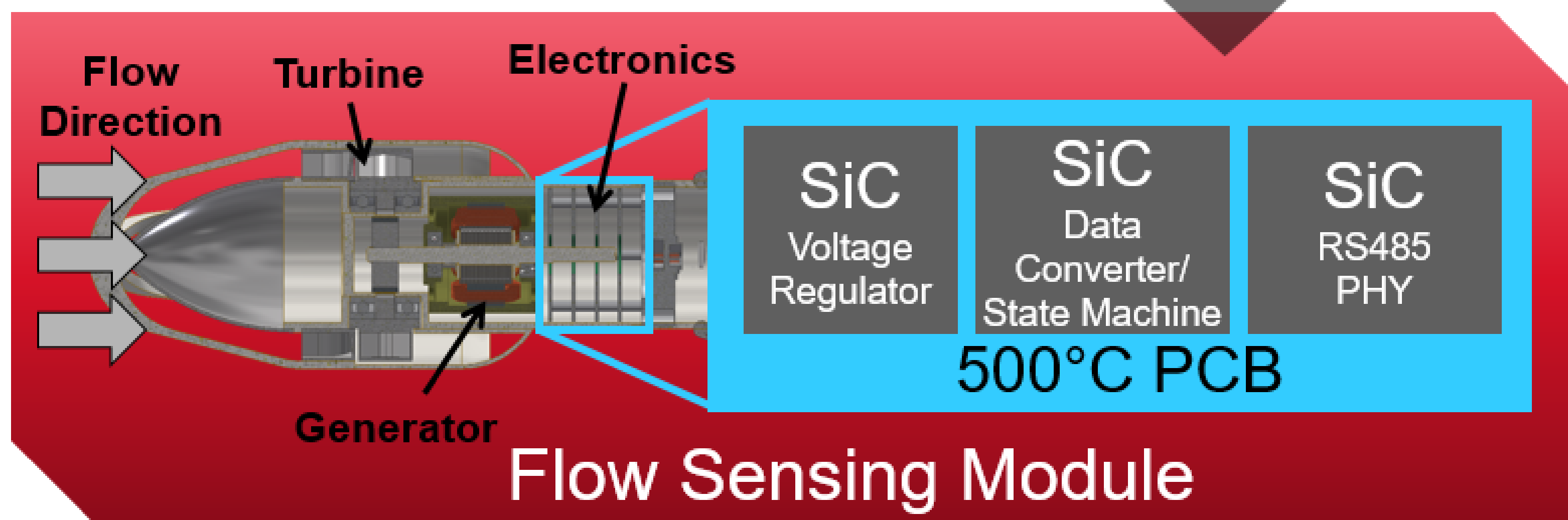
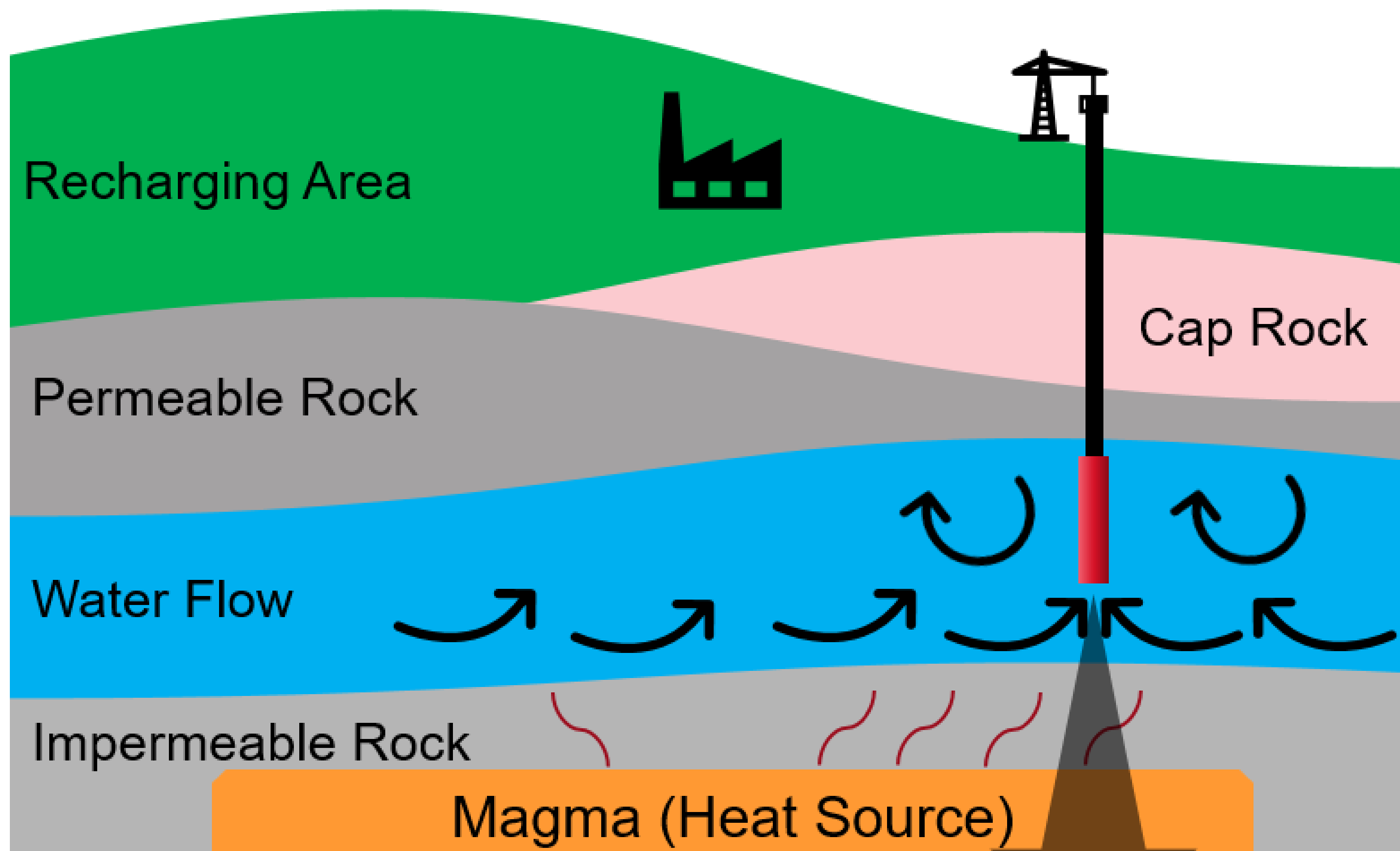


