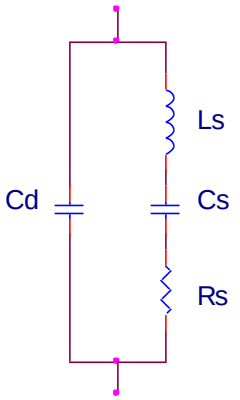
Total Ultrasonic Solution
Pro-Wave Electronics Corp.
E-mail: sales@pro-wave.com.tw
URL: http://www.prowave.com.tw

APPLICATION NOTE – AP050913

Equivalent Circuit of Ultrasonic Transducers

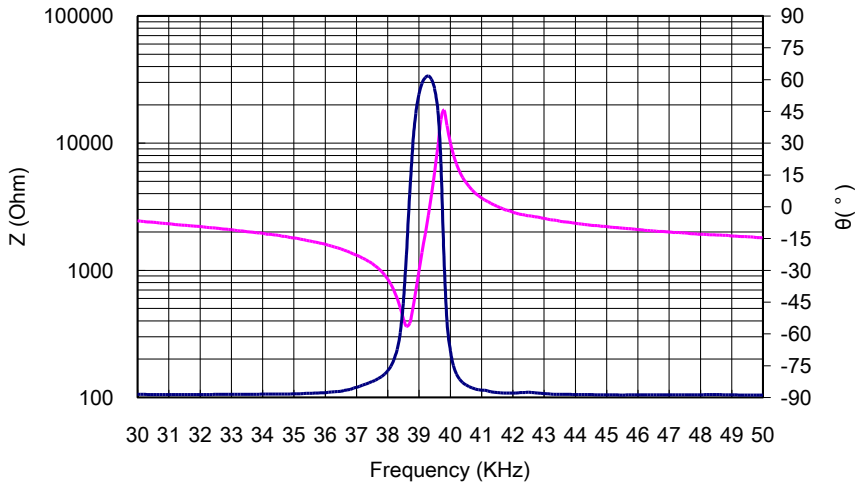
The equivalent circuit of piezoelectric ceramic ultrasonic transducer is similar as the well-known crystal, which is composed of a series branch of L_s, C_s and R_s and a parallel branch of C_d.



The values can be simply obtained from calculation of the impedance data.

Cd:Clamping Capacity, measured at the frequency far away from resonant frequency, which approximates to static capacity.
Ls:Equivalent Inductor = $1/(4\pi^2 f_s^2 C_s)$
Cs:Equivalent Capacity = $C_d * [(f_p^2/f_s^2)-1]$
Rs:Real part of the impedance at resonant frequency

A transducer of model 400ER250 has impedance characters shown as below.



f_s = 38.6 KHz
f_p = 39.8 KHz
Zf_s = 362 Ohm
θf_s = -22.8°
Zf_p = 18200 Ohm
C_d = 2430 pF

Impedance ($Z \angle \theta$) at resonant frequency of 38.6 KHz is 362∠(-22.8°).

$$Cs = 2430 \times \left[\left(\frac{39.2^2}{38.6^2}\right) - 1\right] = 153.4\ pF$$

$$Ls = \frac{1}{4 \times 3.142^2 \times 38600^2 \times (153.4 \times 10^{-12})} = 110.8\ mH$$

$$Rs = \frac{362}{\cos(-22.8^\circ)} = 392.7\ Ohm$$