

Centre for Industrial Ultrasonics Open Day
25th April 2018

High Frequency Flexural
Ultrasonic Transducers: Industrial Opportunities

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WARWICK

Overview of Our Research

- The FUT is currently used primarily for flow measurement, proximity sensing and industrial metrology
- Designed for ambient conditions and low ultrasonic frequencies, up to approximately 50 kHz

Application	Example Pressure (bar)
Domestic water meters	20
Industrial gas meters	300
Industrial flow meters	300+
Environment	Example Temperature (°C)
Oil production	120
District heating	250
Petrochemical	350-450
Power plants	560

How can we adapt FUTs for operation at higher frequencies, in high pressure and temperature environments?

Ultimate Goal

The development of high frequency flexural ultrasonic transducers (HiFFUTs), a new class of ultrasonic transducer.

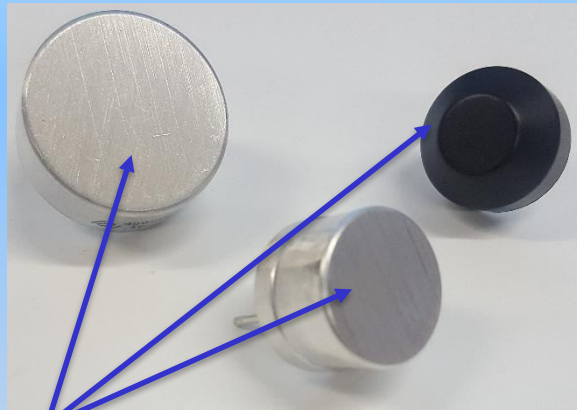
Grant Number EP/N025393/1

EPSRC

Engineering and Physical Sciences
Research Council

The Flexural Ultrasonic Transducer

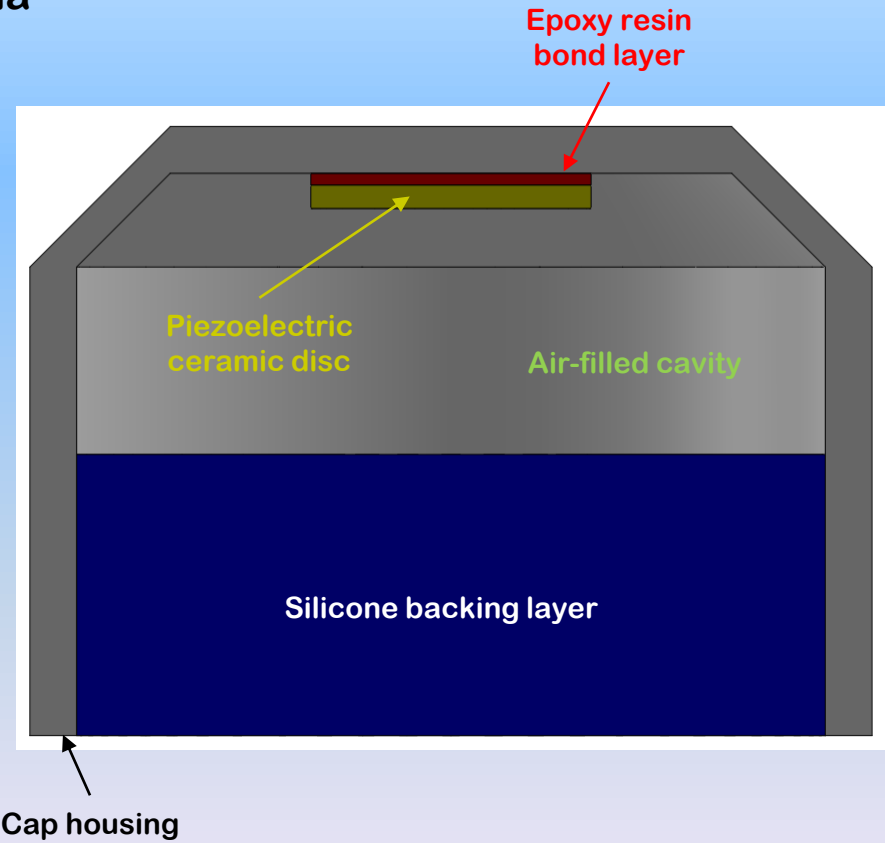
- Unimorph device
- Piezoelectric driver bonded to a metal cap
- Vibration of the piezoelectric causes metal cap bending
- Efficient coupling to low-impedance media