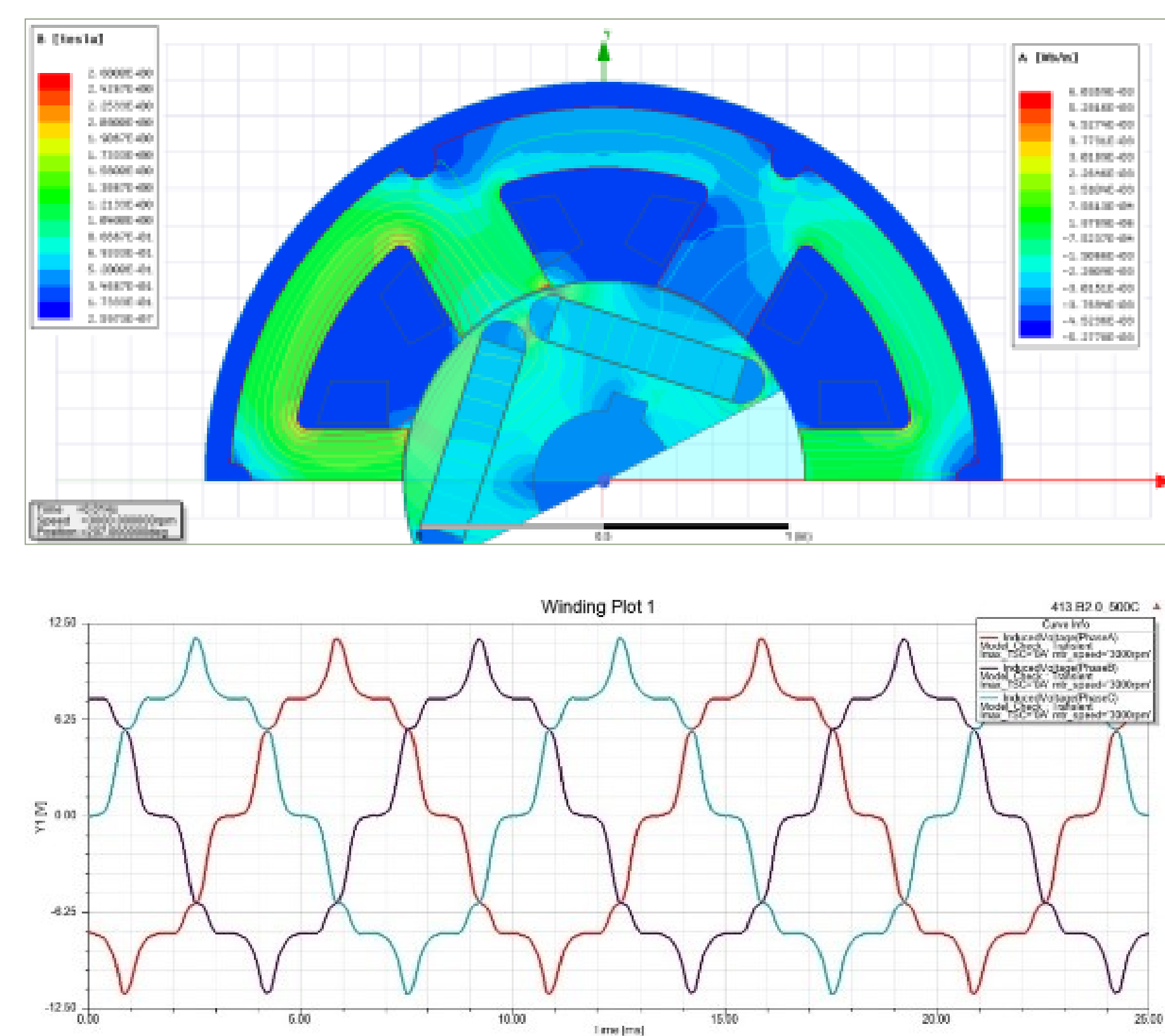
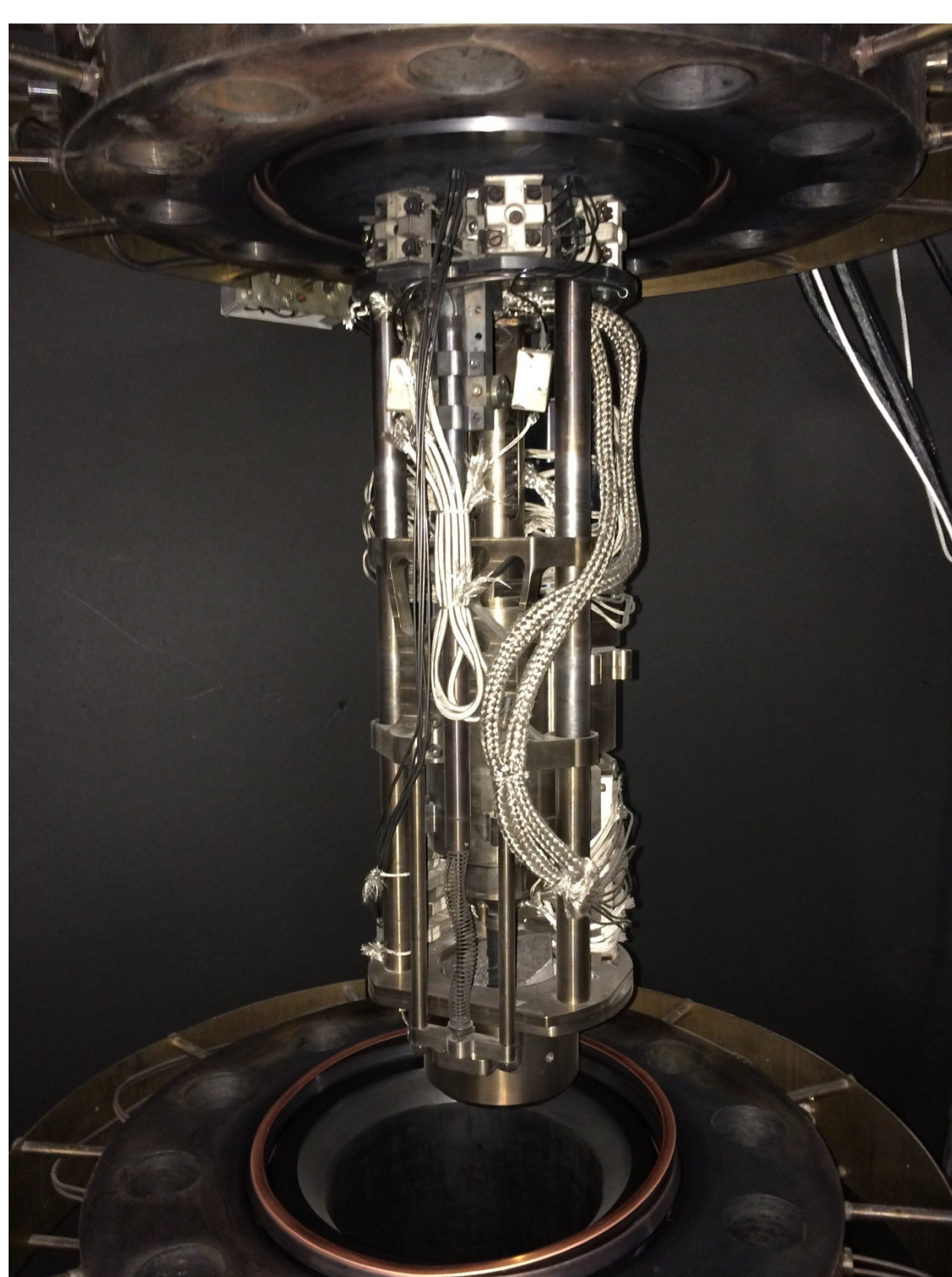
RUGGED, LONG-LIFE FLOW MONITORING FOR ENHANCED GEOTHERMAL SYSTEMS



