Calculating capacitor ESR from Tan(δ)

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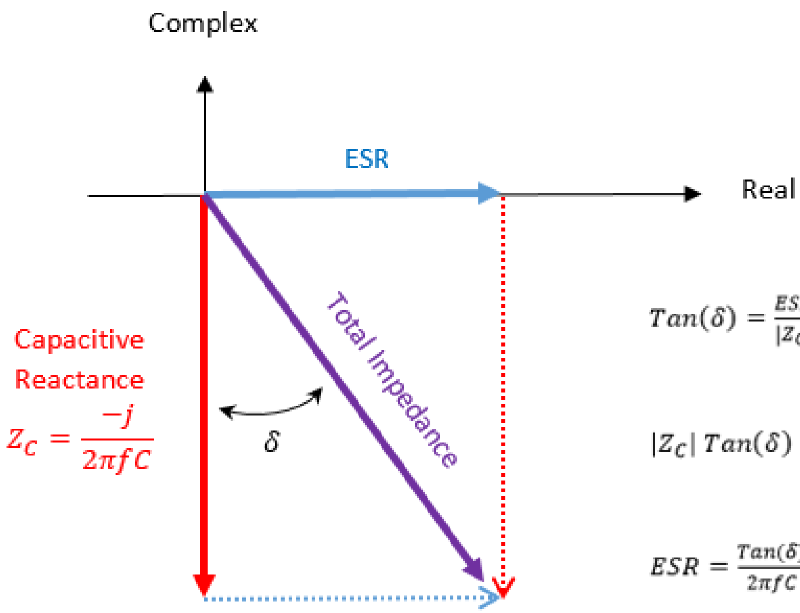
Capacitor equivalent series resistance (ESR) is often a characteristic of interest, that is not directly specified in parametric data or a device datasheet. Information about a device's loss angle (δ) is usually available in these cases, which allows calculating an ESR value.

A capacitor's total complex impedance is represented on a real-complex plane as the vector sum of a real component, (the ESR) and a complex (reactive) component representing the 'ideal' capacitor that things like ESR mess up in all actual components. The angle between the total impedance and its complex component is called the 'loss angle,' and is a figure used to summarize the ratio between the ideal and non-ideal components of a capacitor's overall impedance.



$$Tan(\delta) = \frac{ESR}{|Z_C|}$$

$$|Z_C|\,Tan(\delta) = ESR$$

$$ESR = \frac{Tan(\delta)}{2\pi f C}$$

The tangent of the loss angle is usually provided, which actually simplifies things a bit. Taking the formula for the impedance of an ideal capacitor and doing a bit of algebra, one finds that an ESR value can be obtained by dividing that value from the datasheet by two pi, the test frequency, and the capacitor value. Taking part number **1189-1546-3-ND** as an example, the tan(δ) and f values can be found on page one of the **datasheet** .

Dissipation Factor(MAX) (tanδ)	Rated Voltage (Vdc)	6.3	10	16	25	35	50	63	100	(20℃,120Hz)
	tanδ	0.22	0.19	0.16	0.14	0.12	0.10	0.09	0.08	
	When capacitance is over 1000μF, tanδ shall be added 0.02 to the listed value with increase of every 1000μF.									

From that point, it's a simple matter of putting the actual numbers into the equation:

$$ESR = \frac{0.16}{2 * 3.14 * 120 * 0.000220} = 0.97\ Ohm$$