conditions

	items	conditions
battery (rack)	cell-type	ICR 18650-22F (32S84P)
	voltage operation range of(BMS)	89.6 ~ 34.4[V]
	setting of SOC_M	85[%]
	voltage operation range of(DC input)	90 ~ 134[V]
	rated capacity	30[kW]
CVCF inverter	AC output voltage & frequency	220±6%[V] & 60±0.2[Hz]
	setting of V_M	131.8[V] (η=0.95)
	customer load	6 [kW]
	PV system	0 ~ 18[kW]

- When the energy sinking occurs at 90% SOC of battery system with the lack of operation margin, it is confirmed that voltage of CVCF inverter can rapidly increase from 128.8 V to 134 V, and then the inverter may result in shut down due to the violation of the allowable voltage limit of 90~134 V.
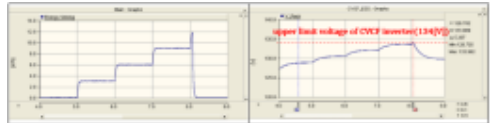
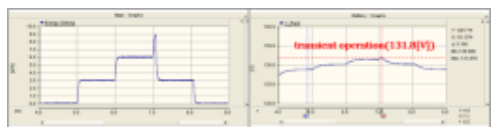(a) energy sinking profile   (b) voltage profile of battey
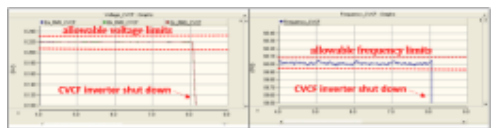
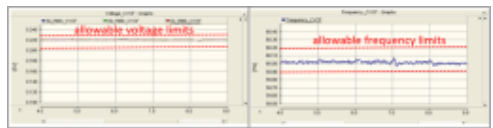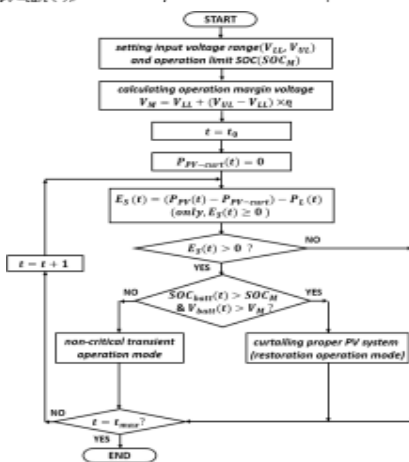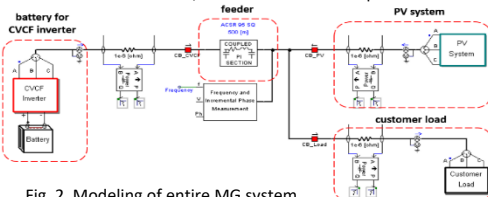(c) volatge profile of MG system   (d) frequency profile of MG system

Fig. 3. Characteristics of non-critical transient operation mode(Case I)

- When voltage of the battery system reach to the setting value, PV systems are starting to curtail 3 kW units step by step according to proposed algorithm to restore the non-critical transient operation mode.

- From the restoration procedures it is clear that the magnitude of energy sinking and voltage of the battery system are being simultaneously reduced and maintained within the proper operation range.

(a) energy sinking profile   (b) voltage profile of battey

(c) volatge profile of MG system   (d) frequency profile of MG system

Fig. 4. Characteristics of restoration operation mode(Case II)

5. Conclusions

- This paper has proposed the transient operation algorithm for a stable operation of 30 kW CVCF inverter-based MG system to prevent the shut-down of the inverter despite the energy sinking phenomenon in advance.