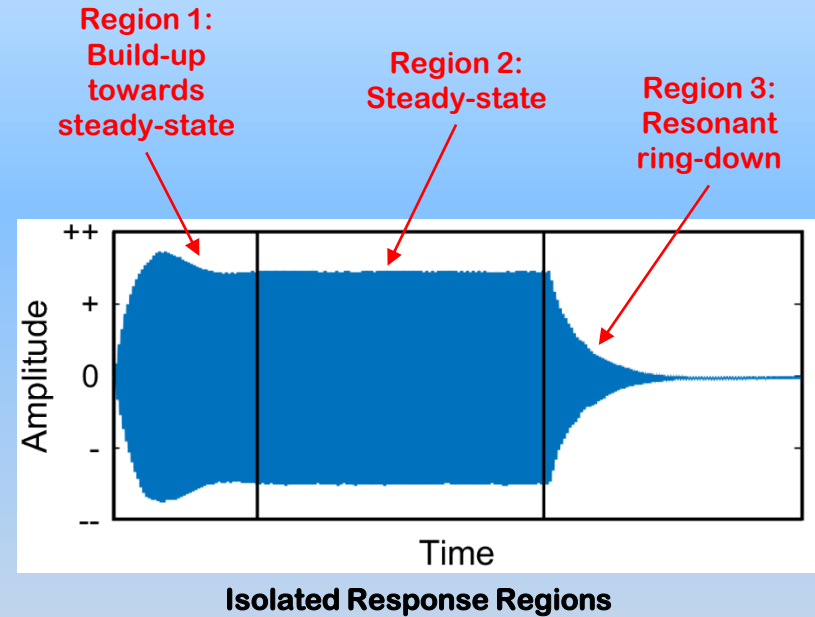
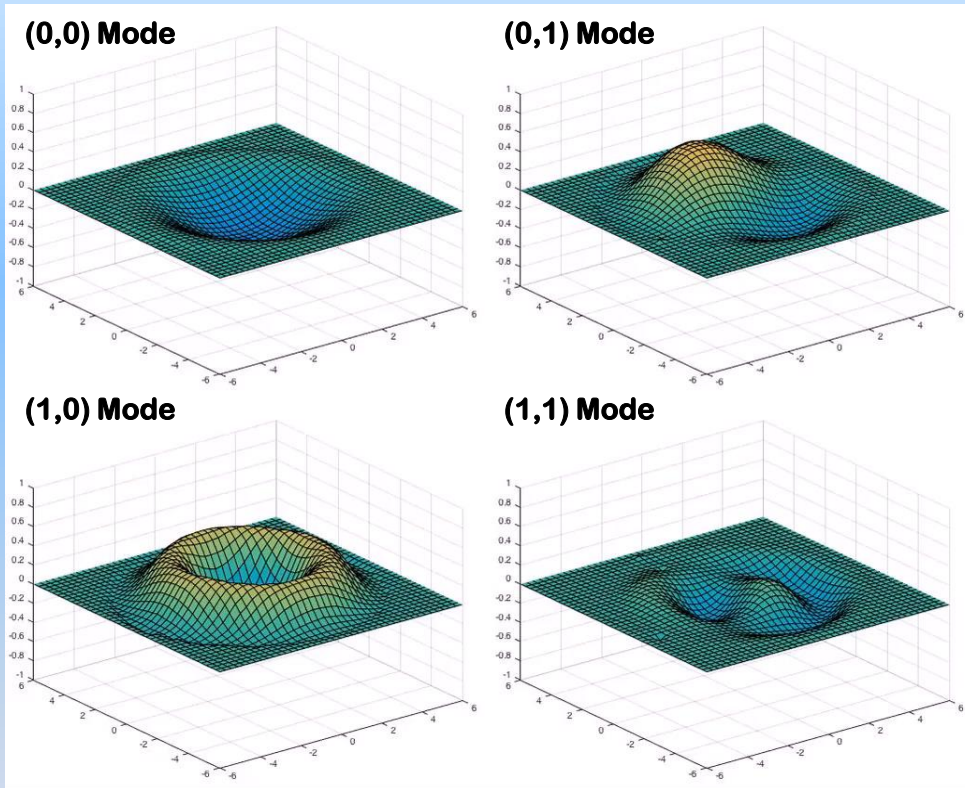
Vibrating membrane



