408W - Team One

Satellite Radar Altimeter

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Kelly Cusick, Abi Guicheteau, Garima Gupta, Andrew Ryland, Abigail Smith, Lynn Sunderman, Nicholas Venginickal

A. JAMES CLARK SCHOOL OF ENGINEERING

Problem Definition

This project presents a design for a Radar Altimeter intended to measure sea and ice heights based on the European Remote-Sensing Satellite-1, modified to work at an altitude of 1000 km. The design incorporates a Traveling Wave Tube to amplify the RF input signal and an antenna to direct it towards the earth, along with the necessary power supply, cooling systems, and waveguides.

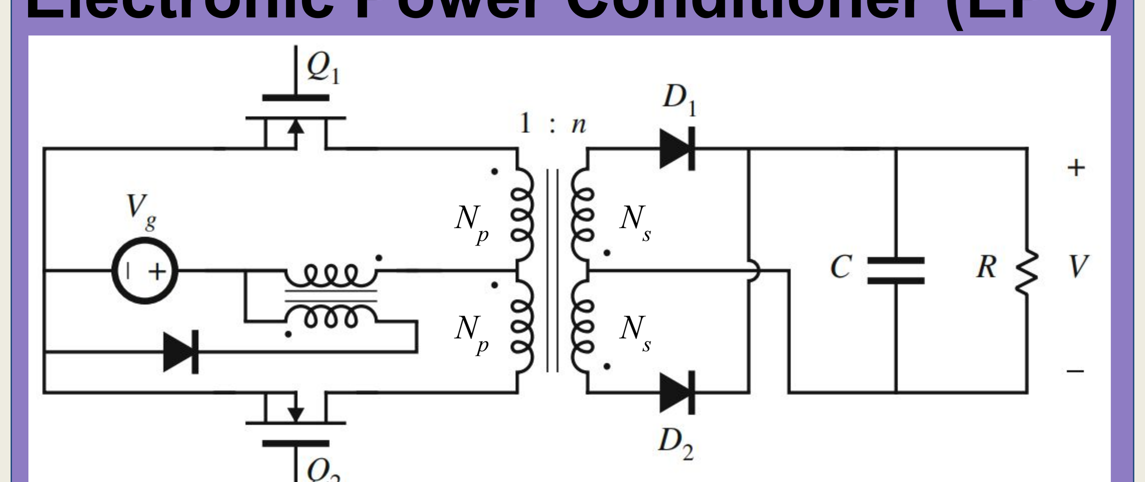
Power Input

The radar altimeter will be powered through solar, which will be connected to an onboard 28 V battery. This battery then powers two separate conversion systems to supply the RF input source and the different voltages needed to collect electrons from the source beam.

RF Input Source

From the battery, voltage is stepped down to 5/3.3/1 V. The RF input source provides the RF signal to be amplified by the TWT and is comprised of a chirp generator, local oscillator mixer, and band pass filter. Pulse gating is used to separate the RF signal, which is then amplified to a set gain and connected to the TWT with a coaxial cable.

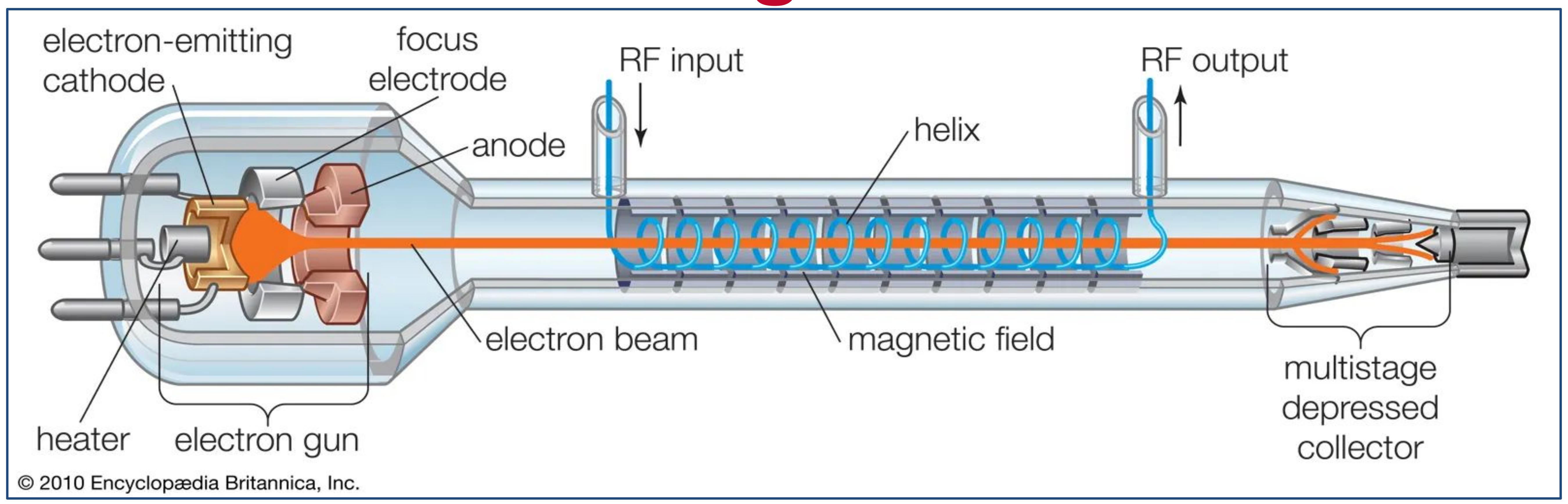
Electronic Power Conditioner (EPC)



