U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.

Wireless LVDT for TREAT

Advanced Sensors and Instrumentation Annual Webinar

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Project Overview

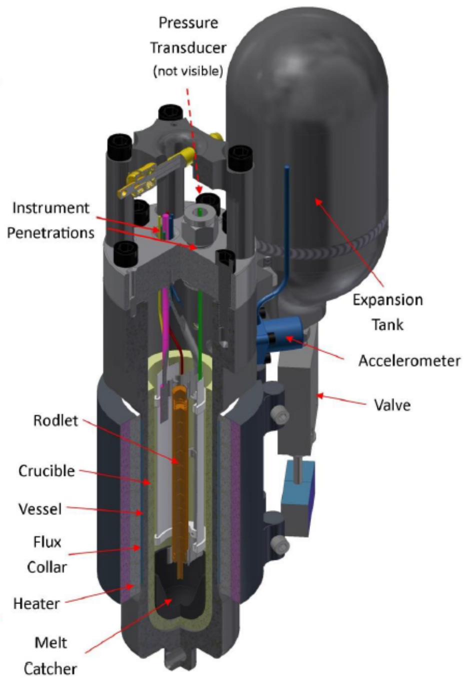
- **Goal**
  - Develop a wireless LVDT measurement system for TREAT
- **Objectives**
  - Develop theoretical and computational capabilities for wireless LVDT system design, optimization and performance prediction
  - Build prototype systems and conduct lab testing
  - TREAT demonstration
- **Participants (2020)**
  - Yuan Gao, PhD candidate in Mechanical Engineering
- **Schedule**
  - FY2020: design capability and computation simulation
  - FY2021: prototype design, fabrication and lab testing
  - FY2022: TREAT testing

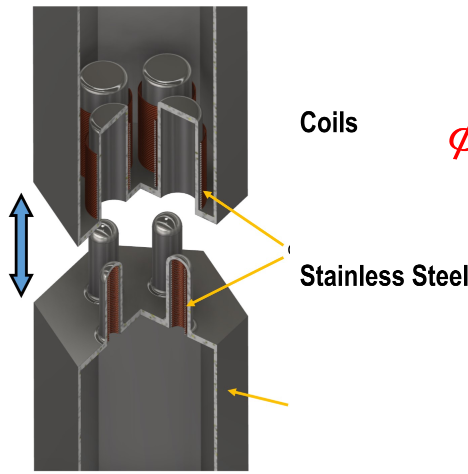
Summary of accomplishments

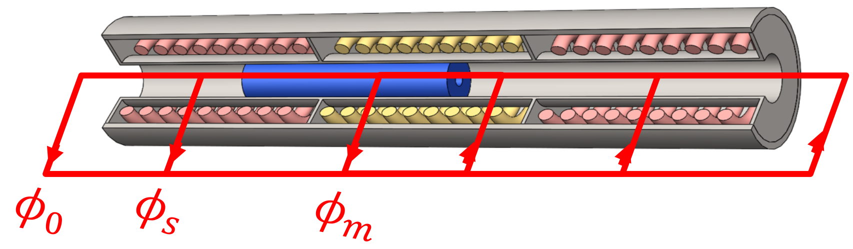
- Developed a theoretical basis for wireless LVDT system
- Examined system design options for reactor specific challenges
- Performed computational simulation of the wireless LVDT EM fields and system performance
- Quantified sensor uncertainty and sensitivity

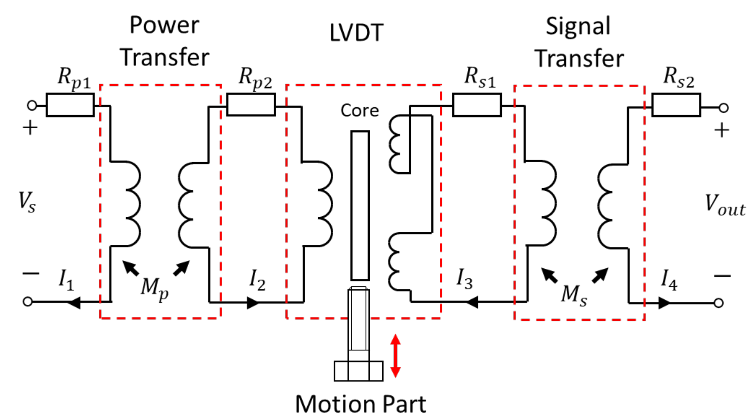
Technology Impact

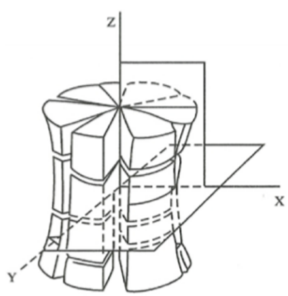
- ***Advances the state of the art for nuclear application***
  - *Wireless LVDT will expand the application of the reactor-proven LVDT technology*
- ***Supports the DOE-NE research mission***
  - *Application of the wireless LVDT technology in research reactors enables measurement capabilities that can accelerate advanced fuels, materials and systems development*
- ***Impacts the nuclear industry***
  - *The wireless LVDT technology has potential to be deployed in commercial reactors for enhanced performance and safety*
- ***Will be commercialized***
  - *TBD*

