APPENDIX 1
CALCULATION OF CAPACITANCE AND DISSIPATION FACTOR USING SCHERING BRIDGE

The general circuit diagram of Schering bridge in the arrangement used for our study is shown below:

![Schering Bridge Circuit](image)

**Figure A1.1 : Schering Bridge Circuit**

Referring to the figure, the impedances between ABC in delta can be replaced by Star connected impedances as shown below:

![Impedances Representation](image)

**Figure A1.2 : Representation of Impedances between Terminals ABC in Star and Delta**
Redrawing the original bridge arrangement (Figure A1.1) with resistances $R_A$, $R_B$ and $R_C$ in their appropriate places we get the following circuit:

![Schering Bridge Circuit](image)

*Figure A1.3: Schering Bridge Circuit in a Modified Form*

Referring to the above circuit, under balance conditions,

$$\dot{Z}_1 \dot{Z}_4 = \dot{Z}_2 \dot{Z}_3$$  \hspace{1cm} A(1.4)

where

$$\dot{Z}_1 = R_A + R_x + 1/\omega C_x$$

$$\dot{Z}_2 = 1/\omega C_N$$
\[ Z_3 = R_C \]
\[ Z_4 = \frac{R_4}{1 + j\omega C_4 R_4} \]

Substituting Equation A(1.5) in A(1.4) we get,

\[
\frac{R_A + R_X + \frac{1}{j\omega C_X}}{1 + j\omega C_4 R_4} \cdot \frac{R_4}{1} = \frac{R_C}{j\omega C_N}
\]

\[
\frac{1 + j\omega C_4 (R_A + R_X)}{j\omega C_X} \cdot \frac{R_4}{R_C} = \frac{1 + j\omega C_4 R_4}{j\omega C_N}
\]

\[
j\omega C_X (R_A + R_X) \frac{R_4}{R_C} + \frac{R_4}{R_C} = \frac{j\omega C_X}{j\omega C_N} (1 + j\omega C_4 R_4)
\]

\[
= \frac{C_X}{C_N} (1 + j\omega C_4 R_4)
\]

\[
\frac{R_4}{R_C} + j\omega C_X \frac{R_4}{R_C} (R_A + R_X) = \frac{C_X}{C_N} + j\omega C_4 R_4 \frac{C_X}{C_N}
\]

Equating the real parts,

\[
\frac{R_4}{R_C} = \frac{C_X}{C_N}
\]

Substituting for \( R_C \) from A(1.3), the value of unknown capacitance \( C_X \) becomes,

\[
C_X = \frac{C_N R_4 (R_3 + 100)}{(R_3 + s) N}
\]

The dissipation factor \( (\tan \delta) \) of the unknown capacitor is equal to \( \omega C_X R_X \) and it can be found by equating the imaginary parts of Equation A(1.6).
So doing we get,

\[
\omega \frac{R_4}{R_C} (R_A + R_X) = \omega \frac{C_4 R_4 C_X}{C_N}
\]

\[
(R_A + R_X) = C_4 \frac{R_C}{C_N}
\]

\[
R_X = C_4 \frac{R_C}{C_N} - R_A
\]

Multiplying Equation A(1.7) by \( \omega C_X \), we get

\[
\omega \frac{R_4}{R_C} R_X = \tan \delta = \frac{R_4 C_N}{R_C} \left( \frac{C_4 R_C}{C_N} - R_A \right)
\]

\[
= \omega C_4 R_4 - \omega C_N \frac{R_4 R_A}{R_C}
\]

\[
= \omega R_4 (C_4 - C_N \frac{R_A}{R_C})
\]

Substituting for \( R_A / R_C \) in the above equation, we get

\[
\tan \delta = \omega R_4 (C_4 - C_N \frac{100 - N - s}{R_3 + s})
\]