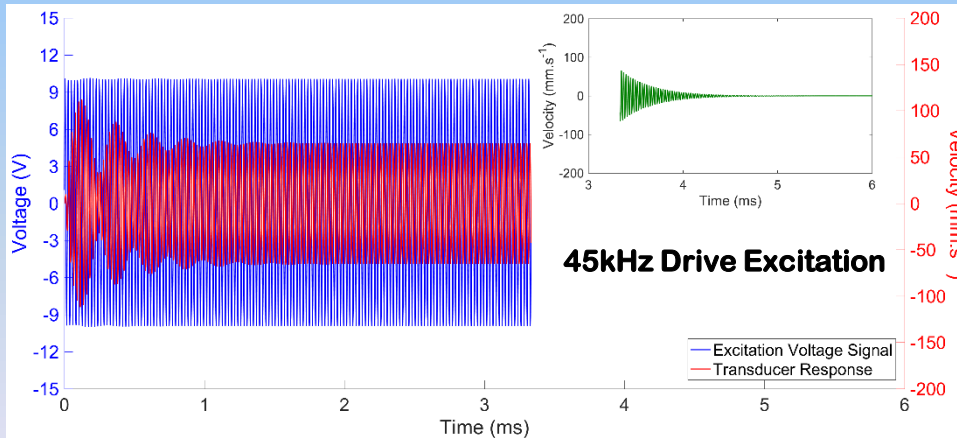
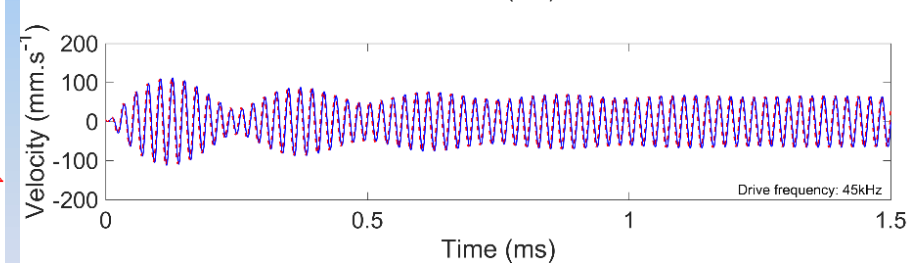
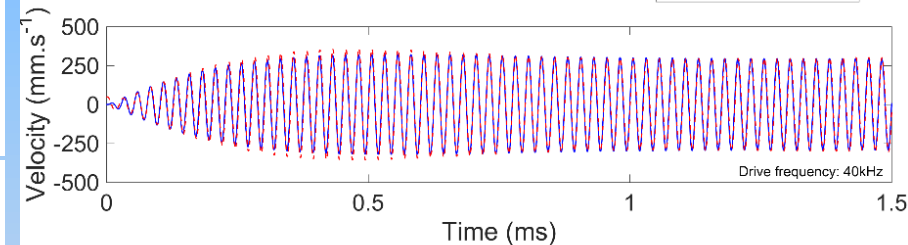
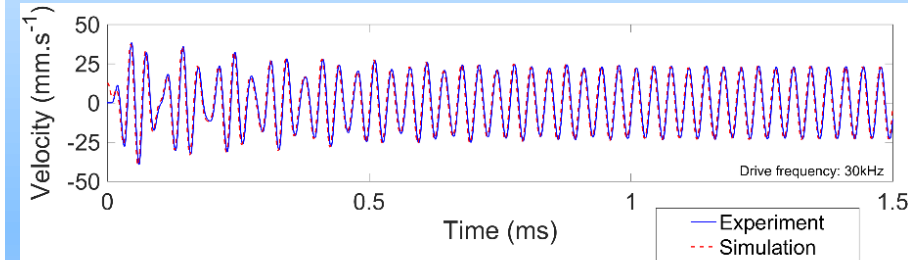
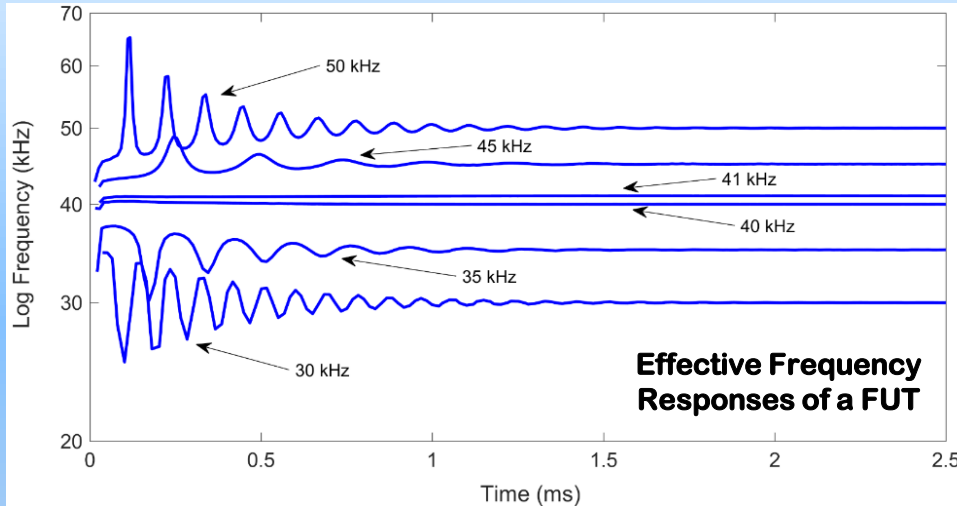
Aluminium 40 kHz FUT