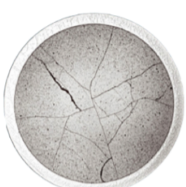






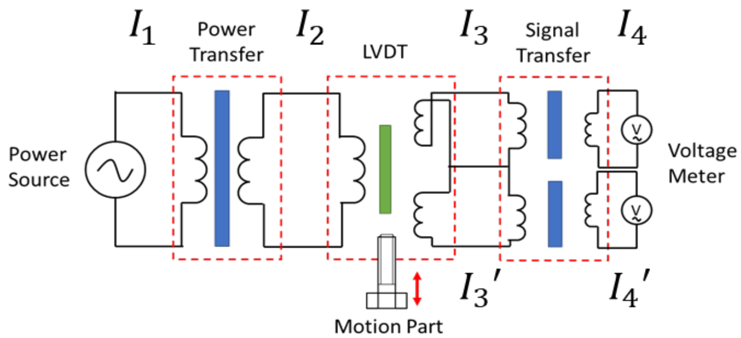






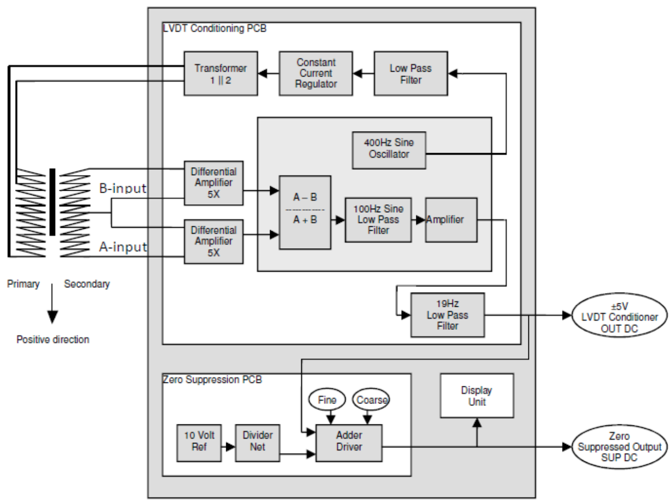
$$y = j\omega M_s \frac{M_1 - M_2}{L_{lout} + L_{s1}} \frac{M_p}{\frac{(M_1 - M_2)^2}{L_{lout} + L_{s1}} + L_{p2} + L_{lin}} \frac{V_s}{j\omega L_{p1} + R_{p1} - \frac{j\omega M_p^2}{\frac{(M_1 - M_2)^2}{L_{lout} + L_{s1}} + L_{p2} + L_{lin}}}$$

Accomplishments (2/2)



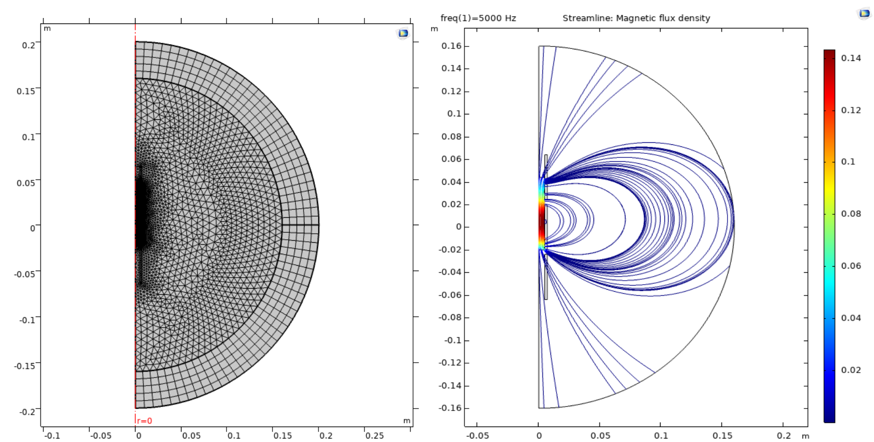
$$y_{two} = \frac{A - B}{A + B} = \frac{F_l L_{lout} \Delta x}{\frac{N_2 N_1 \mu_0 \pi R^2}{h_2 - x_0} + \frac{N_1 N_2 g}{4 h_2} x_0^2} = F_l' L_{lout} \Delta x$$

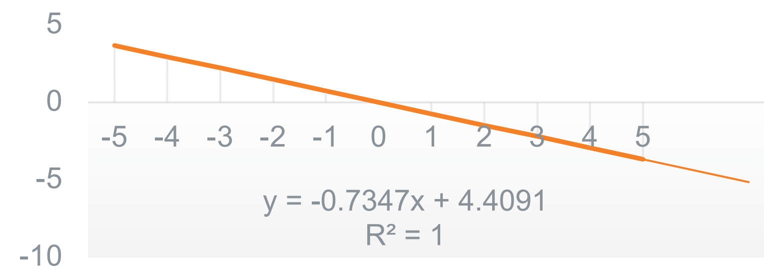
Two outputs will eliminate the influence of wireless transfer system.



Sensitivity Analysis (+5%)

Input	Output
Current	Voltage
Parameters	**Result Max Value Change**
Mutual Inductance	10.25%
Frequency	5.00%
All Resistors	**<0.01%**
All Inductors	5.00%





Summary

- The project has progressed as planned, as the COVID-19 has limited negative impact on the project
- Year 1 objectives are accomplished successfully
- The graduate student is planned to move to INL to work with HTTL on fabrication and lab testing of prototype systems in Year 2

Publications:

1. ANS Transactions: Wireless Signal Transfer Application of LVDT in Nuclear Reactors, Vol.121, No. 1, pp. 435-437, 2019
2. ANS Transactions: Electromagnetic Coupling for Wireless Signal Transmission in Nuclear Reactors, Vol. 122, No. 1, pp. 109-112, 2020
3. An ANS summary accepted in ANS Winter Meeting, November 2020
4. A journal manuscript completed

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