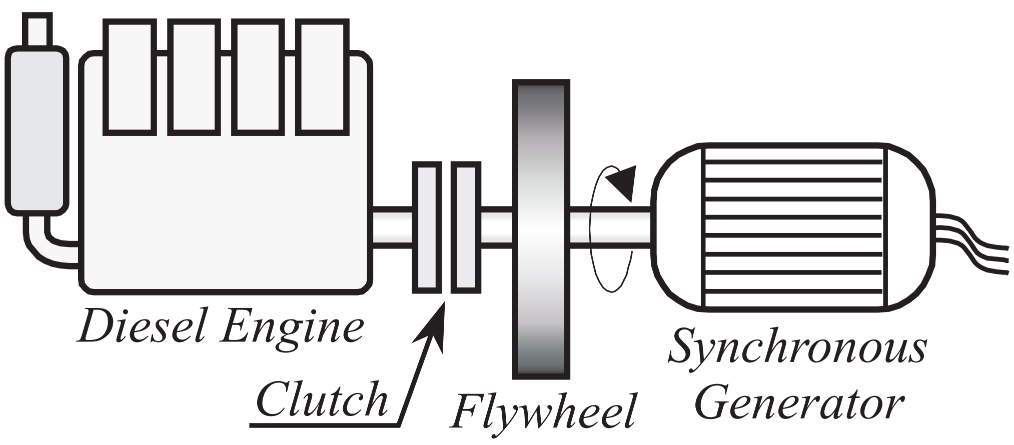
COMPARISON BETWEEN DIFFERENT FLYWHEEL CONFIGURATIONS IN ISOLATED WIND PLANTS

C. Carrillo carrillo@uvigo.es
J. Cidrás jcidras@uvigo.es
A.E. Feijoo afeijoo@uvigo.es
Dep. de Enxeñería Eléctrica, Univ. de Vigo
ETSEIM, Lagoas Marcosende s/nº, 36200 Vigo SPAIN

J.F. Medina jmedina@cicei.ulpgc.es
Dep. de Ingeniería Eléctrica, Univ. de Las Palmas

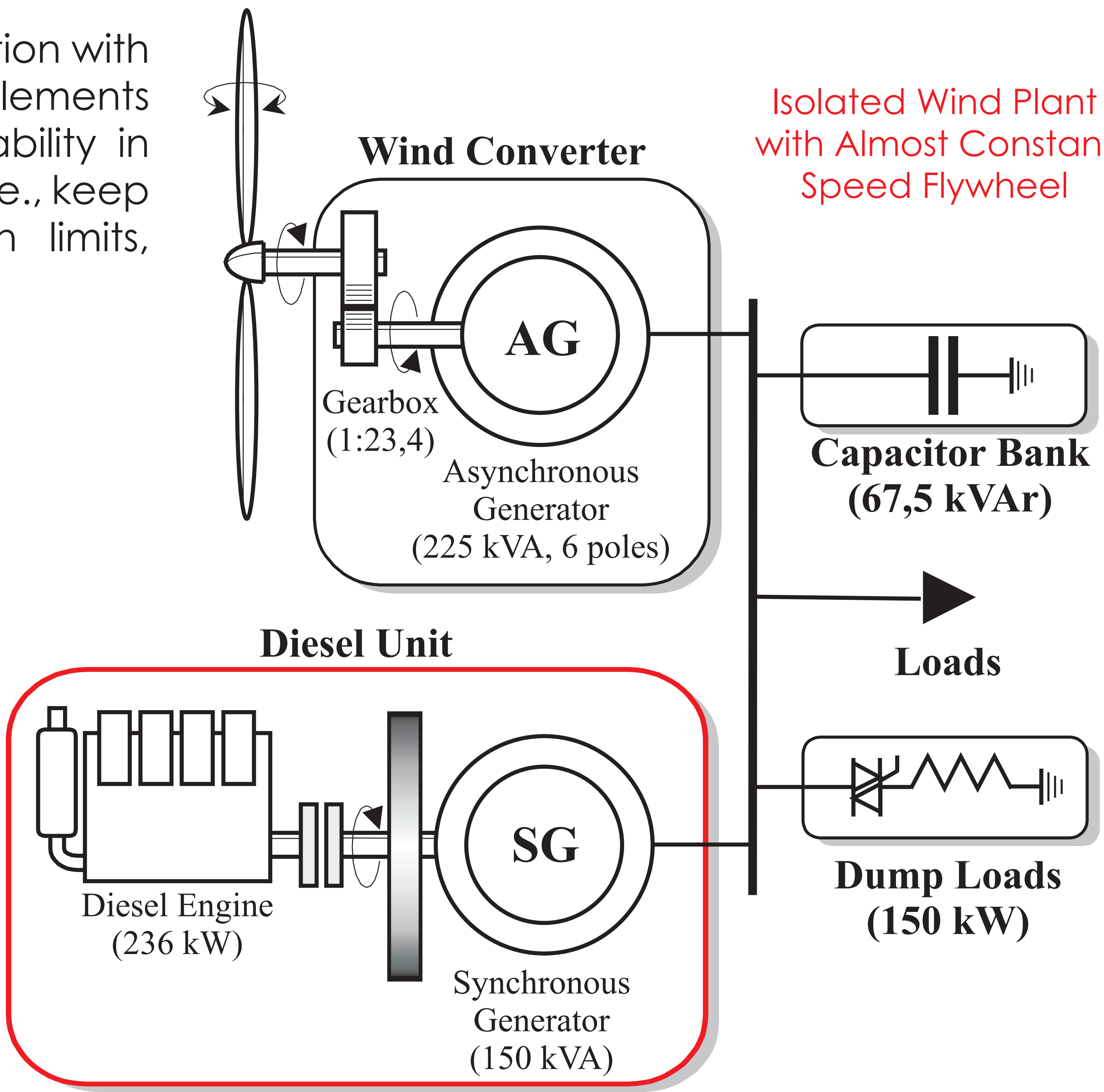
Power systems based on renewable sources are affected by fluctuations in the generation side due to the seasonal and random nature of the source. At the same time, the load also has a variable power demand. In this case, energy storage systems (batteries, flywheels and so on) play an important role to match up generation and demand.
Flywheels are a popular energy storage system in the short and medium term (from seconds to minutes) in wind plants. A flywheel coupled to a synchronous generator (SG) running at an almost constant speed (less than 5% variation) form the simplest configuration.

