



A Micro Oven-Control System for Inertial Sensors

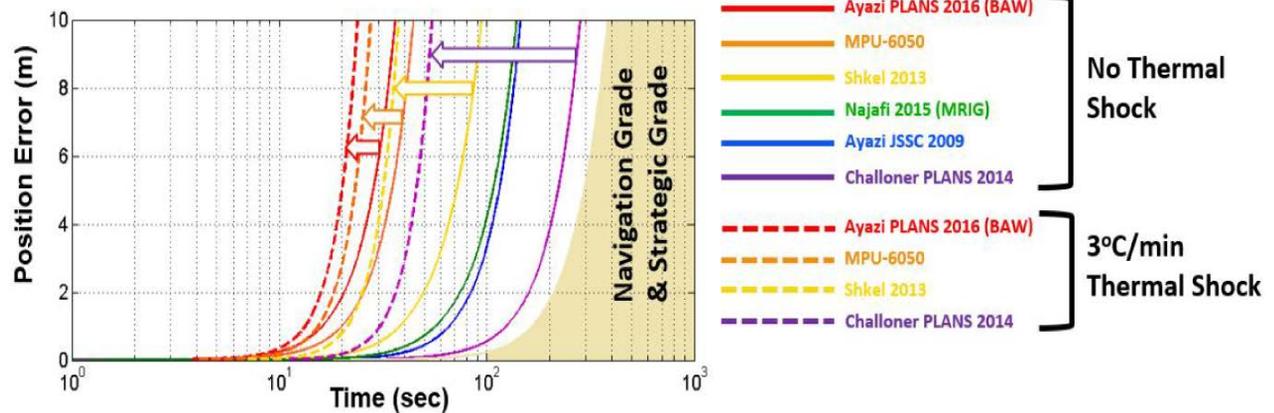
Donguk Max Yang, Jong-Kwan Woo, Jay Mitchell*, Sangwoo Lee*, Dorian Challoner**, Khalil Najafi
Electrical Engineering, University of Michigan

* ePack, Inc.

** InertialWave, Inc.

Problem Definition

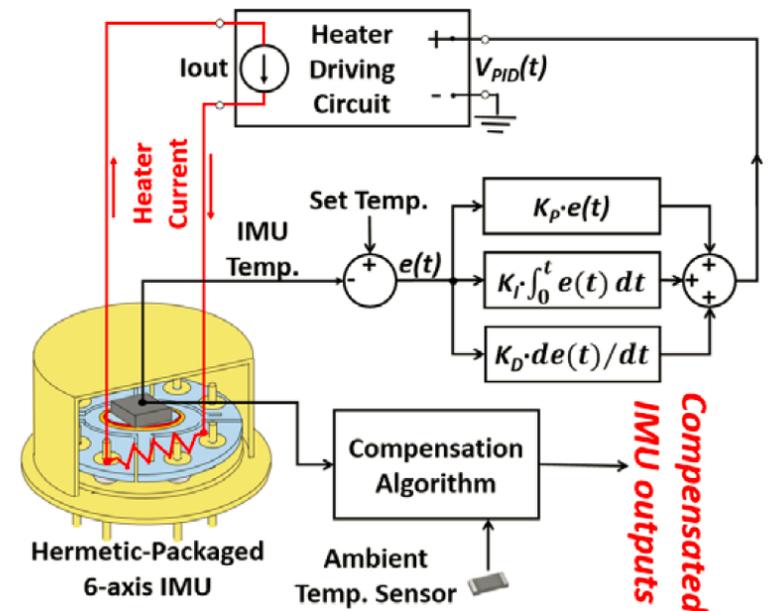
- Navigation system using MEMS inertial sensors greatly suffers from temperature change
- For example, position error of one of the best MEMS gyroscopes, Challoner PLANS 2014, is < 1m at 100s at RT, while it increased to > 50m at 100s with 3°C/min thermal shock
- Other inertial sensors show much degraded performances with thermal shock