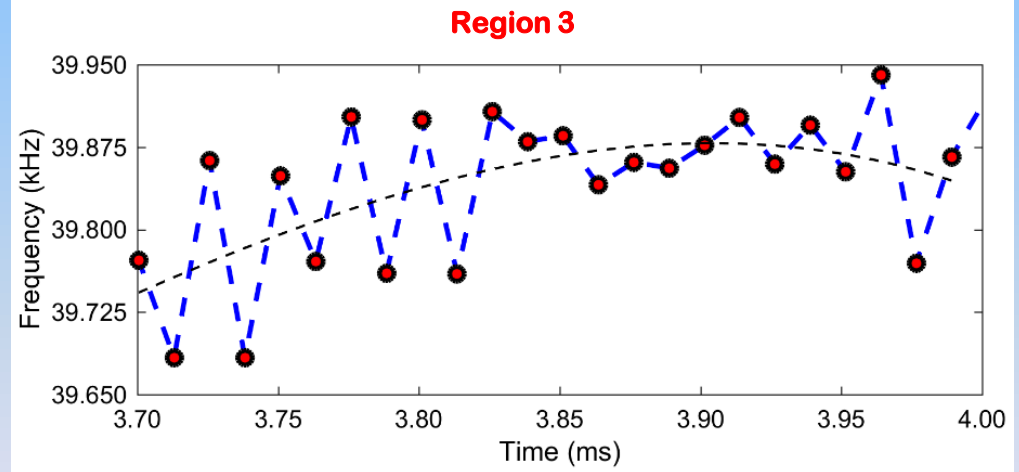
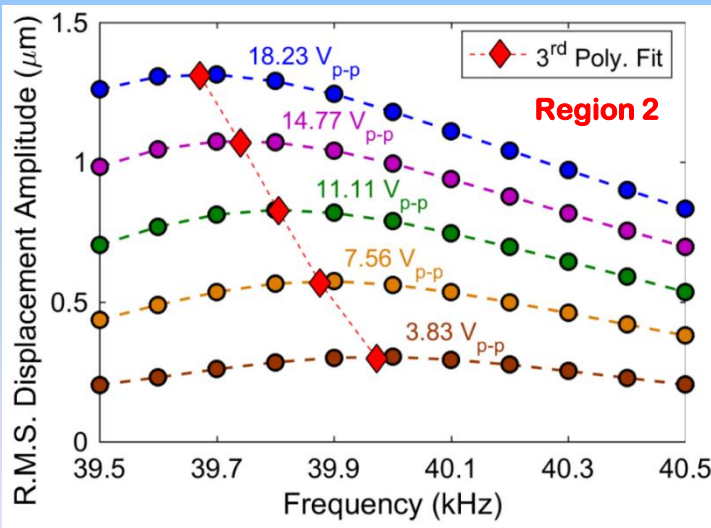
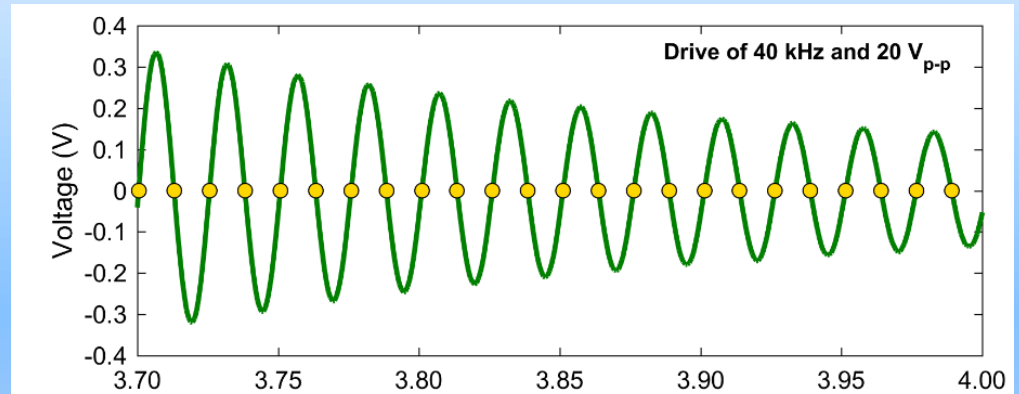
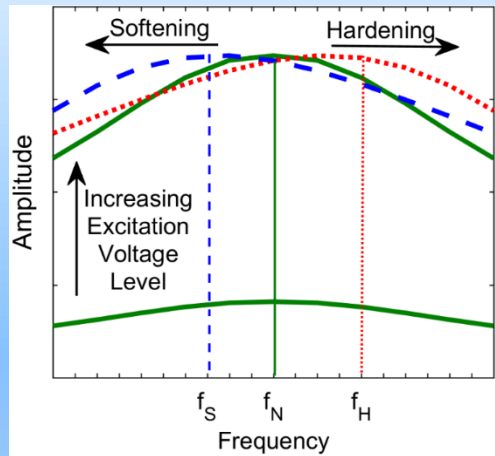
Operating Characteristics



Correlation of Analog Model and Experimental Data

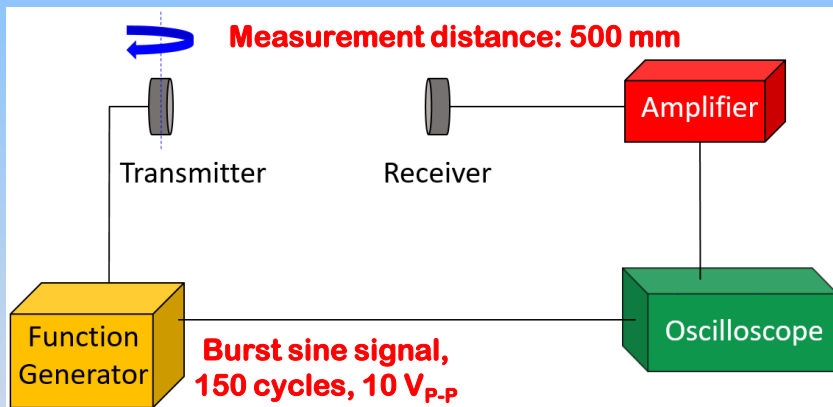
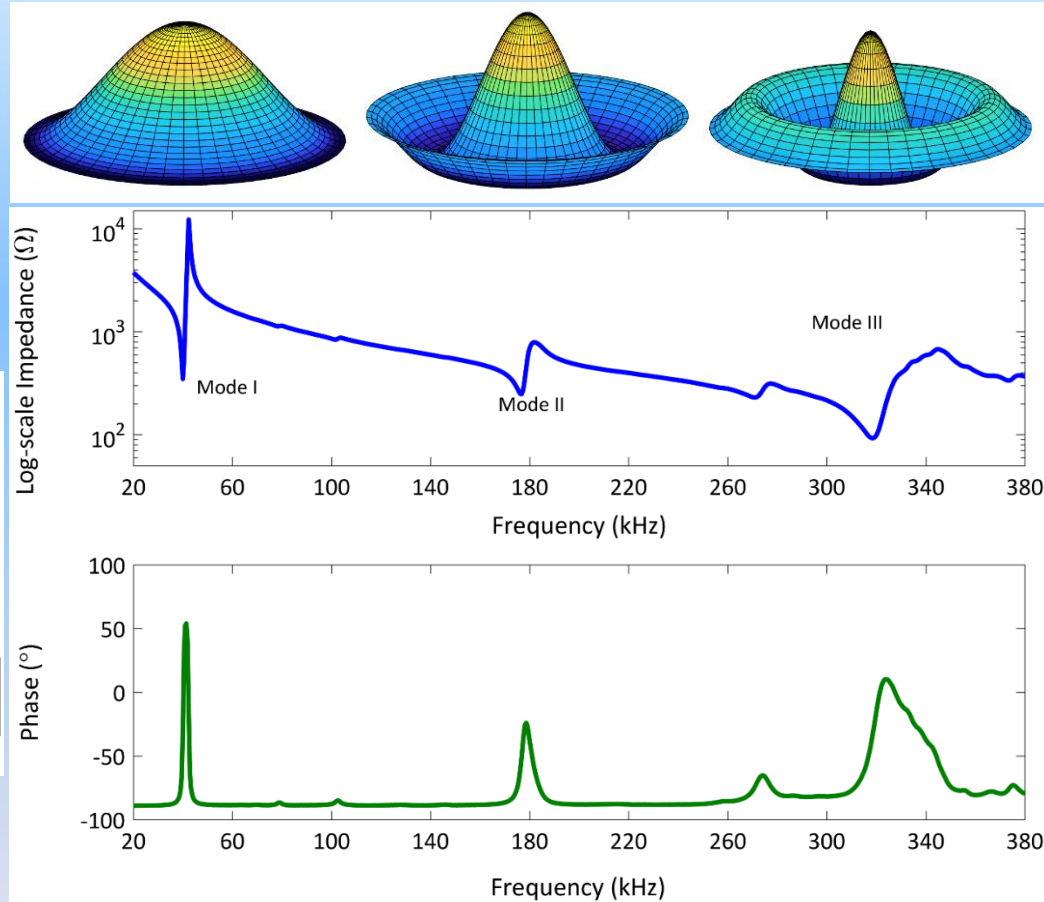