ALMOST CONSTANT SPEED FLYWHEEL WITH SYNCHRONOUS GENERATOR



An almost constant speed flywheel is usually connected to a synchronous machine whose speed and frequency are directly related. This is why only small variations in speed are allowed, and only a small amount of the stored energy is available.

A flywheel in conjunction with dump loads are the elements that maintain the stability in isolated wind plants, i.e., keep the frequency within limits, e.g. 50Hz 1%.

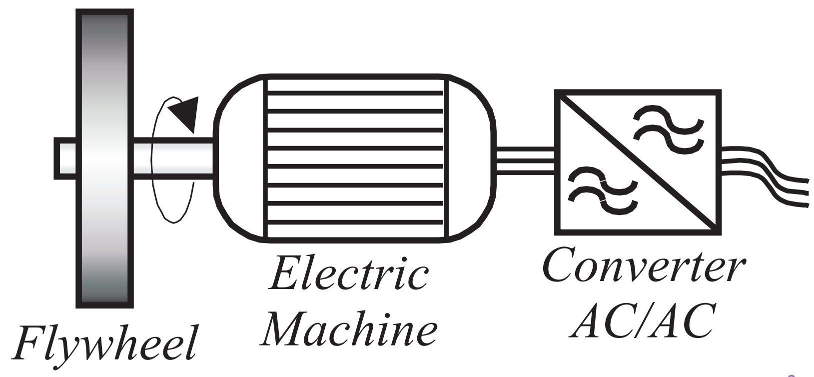


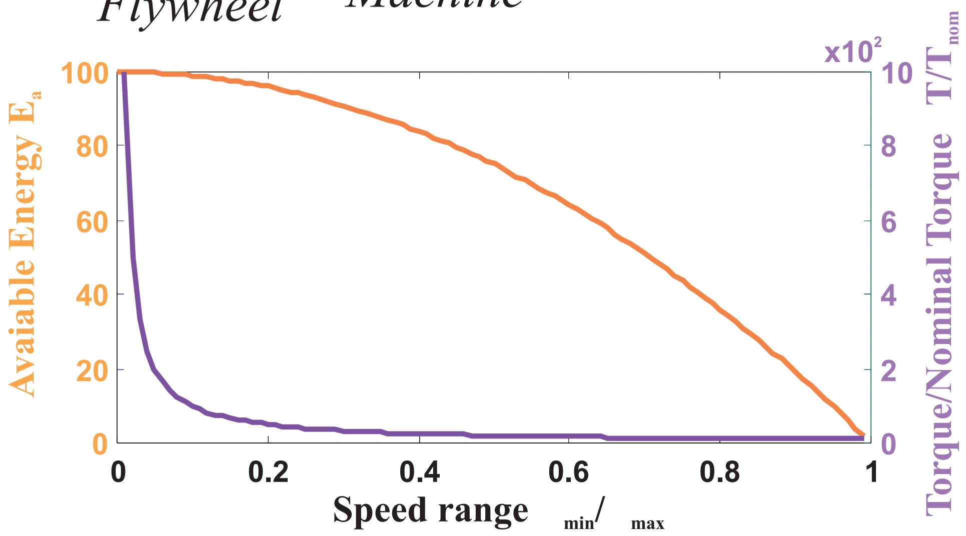
Isolated Wind Plant with Almost Constant Speed Flywheel