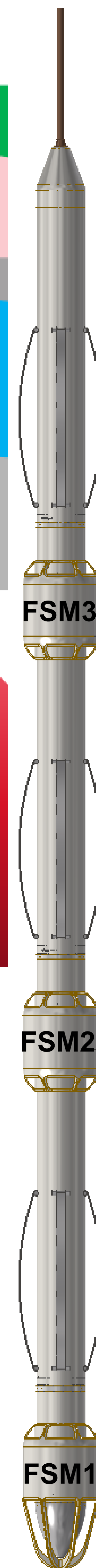
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Flow sensing module is stackable and may be combined with other modules in any desired configuration. Possibilities include redundant sensors, measurement at multiple depths and a flexible suite of sensors.



Honeybee motor has been tested at full Venus conditions (CO₂ atmosphere at 500°C and 92 bar of pressure).



Introduction

Problem:

- How to measure movement of well fluids
- The efficacy of a geothermal well is determined by measuring the fluid enthalpy

Proposition:

- Using hardened technologies, Ozark IC and Honeybee will demonstrate the use of a turbine/spinner to measure this flow

Methods

Ozark IC and its partners have developed unique technologies for sensing and actuation for future NASA missions to the Venus surface (up to 500°C and 100 bar) – similar to conditions within enhanced geothermal wells on earth.

Honeybee Robotics has demonstrated brushless DC motors operating at these conditions as the basis of advanced robotics.

