

3. Design of the VSI-Fed PMSM Drive System with Active Load

3.1. System Specifications

The starting mechanism for an aircraft auxiliary power unit (APU) contains a PM synchronous motor (PMSM) drive, which starts a gas (or interior combustion) turbine and gives it support to accelerate the APU's synchronous generator to its synchronous speed, shown in Figure 13. Since the turbine doesn't have enough power to accelerate the generator by itself until a certain speed is reached, the turbine-generator system forms an active load (since the load torque changes dynamically with speed) on the PMSM shaft. Typical load torque versus speed characteristics are shown in Figure 14. A commonly used power electronics topology for running the PMSM is a PWM regulated three-phase voltage source inverter (VSI), [18, 29, 39, 41]. An AC filter is used to eliminate the EMI noise from the voltage on the motor terminals [23]. Its model is reduced to the simplest LC filter topology for the sake of simplicity, since the filter design is beyond the scope of this work. An additional series inductance is added in each phase for di/dt measurements, although the largest series inductance of a multistage AC filter can also serve that purpose.

The PWM controller is a two-stage cascade feedback controller with a PWM modulator and a drive circuit for VSI switching devices [20, 52]. Although some promising analog solutions have been proposed in the literature [38], the controller is chosen to be digital, designed in rotational d-q coordinate space with two inner (d- and q-axis) current loops with a decoupling circuit, and an outer speed loop with flux-weakening (field oriented) control, shown in Figure 15. The main challenge of this application is to provide a robust system with a fast current response and stable speed loop, while extending the PMSM speed limits as much as possible, in order to provide the fastest APU generator acceleration, with the possibility of controlling the system current and speed profiles.

