$\varepsilon0 := 8.854\cdot10^{-12}$ $\mu0 := 4\cdot\pi\cdot10^{-7}$ $c := \frac{1}{\sqrt{\varepsilon0\cdot\mu0}}$ $\eta0 := \sqrt{\frac{\mu0}{\varepsilon0}}$ fundamental constants

$j := \sqrt{-1}$ $\varepsilon r := 2.05$ $\tan\delta := 2\cdot10^{-4}$ dielectric properties of PTFE spacer

$a := 0.8\cdot10^{-3}$ $b := 2.65\cdot10^{-3}$ inner and outer diameters of RG402/U (note 0.255 mm and 0.84 mm, respectively, for RG405/U)

$K := 10^{3}$ $M := 10^{6}$ $G := 10^{9}$ frequency mulitiplication and conversion

$Z := 10^{-9}$

$\rho a := 1.59\cdot10^{-8}$ $\rho b := 1.69\cdot10^{-8}$ resistivites of conductors (inner silver, outer copper); values are those of pure metals at 293 K

$Rsa(f) := \sqrt{\pi\cdot\mu0\cdot\rho a\cdot f\cdot M}$ $Rsb(f) := \sqrt{\pi\cdot\mu0\cdot\rho b\cdot f\cdot M}$ surface resistance of inner and outer conductors

Note: in what follows, frequency has units of MHz (i.e. multiplier M has been chosen)

$Z0 := \frac{\eta0}{2\cdot\pi\cdot\sqrt{\varepsilon r}}\cdot\ln\left(\frac{b}{a}\right)$ $Z0 = 50.157$ characteristic impedance when lossless

$R(f) := \frac{1}{2\cdot\pi}\cdot\left(\frac{Rsa(f)}{a} + \frac{Rsb(f)}{b}\right)$ resistance per unit length

$\alpha c(f) := \frac{R(f)}{2\cdot Z0}$ $\beta(f) := \frac{2\cdot\pi\cdot M\cdot f\cdot\sqrt{\varepsilon r}}{c}$ $\alpha d(f) := \frac{1}{2}\cdot\beta(f)\cdot\tan\delta$ conductor and dielectric attenuation constants; wavenumber in PTFE

$\alpha(f) := \alpha c(f) + \alpha d(f)$ $\gamma(f) := \alpha(f) + j\cdot\beta(f)$ total attenuation constant and propagation constant

$L := 83.8\cdot10^{-3}$ length of coaxial probe

$n := 1, 2 .. 6$

$f0(n) := \frac{n\cdot c}{2\cdot L\cdot\sqrt{\varepsilon r}}$

$f0(n) =$

$1.249\cdot10^{9}$
$2.499\cdot10^{9}$
$3.748\cdot10^{9}$
$4.997\cdot10^{9}$
$6.247\cdot10^{9}$
$7.496\cdot10^{9}$

Resonant frequencies based on actual length

$g1 := 1.1467$

$g2 := 1.1467$

$$Qo(n) := \frac{n \cdot \pi \cdot g1}{2 \cdot 0.0549^2}$$

$Qo(1) = 597.62$ $\quad Qo(2) = 1.195 \times 10^3$ $\quad Qo(5) = 2.988 \times 10^3$

$Qo(3) = 1.793 \times 10^3$ $\quad Qo(4) = 2.39 \times 10^3$ $\quad Qo(6) = 3.586 \times 10^3$

Unloaded quality factor of each mode

$f := 1000 \cdot K, 1001 \cdot K .. 8500 \cdot K$

$$F0(f) := \frac{f - f_n}{f_n}$$

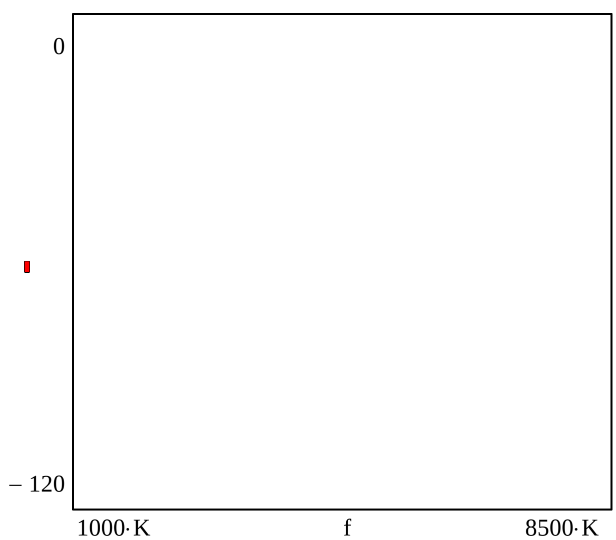
$$S21\_0(f) := \frac{2 \cdot \sqrt{g1 \cdot g2}}{1 + g1 + g2 + j \cdot 2 \cdot Qo(n) \cdot F0(f)}$$

$$P0(f) := \left(\left|S21\_0(f)\right|\right)^2$$

power absorption coefficients

The following graphs show reflected power as a function of permittivity of sample. The final graphs show the curve fitting used to obtain resonator parameters.

$\varepsilon := 80 - 20 \cdot j$



$Smin := 10\cdot$

$Smin =$

$$\log\left(1 - \frac{4\cdot\left|a2\right|}{\left|\left|4\cdot a0\cdot a2 - a1^{2}\right|\right|}\right)$$