Results

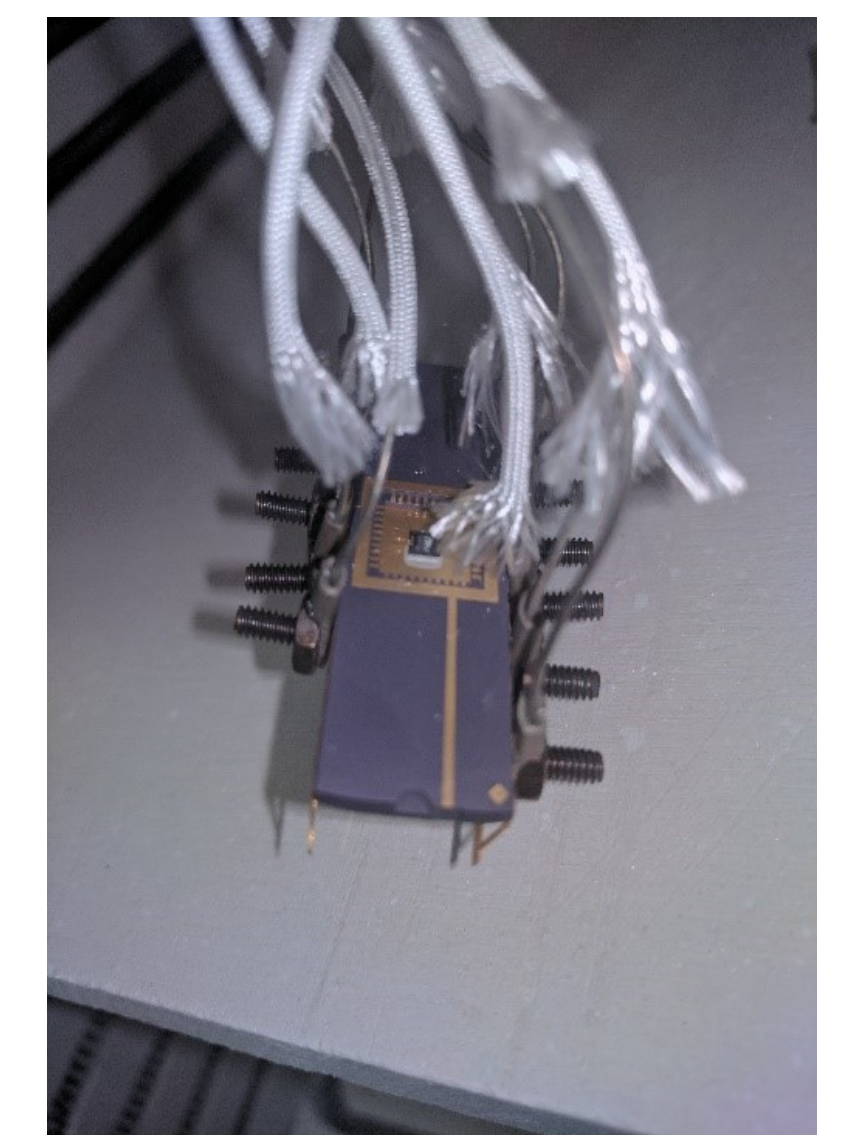
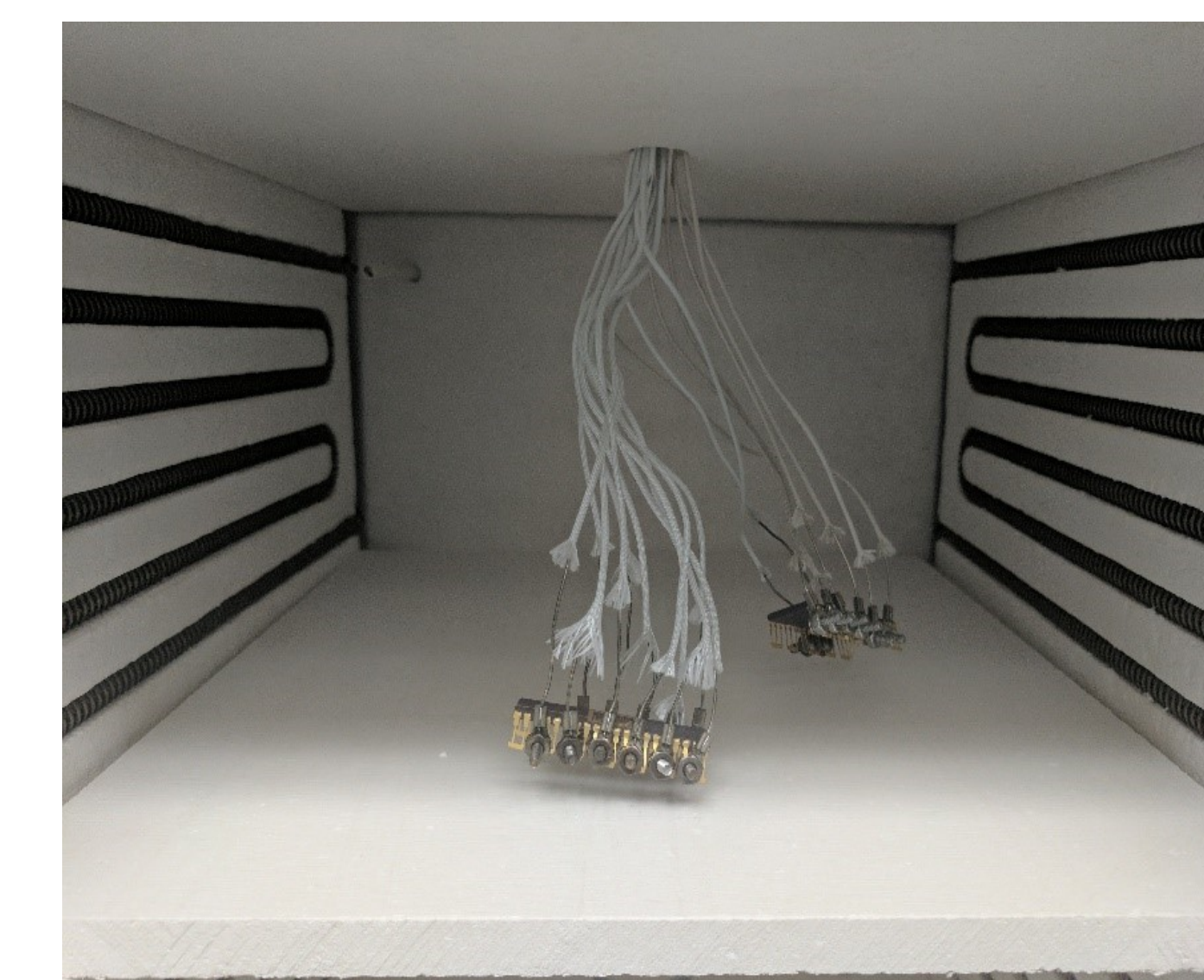
- Honeybee's TRL-5 actuator has demonstrated a continuous power production of ~70W at temperature.
- Ozark IC has fabricated test structures, devices and application circuits in several fabrication runs and demonstrated the most complex integrated circuits to date operating at 470°C for up to 100 hours.