VARIABLE SPEED FLYWHEEL WITH ASYNCHRONOUS GENERATOR AND AC/AC

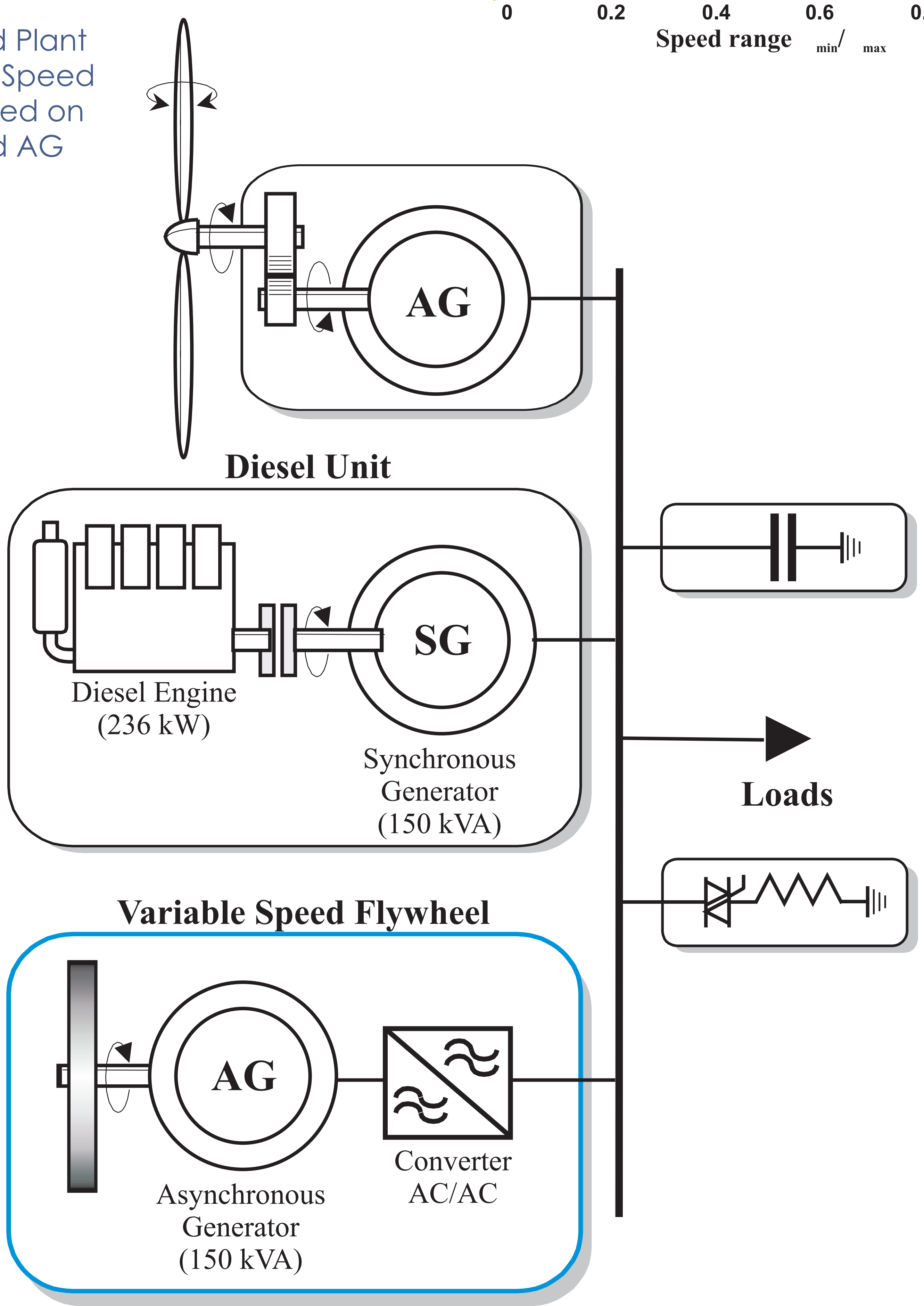
In order to improve the amount of available energy, variable speed configurations are needed. The configuration depicted in this paper is formed by a flywheel coupled to an asynchronous generator (AG) that delivers energy through an

