Impedance Curves and Resonance Frequencies for Piezoelectric Rings – Comparing Theory, Modeling and Measurements

Author: Shmuel Ben-Ezra

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Introduction

We have investigated two piezoelectric rings of the following dimensions:

	Thickness [mm]	OD [mm]	ID [mm]
Small ring	2.0	3.0	1.1
Big ring	3.0	3.5	1.8

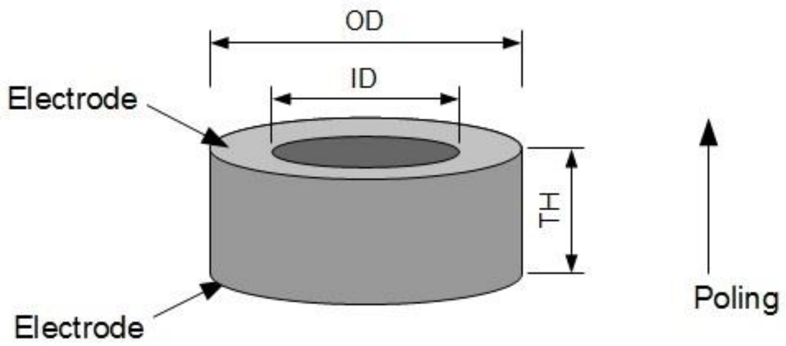

Figure 1: Ring geometry

The manufacturer of the rings is PI ceramics, the material is PIC181 and they have electrodes on top and bottom surfaces. The rings are poled between the electrodes (parallel to axis of symmetry of the ring).

Results

Theory, measurement and modeling main results are summarized below.

Small ring	F 1 [kHz]	Z 1 [ohm]	F 2 [kHz]	Z 2 [ohm]	F 3 [kHz]	Z 3 [ohm]
Measur.	520	67	690	2570	910	365
Modeling	521	67	683	638	908	25

Big ring	F 1 [kHz]	Z 1 [ohm]	F 2 [kHz]	Z 2 [ohm]	F 3 [kHz]	Z 3 [ohm]
Measur.	380	141	460	5514	620	873
Modeling	382	102	450	1995	615	49