Dynamic Nonlinearity

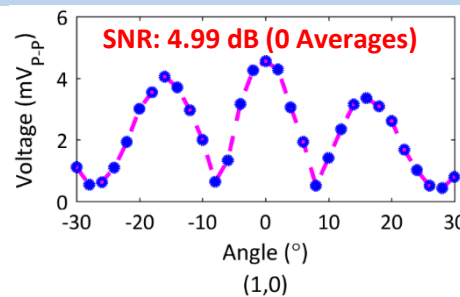
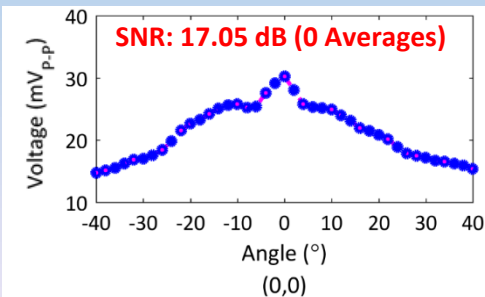
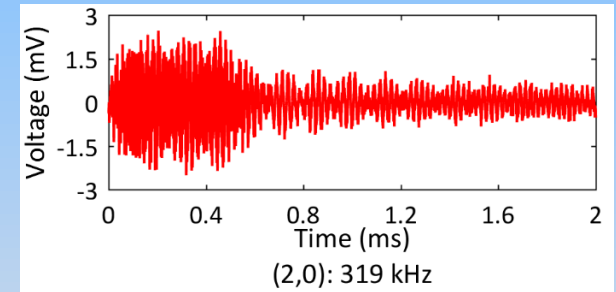
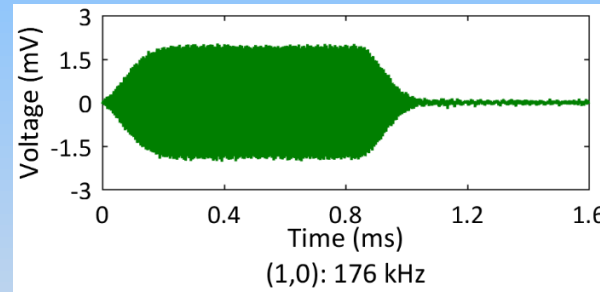
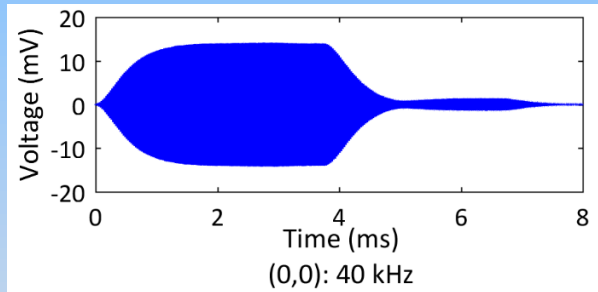
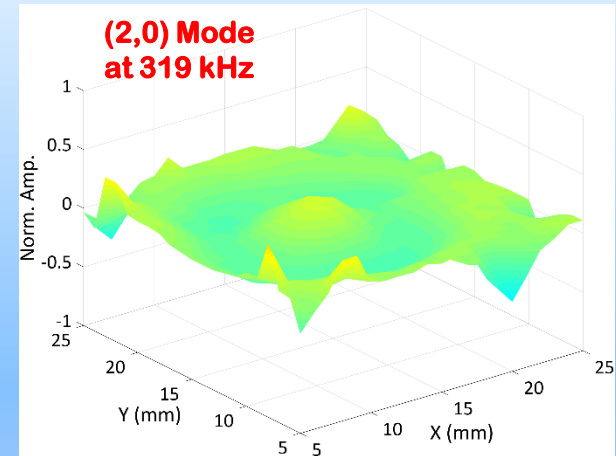
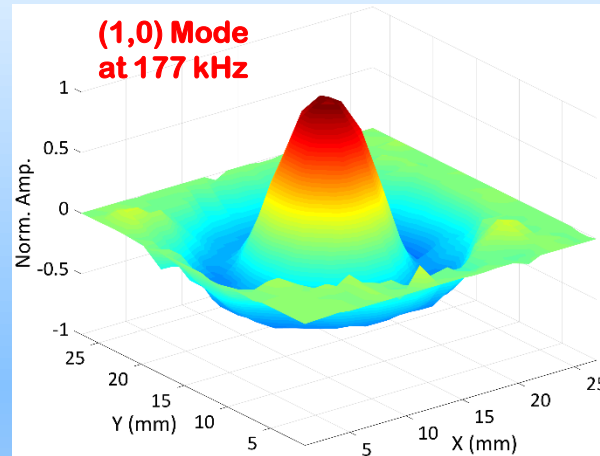
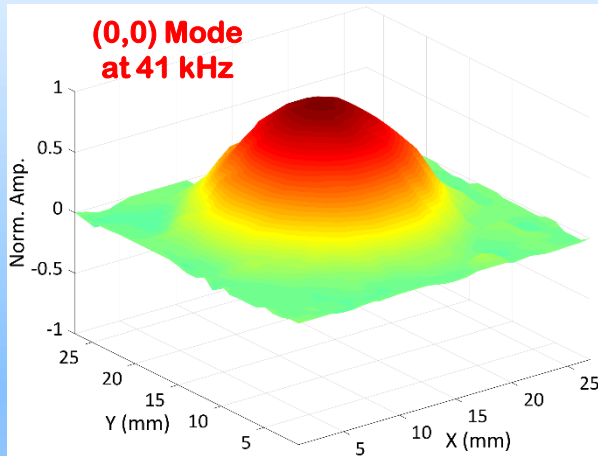


