

Electric Generating Systems

The invention relates to electric generating systems for aircraft.

Historically, aircraft electric generating systems have provided alternating current at a constant frequency. Most of the aircraft in the world today are provided with a constant speed drive coupled to a constant frequency alternating current generator to power the equipment in the aircraft. The aircraft engines are typically started by the application of pneumatic or AC power to drive the generator as a motor.

There is a need, especially in military aircraft, for the generation of DC power for equipment such as radar and avionics. In this new generation of aircraft, a very high proportion of the power required is DC, while the need for AC is relatively small.

A system according to the invention comprises an alternator, reversible AC to DC converter coupled to the alternator to provide DC in a generating mode, and in a start mode a controller cooperating with a DC to AC converter to receive DC and provide AC to bring the alternator operating as a motor up to operating speed and then to couple the reversible AC to DC converter to receive

DC and operate the alternator to start an engine of the aircraft.

5 The system is preferably coupled to the aircraft engine through a torque converter provided with an overrunning clutch which allows the torque converter to be bypassed in the generating mode, and may include a torque converter fill valve coupled to the control unit so that the torque converter is filled when the alternator has reached operating speed in the start mode.

10 The controller generally operates through a number of electrical contactors between the various components in the system. The first of these electrical contactors is in the electrical coupling between the alternator and the reversible AC to DC converter. The second is
15 between the reversible AC to DC converter and a DC bus. A third is between the DC to AC converter and the DC power output from the AC to DC converter. A fourth is between the DC to AC converter and the alternator, and a fifth is between the DC to AC converter and an AC bus. In the
20 generating mode, the fourth contactor is open and the remaining contactors are closed in response to control signals from the controller. In the start mode, all contactors are initially open, and DC power is supplied to the DC bus from an external source. Then the second,
25 third and fourth contactors are closed and the DC power is delivered to the DC to AC converter. AC power so

produced is delivered to the alternator operated as a motor, and brings the alternator/motor up to operating speed. Then the fourth contactor is opened and the first contactor is closed.

The system also preferably includes an alternator rotor position sensor and an engine speed sensor each electrically coupled to the controller. The alternator rotor position sensor provides a control of the DC to AC converter as the alternator motor is brought up to operating speed. The engine speed sensor effects momentary opening and closing of the first contactor and the closing of the fifth contactor upon engine start and commencement of the generating mode.

DRAWINGS:

Figure 1 is a block diagram of an electric generating system according to the invention;

Figure 2 is a schematic showing of the mechanical arrangement of the drive unit of Figure 1 which includes a torque converter and overrunning clutch arrangement drivingly connected to an alternator/motor of Figure 1;

Figure 3 is a block diagram of the controller of Figure 1;

Figure 4 is a block diagram of the control logic and protection function of Figure 3;

Figure 5 is a block diagram of the SCR control of Figure 3; and

Figure 6 is a block diagram of the inverter control of

Figure 3.

There is shown at the left of Figure 1 an aircraft engine 11 which provides power at a variable engine speed through a connection 12 to a drive unit 13. The drive unit 13 has a rotary drive connection 14 to an alternator 16. The alternator 16 provides AC power in a generating mode and can be driven as a motor in a start mode. The alternator 16 provides three phase AC power at an electrical connection 17 to and through an electrical contactor C_1 to the connection 18 and a reversible AC to DC converter 19. The converter 19 provides DC power at a connection 21 through a contactor C_2 to a connection 22 and a DC bus 23 for use by the radar and avionics equipment of the aircraft.

The reversible AC to DC converter 19 is a reversible SCR three phase bridge of conventional design. It is coupled to the alternator 16 by a circuit that includes the connection 18, contactor C_1 and connection 17, and to a controller 31 via an SCR control connection 32. It provides DC power in a generating mode, and receives externally supplied DC power from the DC bus 23 via circuit which includes the connection 22, contactor C_2 and connection 21. DC power so delivered to the converter 19 provides AC power to the alternator/motor 16 via circuit that includes electrical connection 18, contactor C_1 and electrical connection 17. The alternator/motor 16 is then

driven in the start mode by power delivered from the external source.

A DC to AC converter 41 is a conventional inverter coupled to the controller 31 via a transistor control connection 42, and to the DC power output from the converter 19 via circuit which includes a connection 43, contactor C₃, connection 44 and the connection 21. The converter 41 provides the AC power requirement delivered to an AC bus for use by the AC powered equipment of the aircraft through a circuit which includes connection 44, and a contactor C₅. In the start mode, the DC to AC converter 41 is coupled to the externally supplied DC power via a circuit which includes DC bus 23, connection 22, contactor C₂, connection 21, connection 44, contactor C₃ and connection 43. It provides AC power to the alternator/motor 16 over a circuit including connection 44, connections 46,47, contactor C₄, connection 48 and connection 17. The AC power so delivered brings the alternator/motor 16 up to operating speed. Then the converter 19 responds to the externally provided DC power via a circuit that includes the DC bus 23, connection 22, contactor C₂ and connection 21. The alternator/motor 16 delivers rotary power via the rotary drive connection 14, drive unit 13 and drive connection 12 to start the aircraft engine 11.