A current-fed push-pull converter with a flyback inductor is used to generate the three collector voltages to achieve a TWT 65% efficiency:

- Collector I: 1 kV
- Collector II: 1.4 kV
- Collector III: 1.7 kV

Final Design

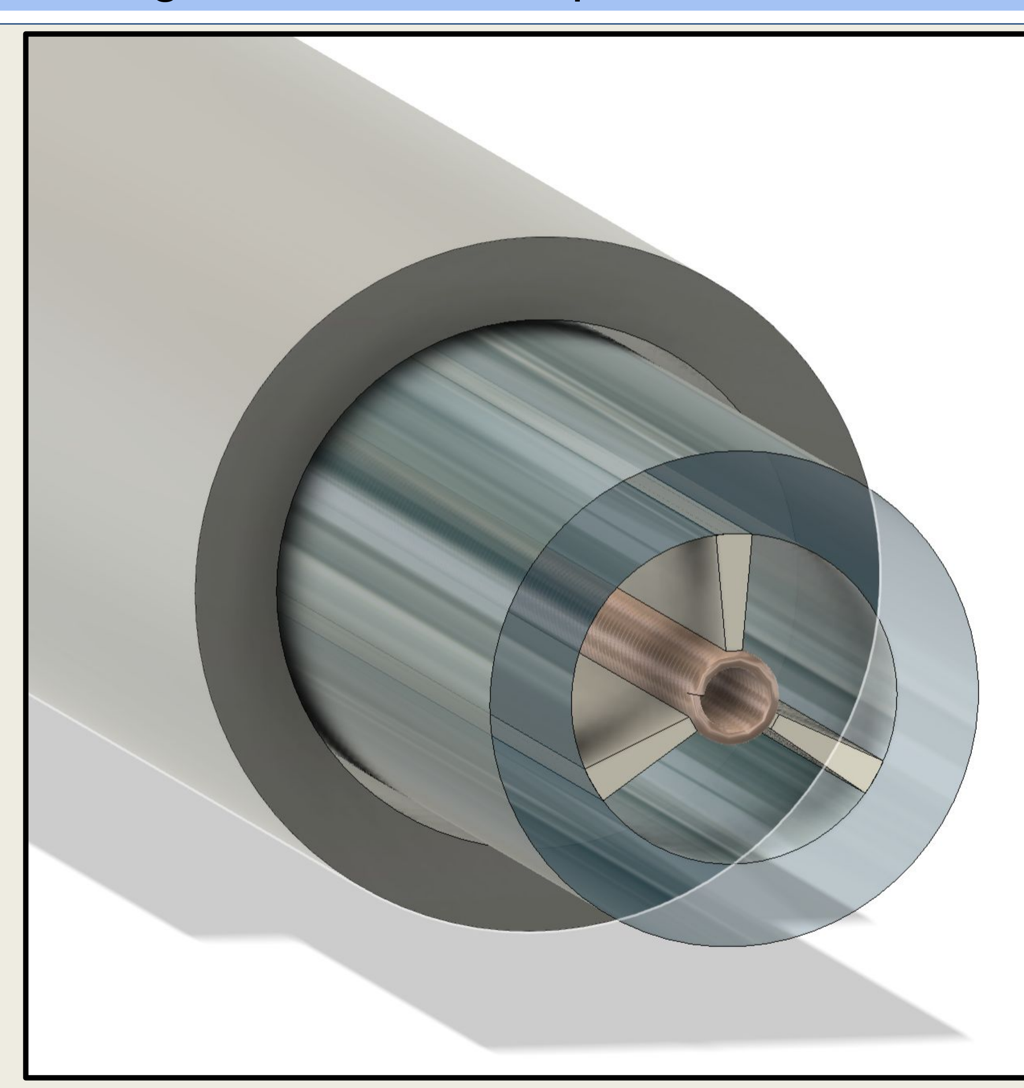


Electron Gun

The electron gun emits a 125 mA, 2 kV beam from a 1.8 mm cathode. It passes through a Pierce electrode and anode inside a pre-baked, metal-ceramic vacuum envelope maintained at $\leq 10^{-7}$ torr. A compression ratio of 1.63 reduces the beam diameter to ~1.41 mm, delivering 250 W of beam power.