High Frequency Operation

- Propagation of ultrasound in air
- Efficient driving mechanism required
- Bespoke amplifier adopted
- Two FUTs, one as a transmitter, one as a receiver, both with a (0,0) mode of 40 kHz



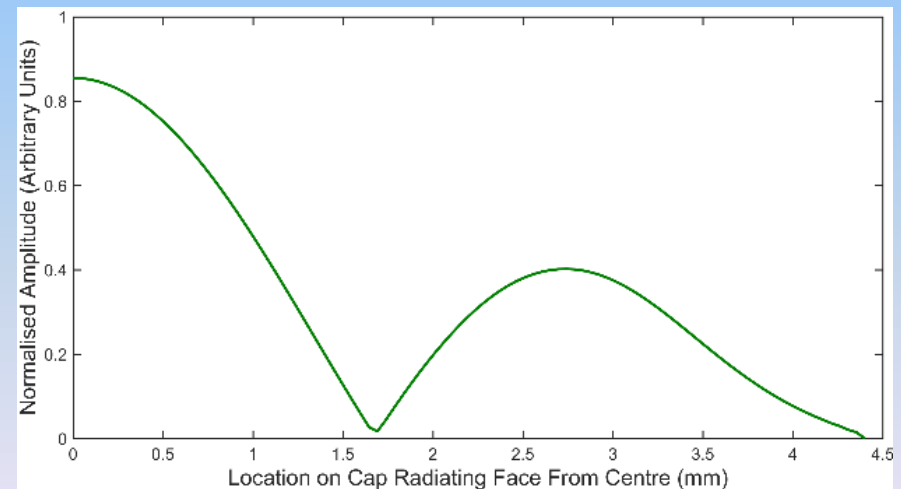
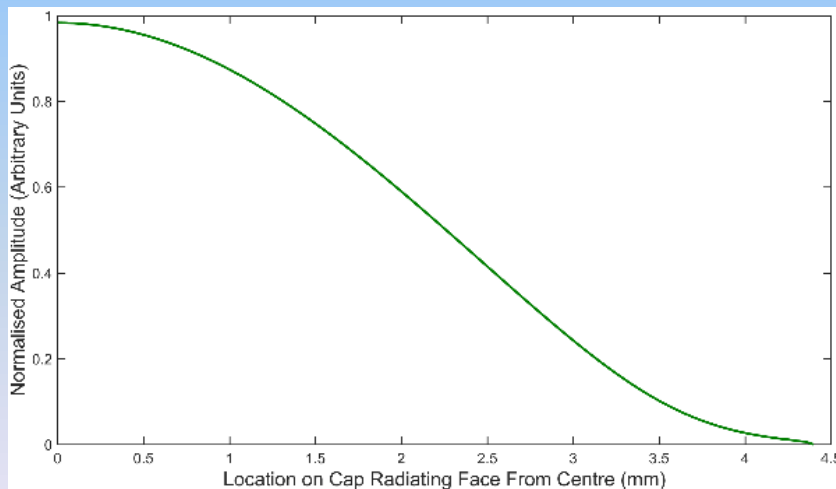
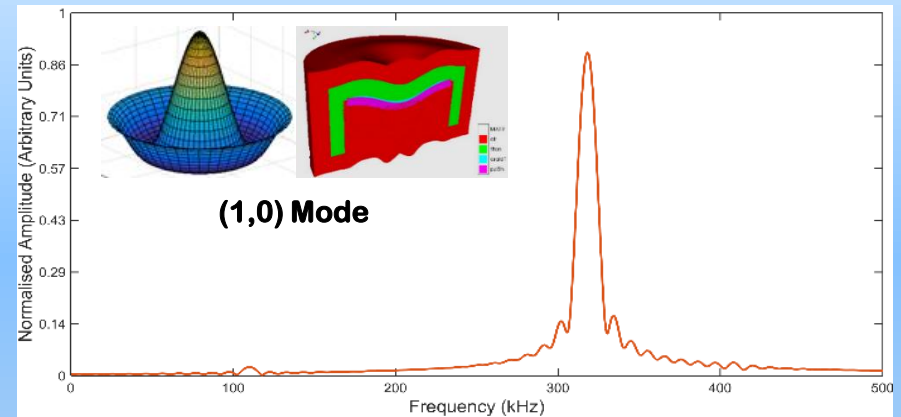
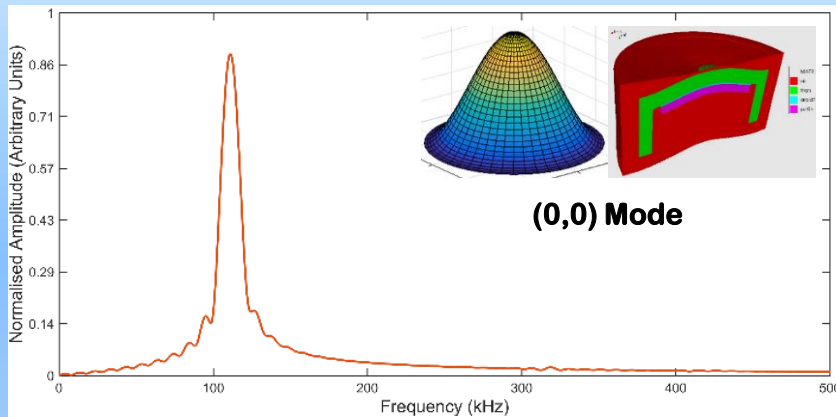
High Frequency Operation