The controller 31 is a microprocessor provided with inputs and providing outputs to control the various contactors and

major components of the system. The controller 31 is provided with speed sensing inputs taken from each side of the drive unit 13. The speed sensed at these points is respectively delivered by connections 33,34 to the controller 31. The efficient operation of the reversible AC to DC converter 19 and the DC to AC converter 41 requires amongst other inputs an indication of the alternator/motor 16 rotor position, and this input is delivered to the controller via electrical connection 35. The controller 31 is also provided with an indication of the AC voltage from the output from the alternator 16 via a circuit including connections 17 and 36. The controller is also provided with an indication of a current from the connection 18 by a connection 37. The DC voltage at the output of the converter 19 is delivered to the controller 31 via a connection 38. The alternating current and voltage at the output of the converter 41 is delivered to the controller 31 via a connections. 46 and 49.

The first electrical contactor C_1 is controlled via a connection 51 from the controller 31, while contactors C_2 , C_3 , C_4 and C_5 are controlled respectively via connections 52, 53, 54 and 55. The generating mode of the system has the contactor C_4 open and the contactors C_1 , C_2 , C_3 and C_5 closed in response to signals from controller 31. The start mode has all contactors C_1 to C_5 initially open.

The sequence is as follows: contactors C_2 , C_3 and C_4 are closed and the externally provided DC power is delivered to the DC to AC converter 41 over a circuit including the DC bus 23, connection 22, contactor C_2 , connection 21, connection 44, contactor C_3 , and connection 43.

Consequently AC power is delivered to the alternator/motor 16 via a circuit including connections 44, 46 and 47, contactor C_4 , and connections 48, 17. The AC power so delivered brings the alternator/motor 16 up to operating speed. Then the contactor C_4 is opened and contactor C_1 is closed.

A torque converter fill valve 56 is hydraulically coupled to the drive unit 13 by fill and drain conduits 57, 58. The fill valve 56 is controlled by the controller 31 via an on/off connection 59. Figure 2 shows that the drive unit 13 includes a torque converter 61. A pair of over-running clutches 62, 63 cooperate with the drive connection 12 to deliver rotary power from the aircraft engine 11 to the alternator/motor 16 in the generating mode. The overrunning clutch arrangement allows the rotary power from the engine 11 to bypass the torque converter 61 in the generating mode. The torque converter fill valve 56 is hydraulically coupled to a pump 60 via conduits 62 and to the torque converter 61 via conduits 57, 58. The torque converter 61 is filled only after the alternator 16 operating as a motor has come up to operating speed and the reversible AC to DC converter 19 is providing variable

voltage variable frequency AC power to the alternator/motor 16 during the engine start mode.

5 A pair of speed sensors 28, 29 provide inputs to the controller 31 via electrical connections 33, 34. The controller 31 is responsive to the sensed speeds and effects a momentary opening and then closing of the electrical contactor C_1 and the closing of electrical contactor C_5 upon engine start and commencement of the generating mode. An alternator rotor position sensor 30
10 is coupled to the controller 31 via electrical connection 35 to provide through the controller 31 and connection 42 a control of the DC to AC converter 41 as the alternator/motor 16 is brought up to operating speed. The manner in which the control of the DC to AC converter 41 is
15 accomplished is set forth in Figure 6.

The controller 31 in Figure 3 comprises three basic control units: SCR control 40, control logic and protection 50 and inverter control 65, details of which are shown respectively in Figures 5, 4 and 6.

20 When the torque converter 61 is empty, the alternator/motor 16 is allowed to spin unloaded, driven by the DC to AC converter 41. When the alternator/motor 16 reaches a speed which allows for commutation of the SCR bridge of the reversible AC to DC converter 19, control of the
25 alternator/motor 16 switches from the DC to AC converter 41

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to the SCR bridge of the reversible AC to DC converter.

The SCR bridge polarity is reversed so that power may flow from the DC bus 23 to the alternator/motor 16 via a circuit including electrical connection 22, contactor C₂,

5 connection 21, reversible AC to DC converter 19, connection 18, contactor C₁, and connection 17. The operation of the alternator/motor 16 as shown in Figure 5 is under the control of a current limit AC voltage applied, and the rotor position sensor output of connection 35 to thereby
10 time the SCR firing.

The arrangement of Figure 6 in the start mode provides a control of the inverter of the DC to AC converter 41 from the controller 31 via the connection 42. The DC to AC converter provides a constant volt second per cycle

15 waveform with an appropriate current limit to the alternator/motor 16 via a circuit including connections 44, 46, 47, contactor C₄ and connections 48, 17. This variable frequency variable voltage waveform uses an input 35 from the rotor position sensor 30 (Figure 2) to time the
20 signals.



CLAIMS:

1. An electric generating system for an aircraft comprising an alternator, reversible AC to DC converter coupled to the alternator to provide DC in a generating mode, and in a start mode a controller cooperating with a DC to AC converter to receive DC and provide AC to bring the alternator operating as a motor up to operating speed and then to couple the reversible AC to DC converter to receive DC and operate the alternator to start an engine of the aircraft.

2. A system according to claim 1 in which the controller is provided with a sensor of the position of the rotor of the alternator.

3. A system according to claim 1 or claim 2 in which the controller is provided with a sensor of the speed of the aircraft engine.

4. A system according to any preceding claim in which the controller is a microprocessor.

5 A system according to any preceding claim in which the reversible AC to DC converter is an SCR bridge.

6. A system according to any preceding claim in which the DC to AC converter is an inverter.

7. A system according to any preceding claim which is coupled to the aircraft engine through a torque converter provided with an overrunning clutch which allows the torque converter to be bypassed in the generating mode.
- 5 8. A system according to claim 7 including a torque converter fill valve coupled to the control unit so that the torque converter is filled when the alternator has reached operating speed in the start mode.
9. An electric generating system for an aircraft as
- 10 herein described with reference to the drawings.

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