

A Study on Effect of Asynchronous Control with Cttsin Micro grid System

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Abstract

Background/Objectives: Recently, electrical consumption is increase every years. But expansion of power generation faced with environmental regulation. So, the government process 3020 policy of renewable energy and microgrid system.

Methods/Statistical analysis: Microgrid system has Many DERs(Photovoltaic, Wind Power, Generator) and need to transfer uninterrupted control. So, this paper studies effect of asynchronous control with CTTS in microgrid system.

Findings: To simulate effect of asynchronous control in microgrid system, we consist CTTS modeling with EMTDC/PSCAD program. This program analyzes transient status of power system. CTTS operated synchronous conditions(Voltage, Frequency, Phase difference). First, we simulated reference simulation with same voltage, frequency and phase. Next, we experiment changing each condition. Then, we compared between reference simulation result and asynchronous simulation result. The result of maximum surge current can analyze effect of uninterrupted microgrid system.

Improvements/Applications: This result can be adapted design microgrid safety operating process and improve safety standard of CTTS operation.

Keywords: Closed Transition Transfer Switch, microgrid system, Synchronous operation, surge current, renewable energy

1. Introduction

Total TOE & electrical consumption is 477,592[GWh] at end of 2014 and rises 4.1 percent for 10 years(2015~2014)[1]. It is necessary to establish stable power supply, such as expansion of power generation facilities, but it is difficult to construct power generation and environmental regulation[2]. So, the government is processing for 3020 policy of renewable energy based on photovoltaic, wind power, energy storage system[3]. Especially, microgrid system is combined by photovoltaic and energy storage system. This system composes many power sources and need to transfer uninterrupted process. The transfer switch generally used automatic transfer switch(ATS). When the system is outage, automatic transfer switch detect low voltage and transfer another power source. This switch can't prevent power outage. So, To prevent system outage, Closed Transition Transfer Switch(CTTS) is developed. CTTS is utilized for interconnected system like generator and photovoltaic or energy storage system in microgrid. If synchronization conditions with two power sources is satisfied, it is transfer to another source after parallel operation within 100ms[4]. So, uninterrupted system in microgrid needs synchronous control process. This paper analyzes asynchronous control effect of closed transition transfer switch in microgrid system. We simulated EMTDC/PSCAD for simulating asynchronous control of CTTS model.

2. Modeling CTTS with PSCAD

CTTS composed two switch connecting each power source and controller with monitoring voltage, frequency, phase different. The synchronous conditions are defined by UL 1008 standard as

shown Table 1. CTTS synchronous conditions are under 10% voltage difference, under 1Hz frequency difference and under 5° phase difference.

Table 1: Synchronous conditions of CTTS

Voltage Difference	<10%
Phase Difference	<5°
Frequency Difference	<1Hz

CTTS generally utilized interconnected generator like DERs(photovoltaic, wind power, diesel generator) with power grid system, for interconnecting DERs with power system, it adapted distributed interconnection synchronous standard by KEPCO in KOREA[5]. The standard is shown as Table 2.

Table 2: Synchronous limit with interconnecting grid

DERs capacity [kW]	Frequency Difference (Hz)	Voltage Difference (%)	Phase Difference (°)
0 ~ 500	0.3	10	20
500 ~ 1,500	0.2	5	15
1,500 ~ 20,000	0.1	3	10

If the two power sources between generator and grid synchronous conditions didn't match, the surge current damaged facility or load. The surge current can be presented as:

$$I_{\text{surge}} = \frac{V_{\text{diff}}}{Z_s}$$

V_{diff} is the asynchronous voltage difference between two sources

Z_s is total system's impedance

Total system's impedance presented sum of sub-transient

reactance of the parallel generators and sub-transient reactance calculated as:

$$X_{d'}_{sum} = 1 / \{ 1/X_{d'}_{gen1} + 1/X_{d'}_{gen2} + 1/X_{d'}_{gen3} + \dots \}$$

So, most of Z_s consisted reactance, and surge current can be calculated as:

$$I_{surge} = \frac{V_{diff}}{X_{d'}}$$

In this research, we simulated asynchronous control of CTTS through the PSCAD. CTTS have two circuit breakers which connected each power source. Generator model has Automatic Voltage Regulator for changing voltage and Governor for changing motor speed. Grid is infinity bus with 22.9kV voltage and transformer change 22,900/380V. CTTS analysis model is shown as Figure 1.