The energy available has been dramatically raised, e.g., with a 1:3 speed variation ($_{min}$/ $_{max}$ = 1/3) the amount of available energy is 90%. One limitation for speed variation is torque. When a flywheel is delivering (or storing) the nominal power at low speeds, the torque will be much higher than its nominal value (T/T_{nom}>>1), so mechanical parts must be oversized to manage this situation and/or a limit to the managed power as a function of speed must be



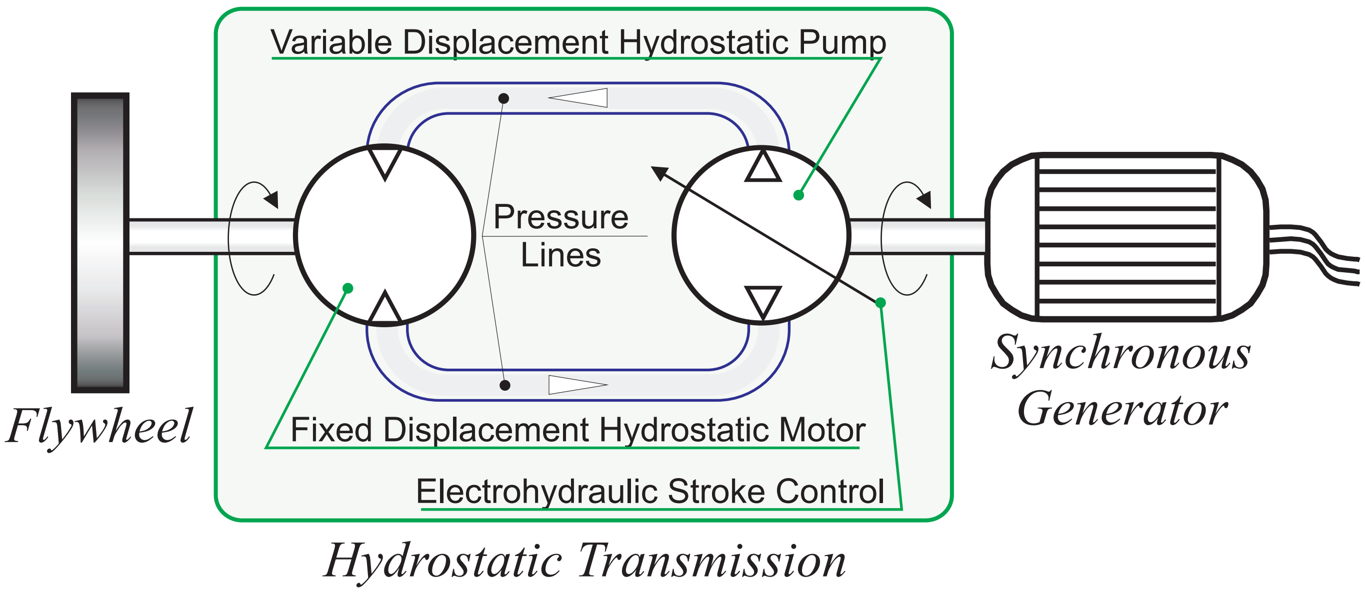


Isolated Wind Plant with Variable Speed Flywheel based on AC/AC and AG



VARIABLE SPEED FLYWHEEL WITH SYNCHRONOUS GENERATOR AND HYDROSTATIC TRANSMISSION

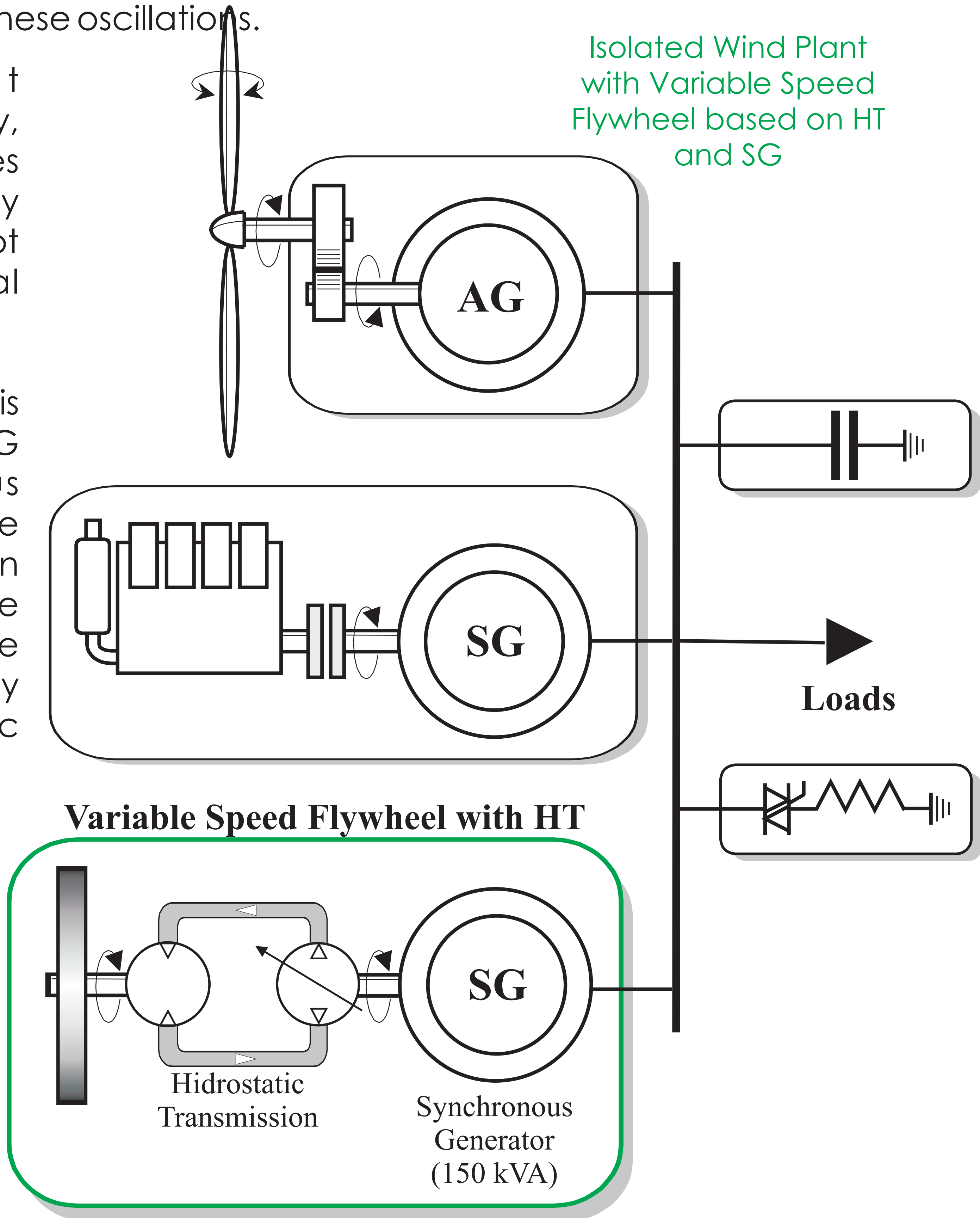
The major characteristic of HT is the ability to allow the energy transference between two systems rotating at different speeds. In this way, a wide range of speeds can be obtained in the motor shaft; meanwhile pump speed can be maintained at a reference valve by acting on the



One of the main advantages of HT is its robustness against torque variations, since the speed of motor and pump remains almost constant during the steady state. This means that these variations are mainly reflected in the pressure. However, during the transient period, the hydrostatics fluid acts as a spring and the speed oscillates around its final value. The controller design and servovalve dynamic characteristic must be able to manage these oscillations.

Another important characteristic is efficiency, because the HT has values below 70%, especially when the system is not running under nominal conditions.

The control strategy for this system is to keep the SG speed at synchronous value; meanwhile, the flywheel speed varies in order to compensate the energy balance in the system. This is obtained by acting on electrohydraulic



COMPARISON BETWEEN DIFFERENT FLYWHEEL CONFIGURATIONS

The wind plants are studied under two different kinds of perturbations: wind speed and electric load variations or output power.

The frequency can be considered as quality indicator for the energy delivered by the wind plant. Taking this into account, variable speed configurations have the best response.

Nevertheless, against load variations (t=150 s) the response of variable speed storage systems is worse than the almost constant one. This is due to the fact that in variable speed systems the response against load variations depends heavily on the ability of the controller to manage it.

Another consequence is that in variable speed configurations the use of dump loads is greatly reduced due to the extra storage capacity.

The response of the storage system based on AC/AC converter and HT are very similar. However, this last system is based on a mechanical system which is more robust, and

CONCLUSIONS

The variable speed configurations have a more appropriate behaviour against wind speed variations, however, against load variations the almost constant configuration has the better response.

Storage systems based on HT, whose response is very close to the one based on AC/AC converter, are introduced. Systems based on HT are more robust but systems based on AC/AC converter have