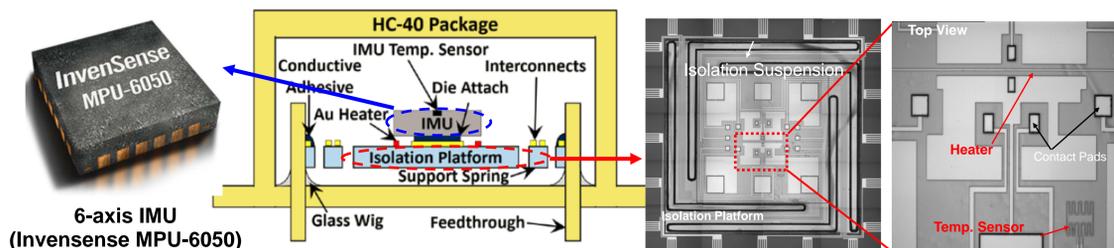
Methods & Materials

- Temperature of inertial sensors is controlled at 90°C at all time using a micro-machined glass isolation platform
- A heater and an RTD sensor are fabricated on the isolation platform
- Least mean square (LMS) and random forest (RF) compensation algorithms are used to minimize residual bias errors
- Thermal circuit analysis is conducted to minimize power consumption

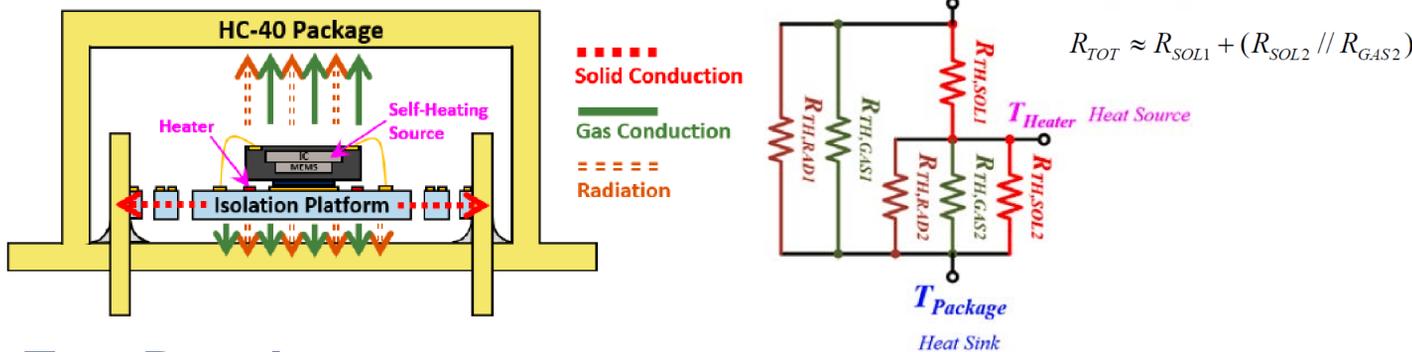
Oven-Control System Diagram



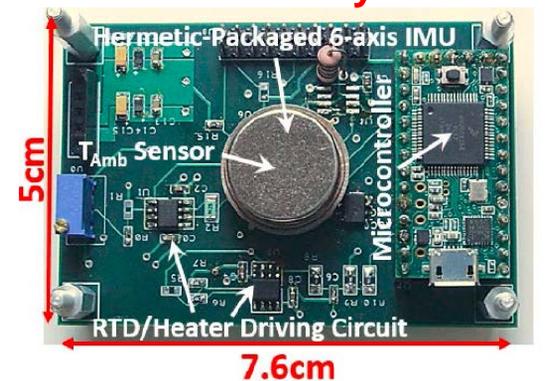
Hermetic-Packaged 6-axis IMU



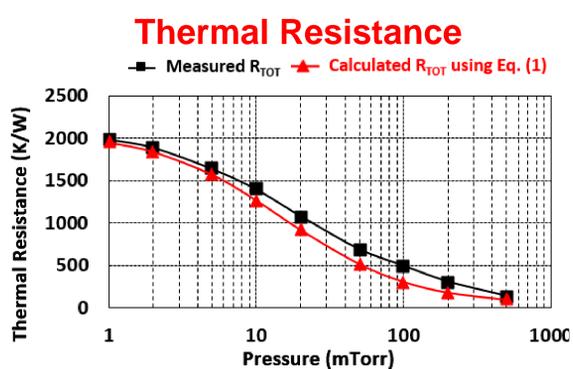
Thermal Circuit Analysis



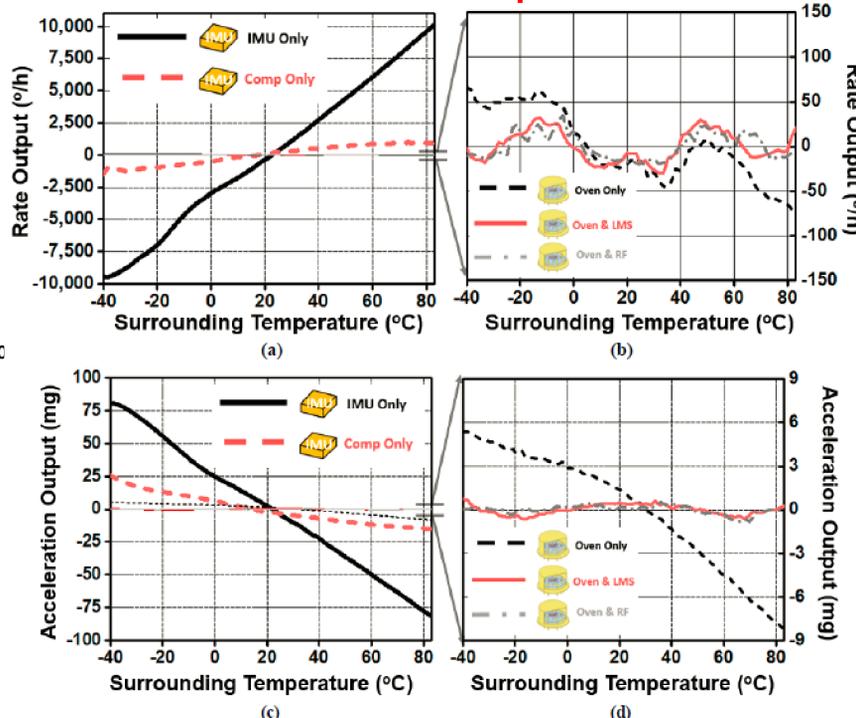
Oven-Control System



Test Results



Bias Drift Over Temperature



Summary & Conclusion

- RSS bias changes of the three gyroscopes and the three accelerometers were reduced by 345 times (from 21645°/hr to 62.71°/hr) and 97 times (from 185.9mg to 1.920mg), respectively during the thermal-cycle test over 125°C surrounding temperature changes, from -40°C to 85°C with a 1°C/min rate of change.
- The platform has a thermal impedance of $\sim 2,000^\circ\text{C/W}$.
- Low power consumption of $< 100\text{mW}$ over temperature range from -40 to 85°C is achieved.
- The entire system measures 7.6cm x 5cm.

Future Works

- Possible future work will include:
 - analyzing and optimizing temperature-induced stress on IMU
 - analyzing run-to-run stability and repeatability of the oven-control system
 - implementing an oven-control system with lower power consumption
 - applying these oven-controlled IMUs to practical applications

Quantitative Comparisons

Combination		None		Oven-Control	
		Drift	Imp.	Drift	Imp.
Gyro	X (°/h)	20610	378x	54.54	
	Y (°/h)	6486	230x	28.20	
	Z (°/h)	1288	101x	12.78	
Acc	X (mg)	72.22	59.9x	1.205	
	Y (mg)	14.91	22.4x	0.6652	
	Z (mg)	170.6	127x	1.339	

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