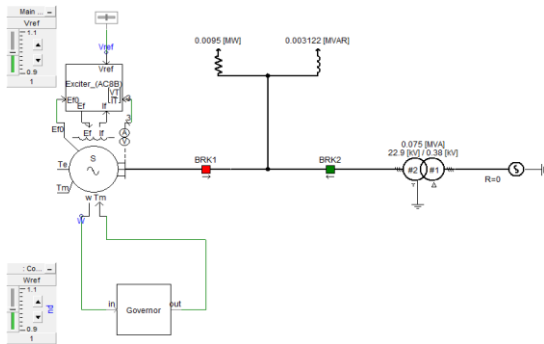


Figure 1: CTTS analysis model

Generator's governor use different model depending on Droop Control. This paper select widely used Woodward's DEGOV governor model as figure 2.

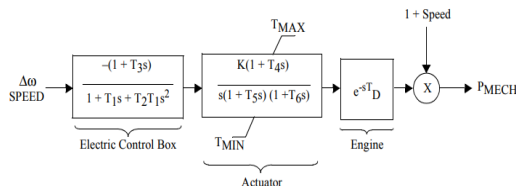


Figure 2: Generator Governor Model (DEGOV)

IEEE Standard introduce various exciter model in IEEE 421.5-2005 (IEEE Recommended Practice for Excitation System Models for Power System Stability Studies)[6]. This paper used IEEE AC8B which used low capacity generator exciter model as figure 3.

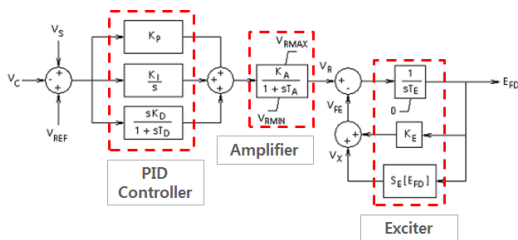


Figure 3: IEEE AC8B Exciter Block Diagram

3. Reference Simulation

To simulate reference simulation model, Load capacity is 20kW and CTTS transfers 15s after initial operating generator. Parallel operation time is 100ms and CTTS operated single operation after parallel operation. This paper simulated same voltage, frequency, phase with two sources for CTTS surge current.

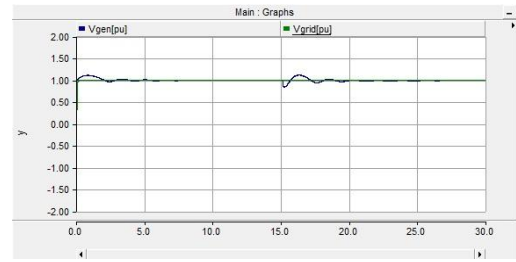


Figure 4: Grid & Generator Voltage Waveform

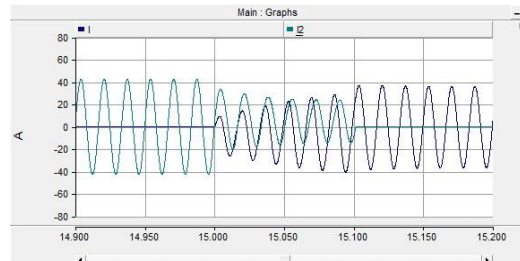


Figure 5: Grid & Generator Current Waveform

Figure 4,5 are grid & generator wave form about voltage and current. Maximum surge current with parallel operation is 33.02A(Grid) and 40.65A(Generator).

4. Results and Discussion

This paper simulated various synchronous condition change in 1.1pu voltage difference, 1Hz frequency difference and 20° phase difference.

