

## Voltage Sags Impact on CAR and SOR of HANARO

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### 1. Introduction

The combination of the unstable electric power and sensitive equipment may cause the nuisance of reactor trip. The reactor is tripped by the RRS and RPS during the occurrence of the voltage sags or momentary interruptions. We tested the components of RRS and RPS for the immunity from voltage sags and momentary interruptions. The tested components are DC power supply for CAR (control absorbed rod) of RRS and AC coil contactor for SOR (shut off rod) of RPS. We briefly describe the power quality standard for the voltage sags. This paper summarizes the magnitudes and durations of the voltage sags which impact on the CAR and SOR system.

### 2. Power Quality Standard - Voltage Sag

Present power quality standards define voltage sags as a short duration variation of the voltage of any or all phase voltage of a single phase or a polyphase supply at a point in the electrical system. Although there are slight differences between the various standards, the voltage sag is always expressed and referred to as the rms voltage event. The voltage sag is usually defined as the time measured from the moment the rms voltage drops below 90% of the declared voltage to the moment when the voltages rise above 90% of the declared voltage. The voltage sags are generally defined and described by only two parameters, magnitude and duration [1]. According to IEEE Std 1159, sag magnitudes range from 10% to 90% of a nominal voltage and sag durations from one half cycle to 1 min.

There are several power quality surveys related with the voltage sags. Major characteristic of voltage sags are as follows [2].

- Most voltage sags have a magnitude of around 80% and duration of four to ten cycles [3].
- Most voltage sags last ten cycles or less and are 20-30% in magnitude [4].
- Voltage sags and interruptions under one minute exceed interruptions of over one minute by ten to one. The number of voltage sags to 70-80% is three times the number of interruptions, 35% of the events shorter than 3 sec have duration of less than six cycles [2].
- Many Temporary voltage sags become short interruptions due to a widespread application of the bus transfer schemes.

### 3. Immunity Test for Voltage Sags

#### 3.1 DC power supply for CAR

HANARO has four CARs which are connected to the driver through a magnetic clutch and driven by four independent stepping motors. We undertook the immunity test for the voltage sags for the dc power supply. The dc power supplies power to the magnetic clutch. Its input is 110Vac, 60Hz and output is 12Vdc. The dc power supply consists of transformers, inductors and capacitors which are able to storage the electrical energy. So the dc power supply has good immunity from the voltage sags or the momentary interruptions. From this experiment, we knew the characteristic of the dc power supply for the voltage sags. Fig. 1 is the characteristic curve of the dc power supply for the voltage sags.

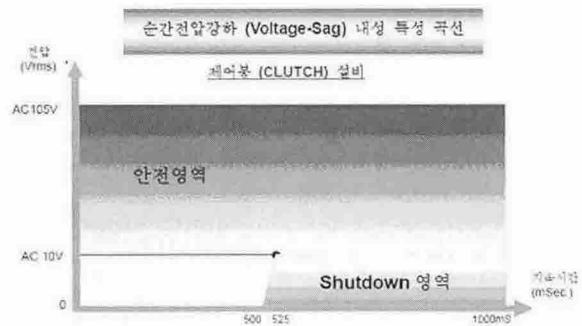


Figure 3. The characteristic curve of dc power supply for the voltage sags.

At the voltage sag to 10V, 525msec, the dc power supply lost the power to connect the CAR. At the voltage sag to 0V, in other words momentary interruption, the dc power supply still supplied the dc power to magnetic clutch until the duration of 500msec. From this experiment, 10V is the minimum steady state voltage of this dc power supply.

#### 3.2 AC coil contactor for SOR

This Experiment is performed to show the impact of the sag duration and magnitude on the performance of the ac coil contactors. The ac coil contactor used for this experiment is HMC37 which is manufactured by Hyundai Heavy Industry Company. The nominal voltage of the contactor is single phase and 110VAC, 60Hz. Experimental setup consists of ac power supply,

dc power supply, resistor, sag generator, sag compensator and a data acquisition system. Figure 2 shows the schematic of experimental setup for ac coil contactor of SOR power supply unit.

