

High-Frequency Piezoelectric on Si MEMS Resonator and Numerical Method for Parameter Extraction

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This paper presents a piezoelectric (AlN) on Si MEMS resonator (Fig. 1) operating in its width-extensional mode at 28.73 MHz. In order to extract the equivalent circuit model (Fig. 2), we write the input admittance of the micro-resonator and introduce a_i parameters defined in (1). This admittance expression has been used in¹ to implement a Least-Square-Error (LSE) numerical method. In this paper we use a modified X data matrix (2) which is populated with N measured data points y_i (2). The LSE solution of (2) is computed and the model parameters are extracted using (3). Fig. 3 plots the measured input admittance of the resonator when operated in vacuum and the corresponding LSE fitted curve. Table I summarizes the extracted parameters where we report a Q factor of 5970 and motional resistance R_x of 273 Ω .

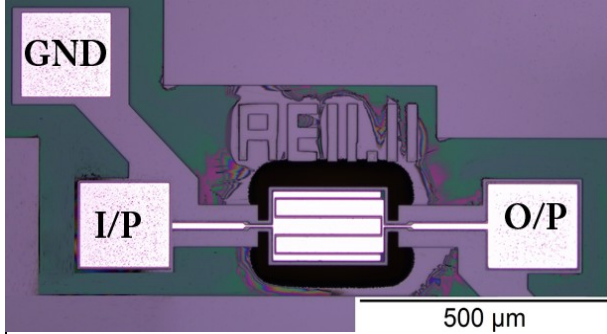


Fig. 1. Optical micrograph of the Piezoelectric (AlN) on Si MEMS resonator operating in its width-extensional mode at 28.73 MHz.

$$y_i = \frac{Y_{in}(s_i)}{s_i} s \frac{a_0 + a_1 s_i + a_2 s_i^2}{1 - a_3 s_i - a_4 s_i^2 - a_5 s_i^3}, i = 1..N \quad (1)$$

$$Y = XM \quad (2)$$

$$Y = \begin{bmatrix} y_1 \\ \vdots \\ y_i \\ \vdots \\ y_N \end{bmatrix}, X = \begin{bmatrix} 1 & s_1 & s_1^2 & y_1 s_1 & y_1 s_1^2 & y_1 s_1^3 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & s_N & s_N^2 & y_N s_N & y_N s_N^2 & y_N s_N^3 \end{bmatrix}, M = \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{bmatrix}$$

$$M = \begin{bmatrix} Re(X) \\ Im(X) \end{bmatrix}^+ \begin{bmatrix} Re(Y) \\ Im(Y) \end{bmatrix} \longrightarrow \begin{bmatrix} R_x \\ L_x \\ C_x \\ C_0 \\ R_0 \\ R_s \end{bmatrix} \quad (3)$$

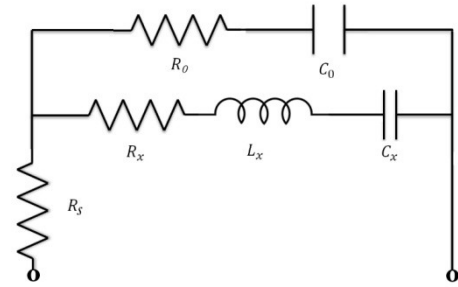


Fig. 2. Equivalent circuit diagram of the resonator.

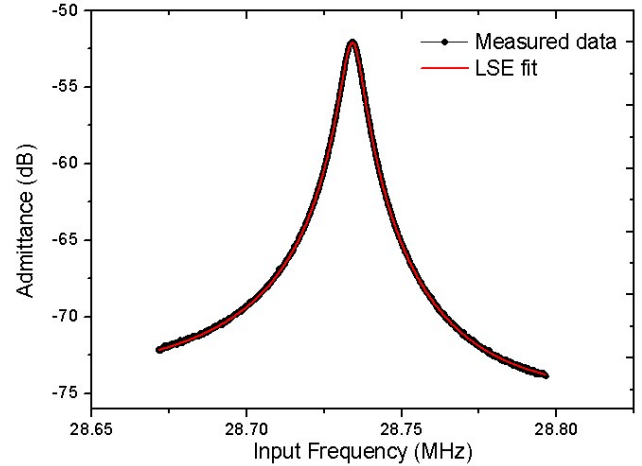


Fig. 3. Measured Admittance data and fitted model.

TABLE I

f_0 (MHz)	Q	R_x (Ω)	L_x (mH)	C_x (fF)	C_0 (pF)	R_0 (k Ω)	R_s (Ω)
28.73	5970	273	9	3.4	5	5.48	141

¹ Bjurstrom, J.; Vestling, L.; Olsson, J.; Katardjiev, I., "An accurate direct extraction technique for the MBVD resonator model," Microwave Conference, 2004. 34th European , vol.3, no., pp.1241,1244, 12-14 Oct. 2004