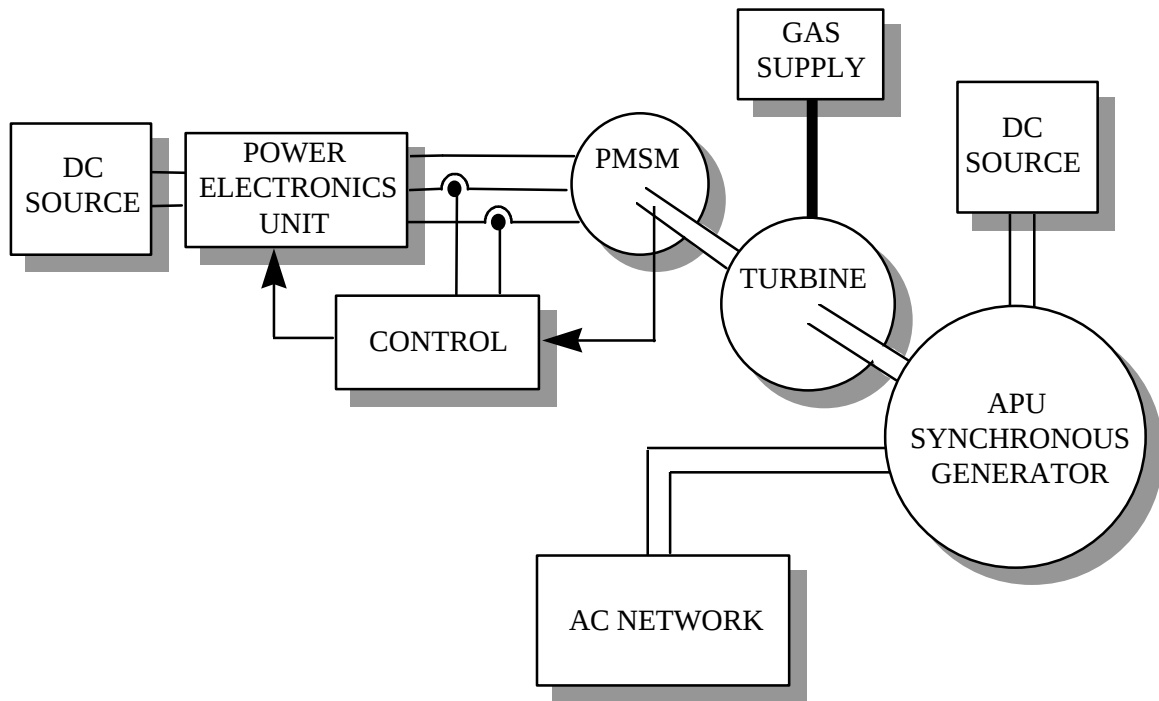


Figure 13. Block diagram of the APU starting mechanism

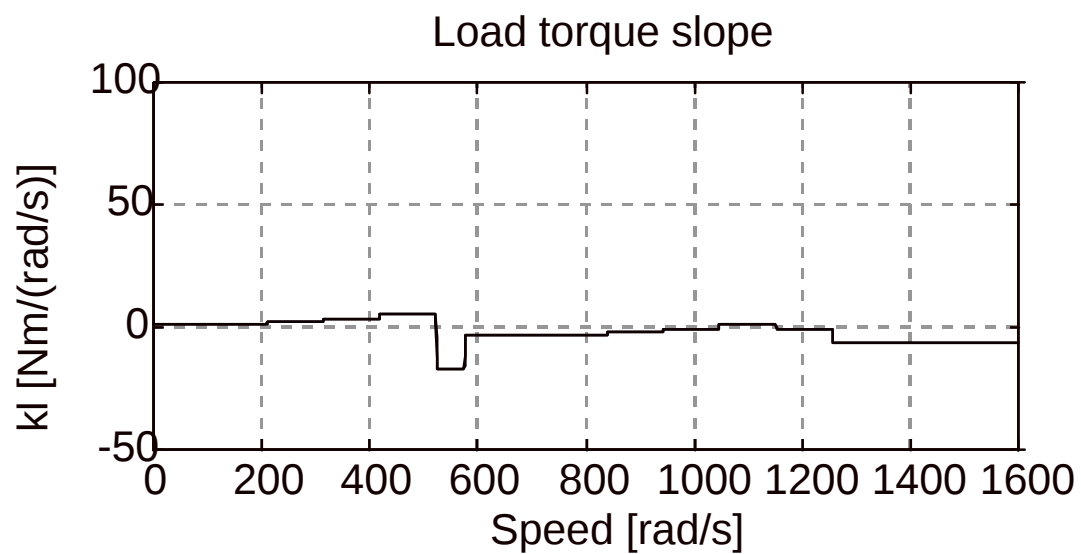
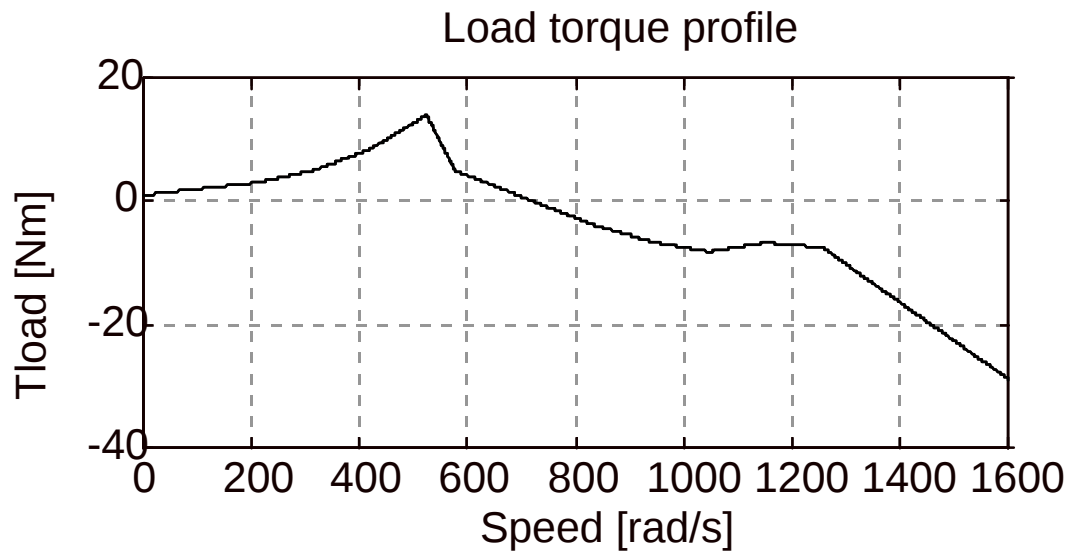


Figure 14. Typical load torque profile on the PMSM shaft during the APU start-up