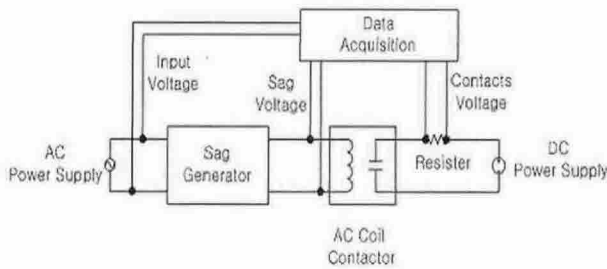


Figure 4 Schematic of experimental setup

At the voltage sag to 70V, 500msec, the contacts just began to be disengaged (Fig 3). The sag duration at this volt is 47msec. The waveform at voltage sag to 60V, 50msec is shown in Fig 4, the contacts were disengaged after 20msec. From this experiment, we knew that the minimum steady state hold-in voltage (MSSHIV) of HMC37 was 70V. Figure 5 is the voltage tolerance curve of this ac coil contactor.

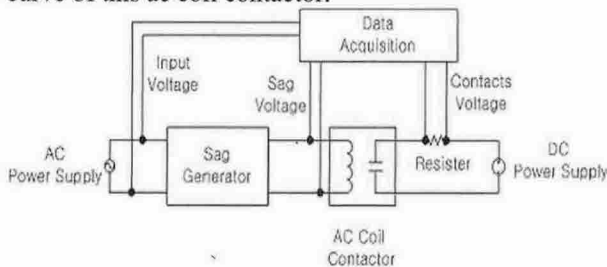


Figure 5 Waveform at voltage sag to 70V, 500msec

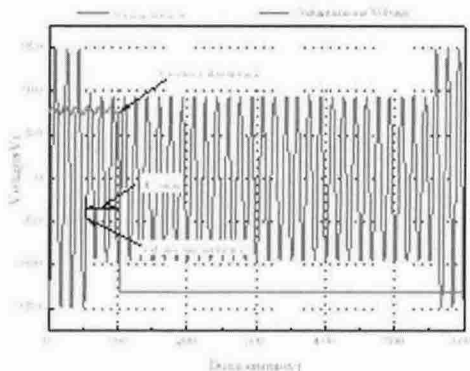


Figure 6 Waveform at voltage sag to 60V, 50msec

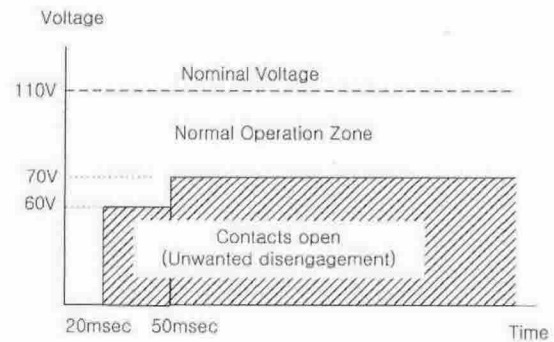


Figure 7 Voltage tolerance curve of HMC37

#### 4. Summary

The reactor protection system (RPS) of HANARO is a safety class system. The reactor is tripped by dropping four shut off rods (SOR). The SOR system consists of a SOR, hydraulic pump, hydraulic cylinder, solenoid valves and a power supply unit which has the AC coil contactor as a switching component. The hydraulic pump lifts up the SOR. The SOR drops by loss of the hydraulic pressure in the hydraulic circuit at the occurrence of voltage sags or interruptions. From this experiment, we knew that the magnitude of the voltage sag which impacts on this system is 70V, 500msec. The reactor regulation system (RRS) of HANARO has four CARs which are connected to the driver through a magnetic clutch. The CAR drops by loss of electromagnetic force of the magnetic clutch when the deeper voltage sags to lower than 10V, 500msec.

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