Study Committee A1
Rotating Electrical Machines
Paper A1_10740_2022

New Proposal of the M-G Set with Renewable Energy and Storage Battery

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1. Motivation

- ✓ In Japan, renewable energy (RE) such as wind turbines (WT) and photovoltaics (PV) has been increasingly integrated into the power grids.
- ✓ Due to the large-scale introduction of RE, the number of synchronous generators (SG) in the power grids will decrease, which may make it difficult to maintain the power system stability.

2. M-G Set with Renewable Energy and Storage Battery

2.1 Outline of the M-G set with RE and SB

- ✓ Motor M is driven by the RE and storage battery (SB), generator G generates electricity to the power system.
- ✓ SB can reduce the active power rapidly after the grid fault for transient stability in addition to governor-free operation.

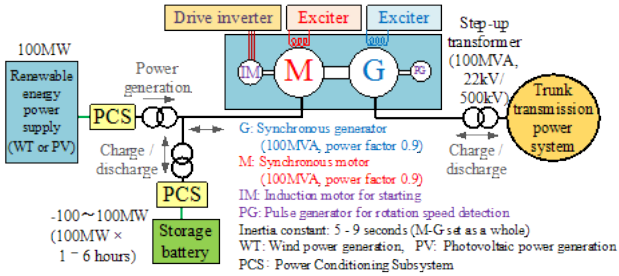

Fig.1. Introduction example 1 of M-G set with RE and SB

- ✓ The capacity of the M-G set does not necessarily have to be larger than the RE rating(Fig.2.).

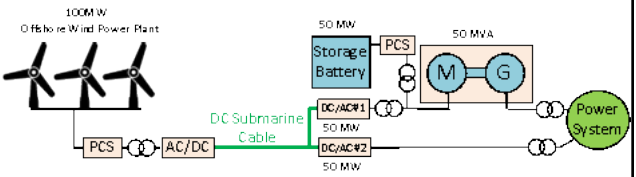

Fig.2. Introduction example 2 of M-G set with RE and SB

2.2 Features of the M-G Set with RE and SB

- ✓ SG contributes to power system security(Table.1).
- ✓ Active power control by SB.
- • M-G set can be operated as both generator and motor.
- • M-G set can reduce the active power rapidly after the grid fault without disconnecting the generator.
- ✓ By connecting the M-G set in series with the grid, only SG is seen from the grids.
- • <u>The risk that the RE and SB trip or the active power decrease due to voltage dip can be reduced.</u>
- • <u>It is possible to increase only the ratio of SG without increasing the ratio of RE.</u>

Table.1. Contribution to Power System Security by Synchronous Generator

Features of large-capacity generators	Contribution to power system security
The active power output can be adjusted according to the frequency	Frequency
	Power System Stability
It has an inertial force (with a constant of about 8 seconds)	Frequency
	Power System Stability
It does not stop due to instantaneous voltage drops (when the voltage drops momentarily) during a power system fault	Voltage
	Power System Stability
The voltage of the trunk transmission power system can be adjusted	Voltage
	Power System Stability

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3. Example of Simulation

3.1 Simulation conditions

- ✓ Simulations confirming the contribution of SG and SB (especially fast charging by SB)

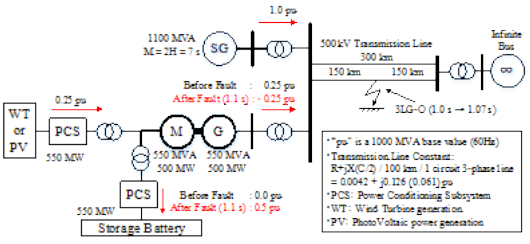

Fig.3. Simulation Model

3.2 Simulation results

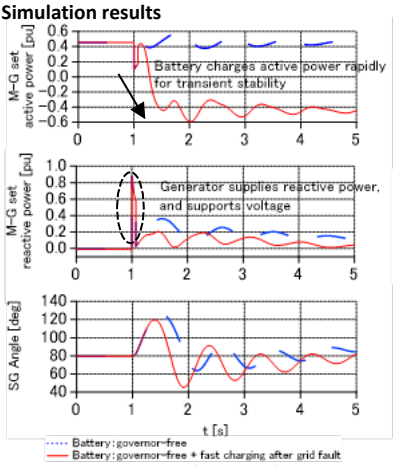

Fig.4. Simulation Result

4. M-G Set Demonstration Equipment

- ✓ The rated capacity of M-G set is 100 kVA and electrical characteristics is close to practical(100MVA or more) machine.
- ✓ SB can be charged at high speed after fault.
- ✓ The M-G set demonstration equipment can also be operated as a synchronous condenser + RE +SB.
- ✓ Ground fault can be simulated by demonstration equipment.

Fig.5. Outline of Demonstration Equipment

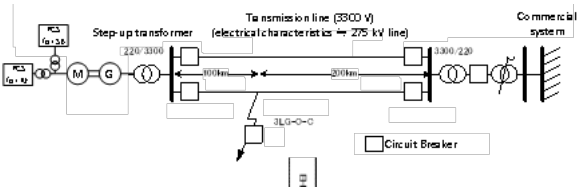

Table.2. Outline of M-G set Demonstration Equipment

Device Name	Specification Summary
Synchronous Generator(G) Synchronous Motor(M)	Rating 100 kVA, 4poles, Xd=1.7 pu, Xd'=0.25pu Xd''=0.2 pu, Xq=1.55 pu Xq''=0.25 pu, Tdo'=2.0 s
Renewable Energy(RE) Simulator	Rating 100kW
Storage Battery(SB) Simulator	Rating 100kW

5. Conclusion

- ✓ As one of the measures to maintain system stability, M-G set with renewable energy and storage battery is proposed.
- ✓ We will examine the feasibility and effectiveness of the M-G set using demonstration equipment.

(especially compare with against " synchronous condenser+ renewable energy + storage battery")