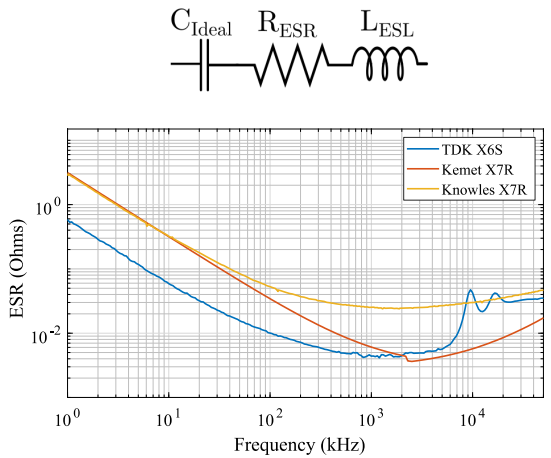
Characterization of Multi-layer Ceramic Capacitors under More Realistic Operating Conditions

Berkeley Power and Energy Center

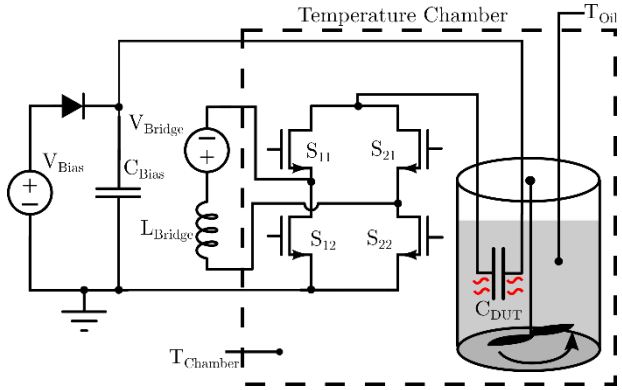
Motivation and Applications



- Multi-layer ceramic capacitors (MLCCs) are a key enabling technology for high density power converters.
- Real losses in MLCCs can be reduced to equivalent series resistance (ESR)
- Data sheets do not provide loss information for realistic operating conditions.

Hardware Implementation

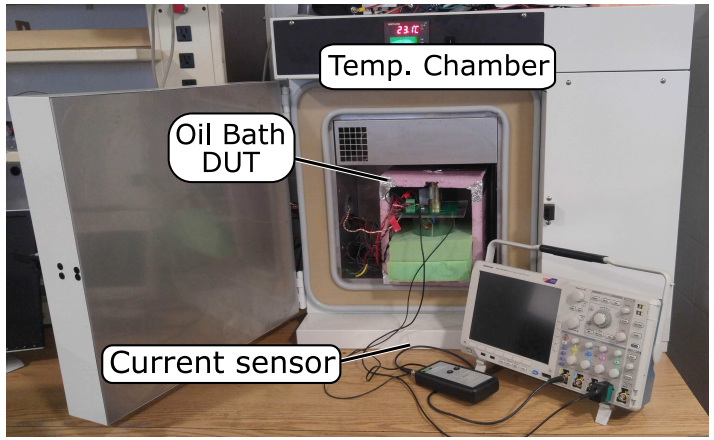
- ESR is dependent on frequency, DC bias, AC amplitude, temperature and harmonic content.
- A circuit was designed to be able to adjust frequency, current amplitude and DC bias of a high harmonic content waveform in order to test the effect on ESR.



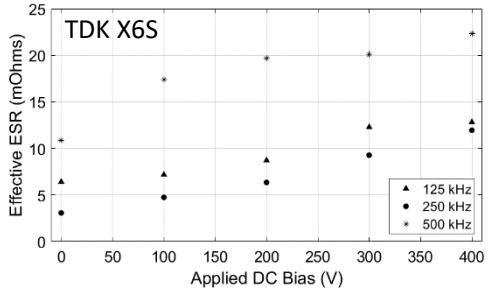
Challenges and Solutions

$$P_{diss} = \frac{1}{T_{final}} \left(k_{oil}\, \Delta temp + \int_0^{T_{final}} \frac{temp_{oil} - temp_{amb}}{R}\, dt \right)$$ [1]

- Measuring loss with electrical characterization is in accurate under desired operating conditions.
- A calorimetric method was implemented in order to accurately observe change in ESR.



Experimental Results



Capacitor Manufacturer	Capacitor De-rating (at 400 V)	ESR increase (at 400 V, 125 kHz)
TDK	80%	200%
Knowles	82%	243%
Kemet	72%	142%

- With increased DC bias, the ESR linearly increases, this has been shown with several dielectric types as well as manufacturers.

References:

[1] G. S. Dimitrakakis, E. C. Tatakis, and A. C. Nanakos, "A simple calorimetric setup for the accurate measurement of losses in power electronic converters," *EPE 2011*.

[2] S. Coday, C. B. Barth and R. C. N. Pilawa-Podgurski, "Characterization and Modeling of Ceramic Capacitor Losses under Large Signal Operating Conditions," *COMPEL 2018.*

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