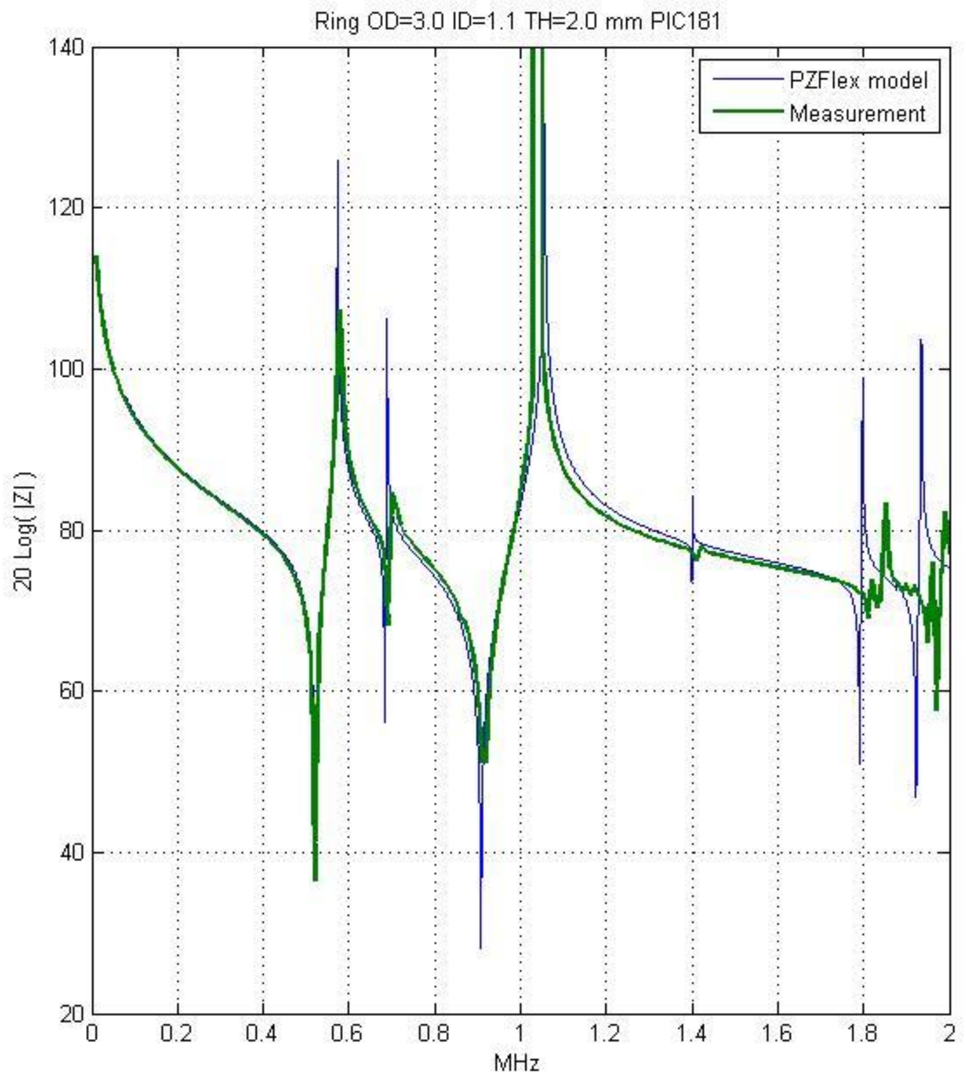

Figure 2: small ring impedance curve

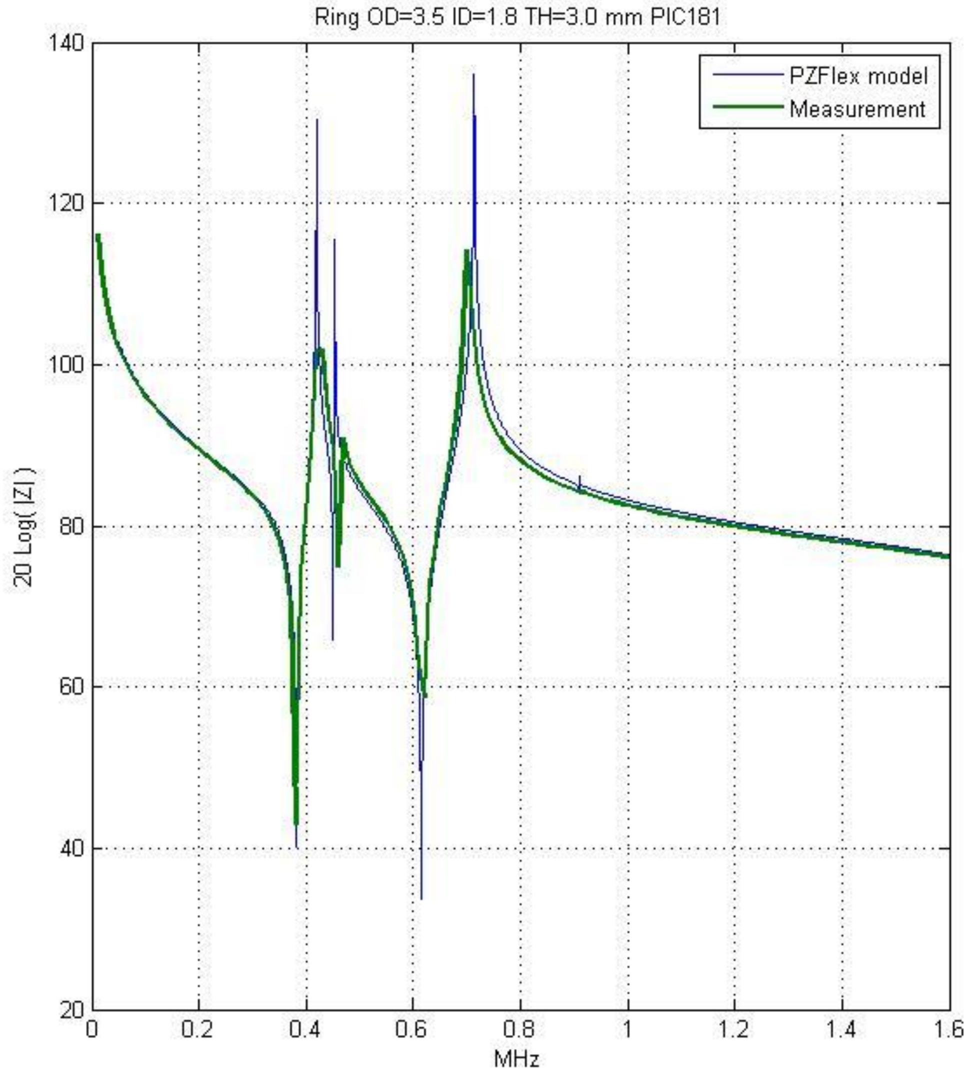

Figure 3: big ring impedance curve

Theory

The formula for the frequency of the first radial mode of a ring [ref. 1]

$$f_R = \frac{u_R}{\pi\,\bar{D}}$$

with $u_R = (\rho\, S_{11}^E)^{-1/2}$ the relevant velocity and $\bar{D} = (ID + OD)/2$ the mean diameter.

This results in 512 kHz for the small ring and 396 kHz for the big ring, with good agreement with experiment and modeling.

References

1. *Determination of resonant frequency of a piezoelectric ring for generation of ultrasonic waves*, Murimi Evan et. al., Innovative Systems Design and Engineering, **2**(4), 2011