Field Testing and Model Validation of Motor-Generators

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***Abstract*—** In this paper, the field tests conducted by the IITREE-LAT to verify the performance of motor-generators are presented. These machines are used as distributed energy resources (DER) in oil fields and different cities across Argentina.

On the basis of these tests, the models regarding generator, power-speed control system and voltage control system are presented.

***Index Terms*—** Tests. Synchronous Generator. Motor-generator. Voltage regulator. Governor.

I. Introduction

A restructured distribution network which uses a large number of distributed energy resources can improve the level of system reliability and allow the division of the network according to the required service quality (critical and non-critical loads).

The DER, including distributed generation and distributed storage are energy sources that are located near local loads and can provide a significant benefit if correctly operated. The distributed generation units are small energy sources, consisting of photovoltaic cells, wind turbines, fuel cells, microturbines, and motor-generators. These last ones use gas or fossil fuel as primary energy.

The motor-generators are equipped with a power-speed control system to regulate the engine speed and an automatic voltage regulator that controls the internal voltage of the synchronous generator, as shown schematically in Fig. 1.

The integration of many small-scale generators in the interconnected power system impacts on their operation, control and protection. Given the proliferation of these small generators, there is uncertainty about the effect thereof on the overall system performance.

Nowadays, power plants equipped with motor-generators represent a major portion in the total generation and are installed approximately 1000 MW for a total of 23000 MW of generation.

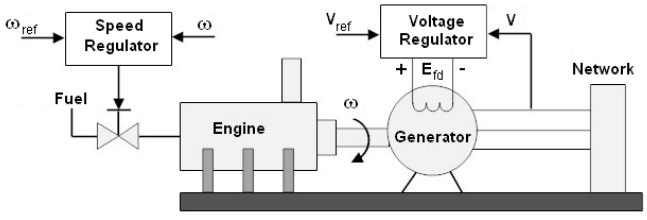

Fig. 1: Motor-generator's schematic diagram and associated control systems.

It is therefore convenient to provide simulation models for these motor-generators, including determination of its dynamic characteristics such as the inertia constant and the determination of excitation and power-speed control systems.

This paper presents, as an example, the field tests conducted on two typical power plants equipped with motor-generators. On the basis of these tests, the models regarding generator, power-speed control system (governor) and voltage system control (Automatic Voltage Regulator, AVR) are presented. The simulation results are compared with field records.

II. Power Plants Description

Power Plant 1 is composed of 14 motor-generators, 2000 kVA /1600 kW each one and is located in the city of La Rioja, La Rioja. Power plant 2 is composed of 16 motor-generators, 1750 kVA/1400 kW each one and is located in the vicinity of the city of Colonia Catriel, Neuquén.

Basic data of two power plants are presented in Table I.

Table I: Basic Characteristics of the Power Plants.

Power Plant 1	Power Plant 2
Engine Brand: Caterpillar Type: 3516 Fuel: diesel Frequency: 50 Hz	**Engine** Brand: Jenbacher Type: JGS 420 GS Fuel: gas Frequency: 50 Hz
Synchronous generator Brand: Caterpillar Type: 826 Excitation: Brushless with rotating excitater and permanent magnet pilot exciter Apparent Power: 2000 kVA Active Power: 1600 kW Power Factor: 0.8 Voltage line/phase: 400/230 V Poles: 4 Efficiency at rated load: 96.9 %	**Synchronous generator** Brand: Jenbacher Type: PE734F2 Excitation: Brushless with rotating excitater and permanent magnet pilot exciter Apparent Power: 1750 kVA Active Power: 1400 kW Power Factor: 0.8 Voltage line/phase: 400/230 V Poles: 4 Efficiency at rated load: 97.5 %
Automatic Voltage Regulator Brand: Caterpillar Type: CAT digital voltage regulator Power Factor Controller: No	**Automatic Voltage Regulator** Brand: STAMFORD Type: MX 321 Power Factor Controller: STAMFORD PFC-3
Power-Speed Regulator Brand: Caterpillar	**Power-Speed Regulator** Brand: STAMFORD
Transformer Brand: Vasile Power: 2000 kVA Connection group: Yd11 DC Voltage: 5.22 % Switch: -2x2,5 % y +2x2,5 %	**Transformer** Brand: Tadeo Czerweny S.A. Power: 1800 kVA Connection group: Yd11 DC Voltage: 5 % Switch: -4x2,5 % y +2x2,5 %
Synchronous machine Protections Over-voltage: 450 V (112,5 %) / 2 s Under-voltage: 320 V (80 %) / 2 s Over-frequency: 53 Hz / 20 s Under-frequency: 47 Hz / 20 s	**Synchronous machine Protections** Over-voltage: 450 V (112,5 %) / 2 s Under-voltage: 320 V (80 %) / 2 s Over-frequency: 53 Hz / 20 s Under-frequency: 47 Hz / 20 s

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