Conclusions/Future Work

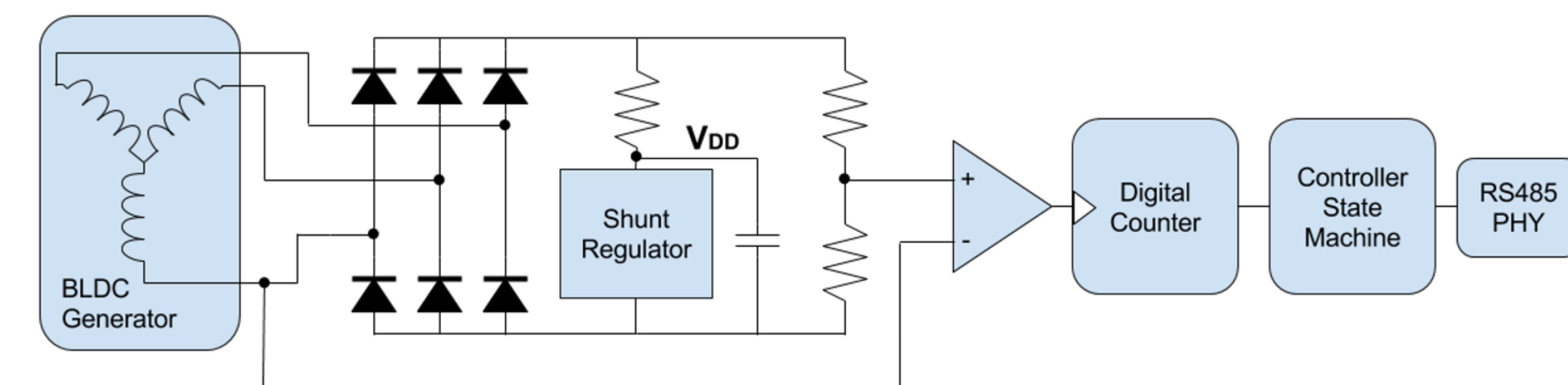
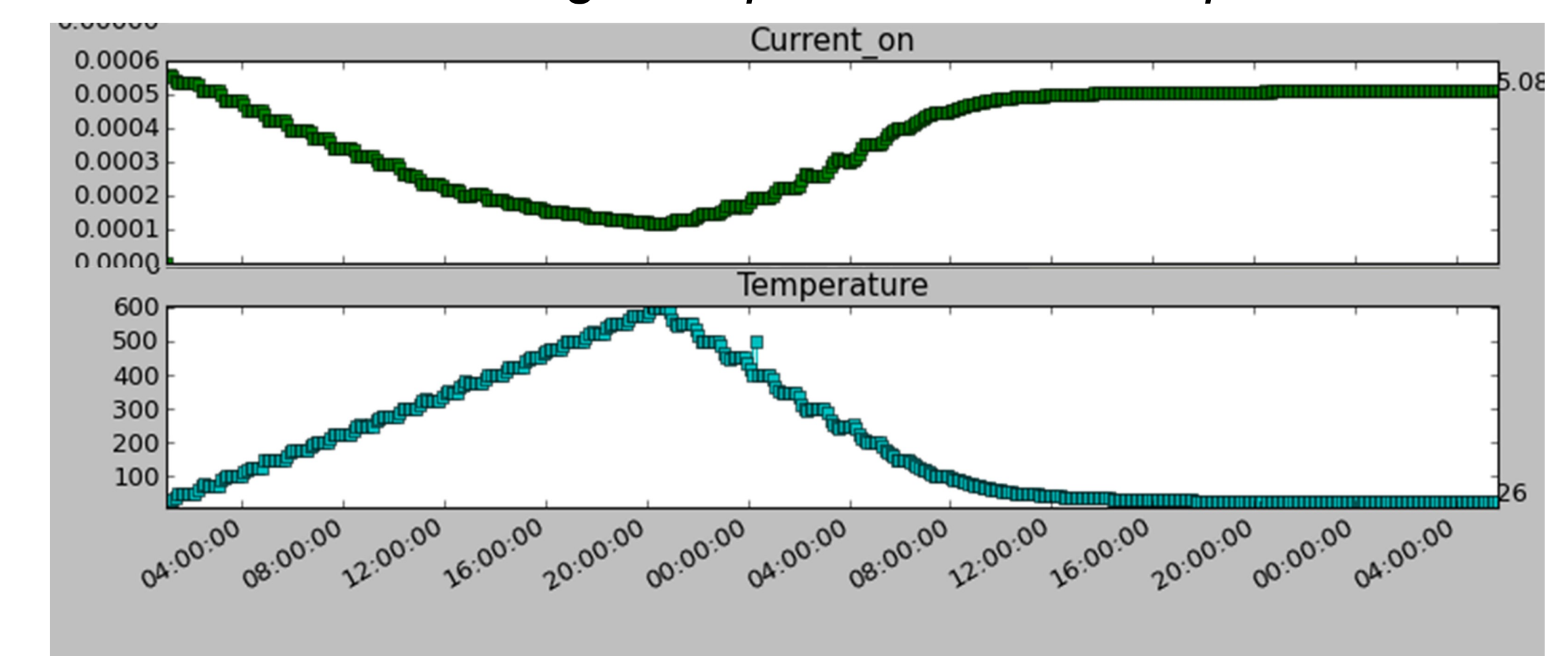
Building on test results at high temperature for both actuation and circuit applications, both Ozark IC and Honeybee will collaborate to design a flow sensing module.

Summary

The efficacy of geothermal wells depend on the ability to monitor fluid flow. The extreme high temperatures of these fluids require hardened technologies currently not available on the market. Ozark IC and Honeybee have developed a solution to this need from previous Venus applications. These modules will be utilized to create a flow sensor rugged enough to withstand the high temperatures found in these fluids.



Ozark IC high temperature test setup.



Temp (°C)	25		100		200		300		470		
	Length (m)	10	3000	10	3000	10	3000	10	3000	10	3000
12 V	1.25 MHz	1.25 MHz	2.5 MHz	2.0 MHz	2.5 MHz	2.0 MHz	2.5 MHz	2.0 MHz	16 MHz	16 MHz	
15 V	1.25 MHz	1.25 MHz	2.5 MHz	2.0 MHz	2.5 MHz	2.0 MHz	2.5 MHz	2.0 MHz	16 MHz	16 MHz	

RS-485 Max data rates over temperature and length.