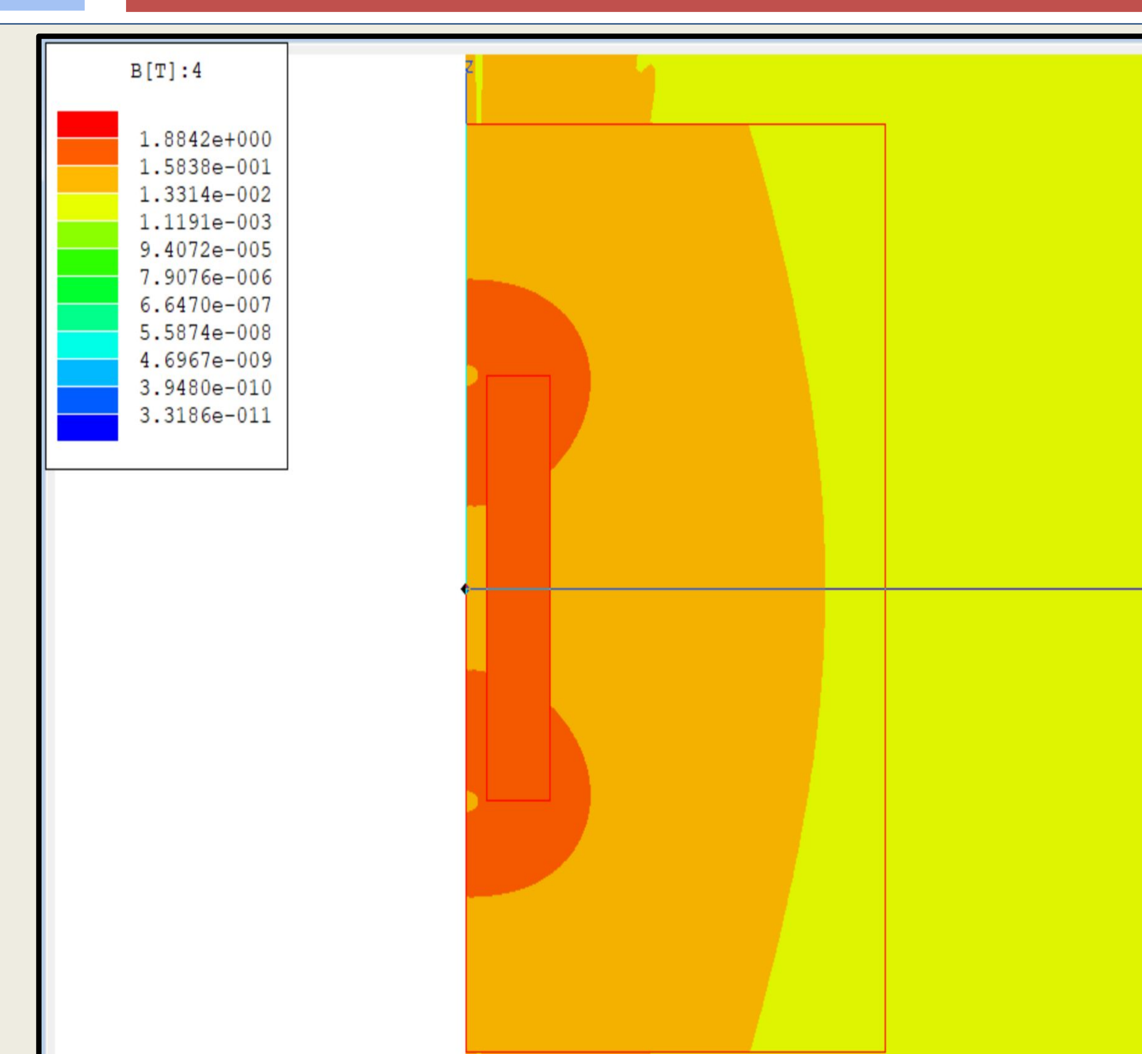
Traveling Wave Tube

The helix slow wave structure in the TWT provides a gain of 40 dB to the 13.8 GHz, for an output power of 50W and an efficiency of 20%. The helix has a pitch of 1.04 mm, radius of 88 mm, a total length of 35.5 cm, characteristic impedance Zc of 16.4 mΩ.



Cutaway View of TWT Interior

- cubic Boron Nitride support rods
- vacuum chamber
- permanent neodymium magnets



Simulation of Magnetic Field of a cylindrical permanent magnet, with a 2 cm inner radius and 8 cm outer radius. The minimum axial field is 1212 Gauss (greater than required 1100 Gauss)

Band Pass Filter

30W filter with a 13.25 -14.25 GHz passband. 0.5 dB insertion loss.

Coaxial Cable & Waveguide

Series of Ku Band Waveguides to transmit microwaves from TWT to Antenna. Square shape tapers to a circle tallowing for a circularly polarized signal, minimizing atmospheric losses.

Antenna

1.5m dish provides ample gain for final SNR to be >20db. Corrugated horn provides minimal side lobes for increased efficiency.

Cooling System

Dual redundant passive cooling system, designed to remove $85W_{th}$ with a 20% safety margin.