$$SNR = 20 \log_{10} \frac{V_{RMS,SIGNAL}}{V_{RMS,NOISE}}$$

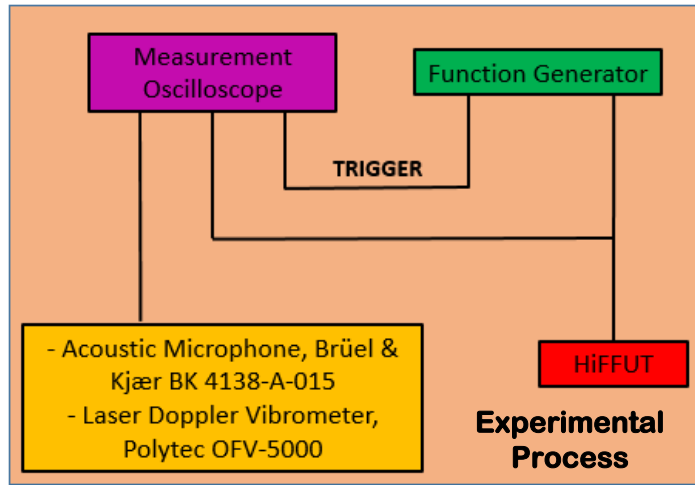
HiFFUT Design: Finite Element Analysis

We use PZFlex® finite element analysis software to design HiFFUTs.

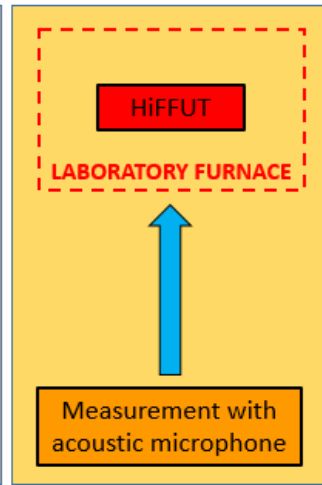


HiFFUTs for High Temperatures

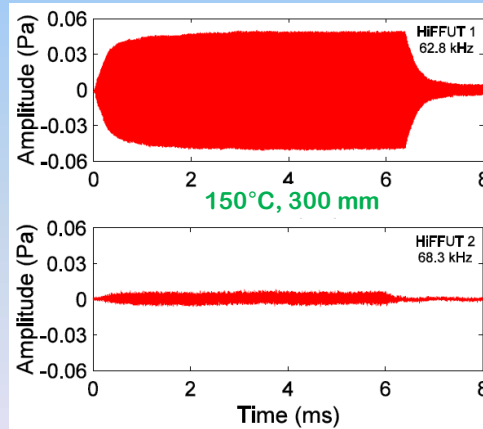
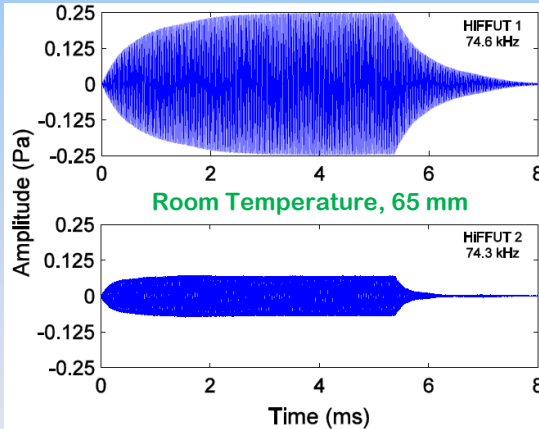
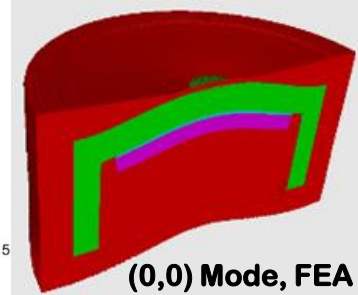
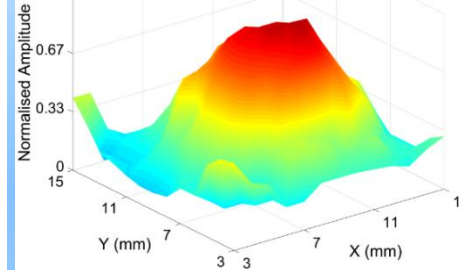
Phase 1



