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Continuing Education Course #272
Electrical Power Generation for Spacecraft

1. The electrical power subsystem is part of the spacecraft _____?
 a. payload
 b. bus
 c. structures
 d. all of the above

2. The electrical power subsystem is one of a set - all important to the success of a spacecraft's mission. What are some of the other subsystems?
 a. attitude control
 b. thermal control
 c. structures
 d. all of the above

3. Because of its orbital altitude - which orbit appears fixed relative to Earth, ideal for communications purposes (e.g. television)?
 a. LEO
 b. HEO
 c. GEO
 d. MEO

4. All of the following events occurred prior to the infamous "Houston, we've had a problem."; which one did the crew report to Houston?
 a. Stabilization control system rate changes
 b. Main B bus undervolt
 c. Oxygen tank No. 2 pressure decreases
 d. Oxygen flow rate to all three fuel cells decreases

5. During what orbital phase will a satellite receive the least amount of sunlight?
 a. Minimum Sun - sun vector is parallel with orbital plane
 b. Minimum Sun - sun vector is perpendicular with orbital plane
 c. 100% Sun - sun vector in parallel with orbital plane
 d. 100% Sun - sun vector is perpendicular with orbital plane

6. Which environmental hazard is the most destructive to solar array cells between 1,000 and 8,000 miles?
 a. Solar flare protons
 b. Electrons in the outer belt of the Van Allen belt
 c. Protons in the inner belt of the Van Allen belt
 d. Protons in the outer belt of the Van Allen belt

7. Which environmental hazard is the most destructive to solar array cells above the Earth's magnetosphere?

- a. Solar flare protons
- b. Electrons in the outer belt of the Van Allen belt
- c. Protons in the inner belt of the Van Allen belt
- d. Protons in the outer belt of the Van Allen belt

8. Which solar cell type converts a broader wavelength of the solar spectrum, from 350 to 1550 nanometers, to increase the cell's efficiency when compared to those used in early space flight?

- a. silicon (single junction)
- b. high-efficiency silicon
- c. single junction gallium arsenide
- d. dual junction gallium arsenide
- e. triple junction GaInP/GaAs/Ge

9. What is the main purpose of the bypass diode in parallel with each triple junction solar cell?

- a. It protects against reverse bias (current flow) damage due to shadowing of the cell.
- b. It protects against reverse bias (current flow) damage due to electrostatic discharge of the cell.
- c. It protects the cell from arcing due to electrostatic discharge.
- d. It protects the cell from arcing due to reverse biasing.

10. What has been the main driver in the technological progression for secondary batteries?

- a. cycle life
- b. wet life
- c. dry life
- d. all of the above

11. What are some of the major characteristics to consider in selecting the optimum primary battery?

- a. long shelf life: dry life and wet life
- b. high energy density
- c. non-hazardous attributes
- d. wide temperature range
- e. all of the above

12. In the Apollo 13 mission, why did the explosion of the oxygen tank in the service module cause an undervoltage condition?

- a. the oxygen was used as an oxidizer for the fuel cell; used to provide electrical power
- b. the oxygen was used as fuel for the fuel cell; used to provide electrical power
- c. the oxygen was used as an oxidizer for the fuel cell; used to provide attitude control
- d. the oxygen was used as fuel for the fuel cell; used to provide attitude control

13. When would an RTG (a nuclear fuel source) be considered as a power source for a spacecraft mission?

- a. when other power sources are not practical (e.g. planetary exploration)
- b. for those in LEO
- c. for those in HEO
- d. for those in GEO

14. You would employ a buck and/or boost type DC-DC converter to do which of the following?

- a. decrease/increase DC voltages during battery charge/discharge
- b. decrease/increase the DC bus voltage to a voltage for a specific load
- c. decrease/increase DC voltage input from solar arrays for peak power tracking
- d. all of the above

15. Typically, an undesired effect of shunting solar array energy is the excess _____ produced - impacting the thermal control subsystem.
- a. voltage
 - b. heat
 - c. current
 - d. resistance
16. Using the _____ shunt type, each transistor/resistor shunt leg can be configured across each series solar array string or across multiple strings; where each transistor is operating in the linear range (unsaturated) as represented by Q (quiescent).
- a. sequentially switched
 - b. sequential linear
 - c. pulse width modulated (PWM)
 - d. full linear
17. Low shunt power is generated using the _____ shunt type since all shunt transistors are ON (shorted, saturated) or OFF (open); essentially functioning as a switch with no current limiting resistors needed.
- a. full linear
 - b. partial linear
 - c. digital
 - d. sequential linear
18. The _____ shunt is essentially a group of full or partial linear shunts connected to the same linear controller where only one transistor is operating in the linear range.
- a. sequential linear
 - b. digital
 - c. sequentially switched
 - d. pulse width modulated (PWM)
19. Instead of its transistor operating in the linear range as in the full/partial linear shunts, the _____ shunt's input to the transistor causes it to switch on/off over a high switching frequency by a controlled duty ratio.
- a. sequential linear
 - b. pulse width modulated (PWM)
 - c. digital
 - d. sequentially switched
20. The _____ shunt regulator (aka S3R) is similar in configuration and operation to the sequential linear shunt, with the power reduction benefits of digital and PWM shunts.
- a. full linear
 - b. digital
 - c. PWM
 - d. sequentially switched
21. Which solar array energy transfer system would you use if you wanted a simple design for a spacecraft which will operate in LEO?
- a. Unregulated DET
 - b. Partially Regulated DET
 - c. Regulated DET
 - d. Peak Power Tracker
22. Which solar array energy transfer system would you use if your mission's orbit will provide you with a long battery recharge time and if after doing a risk assessment - the risk of lock-up was acceptable?

- a. Unregulated DET
- b. Partially Regulated DET
- c. Regulated DET
- d. Peak Power Tracker

23. Which solar array energy transfer system would you use to provide the most design flexibility?

- a. Unregulated DET
- b. Partially Regulated DET
- c. Regulated DET
- d. Peak Power Tracker

24. Which solar array energy transfer system would you use to get the most energy from the Sun?

- a. Unregulated DET
- b. Partially Regulated DET
- c. Regulated DET
- d. Peak Power Tracker

25. Suppose you are in the conceptual design phase and are only provided the following system/mission requirements:

- payload purpose is for television communications
- minimize electromagnetic interference
- DC-DC converter design flexibility
- spacecraft must be solar-battery powered

Based on these given requirements, select the optimum electrical power subsystem from the following:

i. orbital type

ii. power source, battery type (cell type)

iii. power regulation, solar array power control method

iv. power regulation, solar array energy transfer method

- a. i)LEO, ii)Primary Batteries(silver-zinc), iii)Digital, iv)Unregulated DET
- b. i)LEO, ii)Primary Batteries(silver-zinc), iii)S3R, iv)Regulated DET
- c. i)HEO, ii)Primary Batteries(lithium-thionyl chloride), iii)PWM, iv)Peak Power Tracker
- d. i)HEO, ii)Secondary Batteries(nickel-cadmium), iii)PWM, iv)Peak Power Tracker
- e. i)GEO, ii)Secondary Batteries(Li-ion), iii)PWM, iv)Unregulated DET
- f. i)GEO, ii)Secondary Batteries(Li-ion), iii)Digital, iv)Regulated DET

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