- Voltage difference 1.1pu

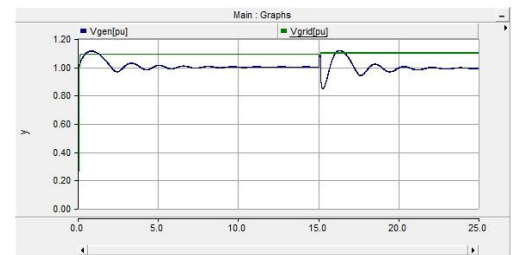


Figure 6: Grid & Generator Voltage Waveform (V_diff = 1.1 pu)

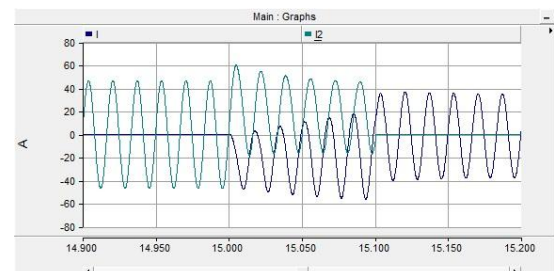


Figure 7: Grid & Generator Current Waveform (V_diff = 1.1 pu)

Maximum surge current with parallel operation between generator and grid is 60.03A(Grid) and 55.93A(Generator) as figure 6,7

- Frequency difference 1Hz

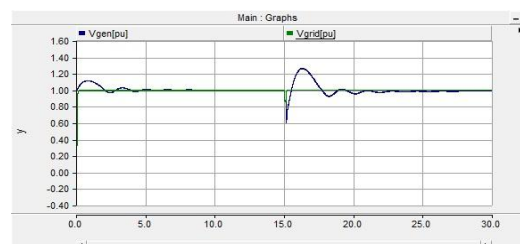


Figure 8: Grid & Generator Voltage Waveform (f_diff = 1Hz)

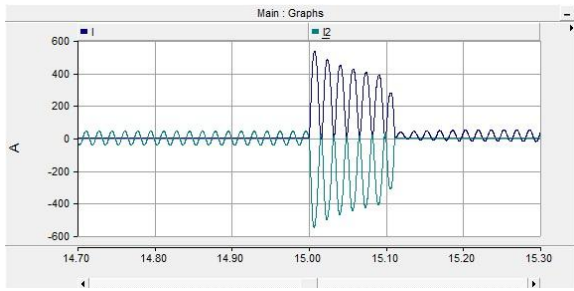


Figure 9: Grid & Generator Current Waveform ($f_diff = 1\text{Hz}$)

Maximum surge current with parallel operation between generator and grid is 549A(Grid) and 531.6A(Generator) as figure 8,9

- Phase difference 20°

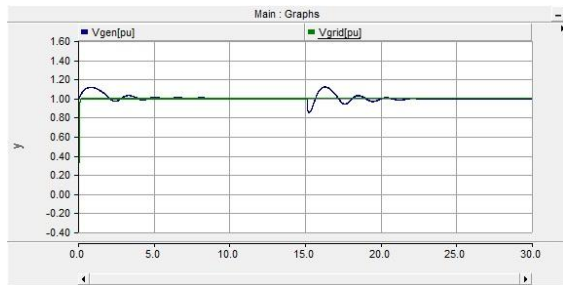


Figure 10: Grid & Generator Voltage Waveform ($\theta_diff = 20^\circ$)

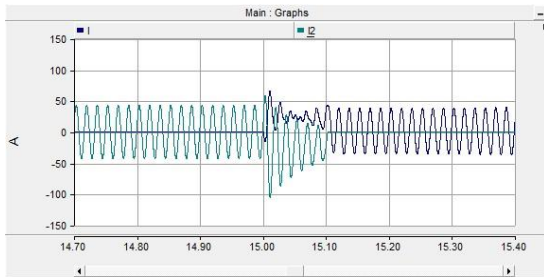


Figure 11: Grid & Generator Current Waveform ($\theta_diff = 20^\circ$)

Maximum surge current with parallel operation between generator and grid is 106A(Grid) and 65.55A(Generator) as figure 10,11.

The result of maximum surge current of each case is shown at Table 3.

Table 3: Result of maximum surge current

Case	Grid Maximum Surge Current(A)	Generator Maximum Surge Current(A)
Reference Result	33.02	40.65
Voltage Difference(1.1 pu)	60.03	55.93
Frequency Difference(1Hz)	549	531.6
Phase Difference(20°)	106	65.55

5. Conclusion

When the synchronous condition is changed, maximum surge current is different every case. Maximum surge current case is 1Hz frequency difference and 12~15 times greater than reference simulation result. Among the synchronous conditions, the most effect of system in parallel operation is frequency > phase > voltage. So, to protect the power system in uninterrupted microgrid system, it needs to control generator. This result can be adapted design microgrid safety operating process.

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