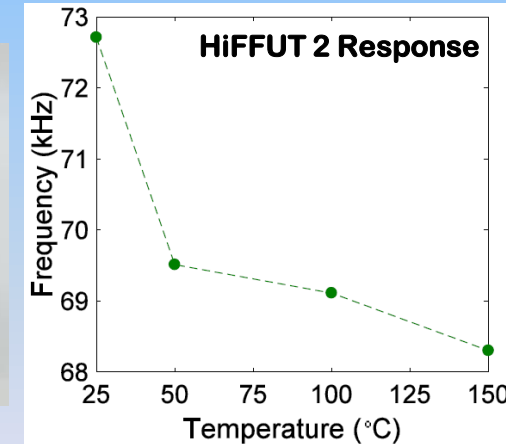
Phase 2



(0,0) Mode of HiFFUT 1 from LDV at 74.5 kHz

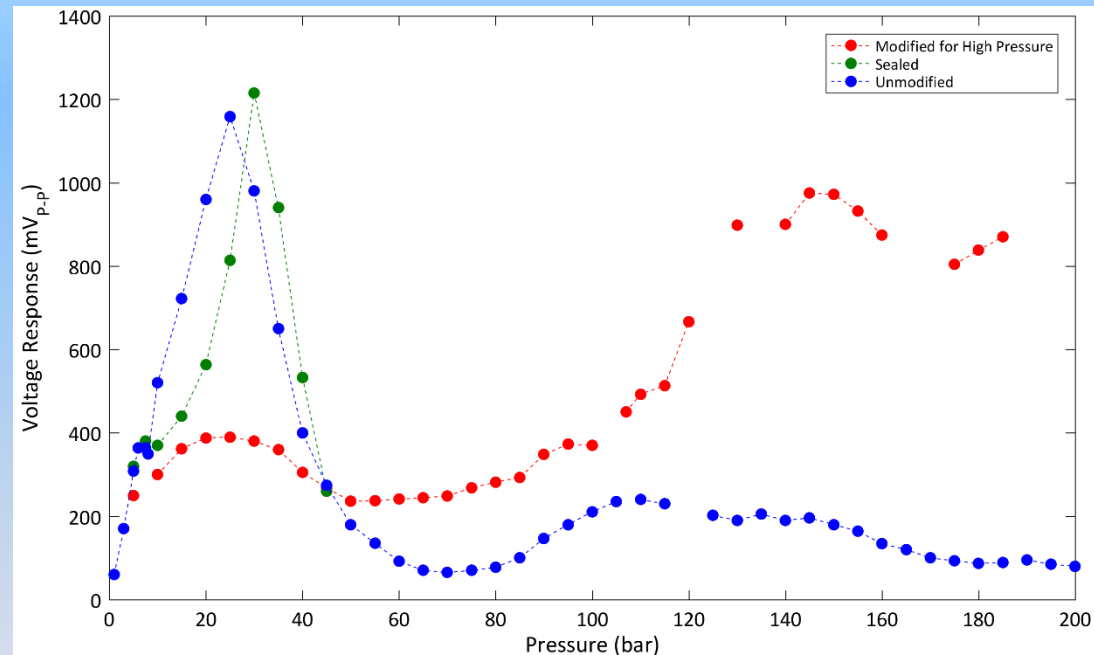
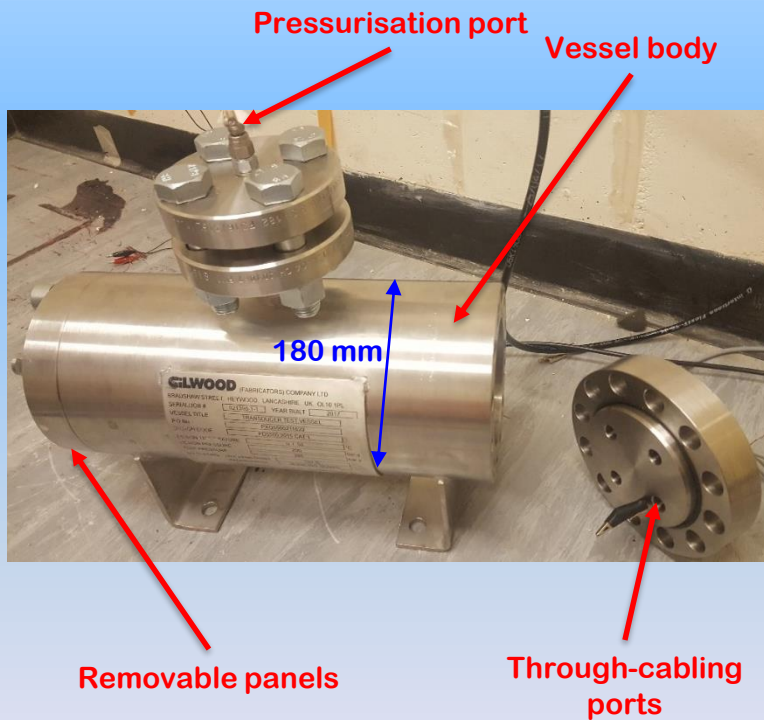


Burst Signal of 400 cycles at 20 V_{p,p}



Measurement at High Pressure

- Design pressure: 286 barg
- Sealing glands (Thermal Detection Limited)
- Ratiometric pressure sensor (Honeywell)



Summary

- FUT-type devices are robust and low cost
- Range of prototype HiFFUTs for hostile environments are in development
- Prototypes show potential for operation at high pressure, temperature and frequency
- Industrial collaboration required for assessment of prototypes

Acknowledgement

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