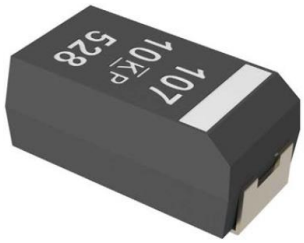
Are the Ta Polymer SMD Automotive Grade Capacitors an alternative in MLCC supply chain issue?



KEMET Electronics introduced the 1st to Market AEC-Q200 Qualified series for automotive applications in August 2015, the T598. The initial design-in activities were done in Infotainment and ADAS (*Advance Drive Assistance Systems*) such as rear cameras and parking sensors. In 2016 KEMET expanded the T598 Portfolio to 35V and 50V capabilities and open a new frontier for automotive applications under Chassis and Safety.Now in 2018 KEMET continues leading the automotive solutions with the 1st to market introduction of a 150ºC product, T599 Series.

The polymer automotive offering represents an opportunity for miniaturization and cost of overall solution reduction and is important as an alternative in actual MLCC supply chain restrictions. In this white paper, we include technical solution examples

Last months news article in the market, highlights issues with potential shortage with MLCC components which creates challenges in the different segments, example is shown in *Figure 1*.

MLCC Shortages Are Creating Challenges In Multiple End-Markets in 2018

03/02/2018 // **Dennis M. Zogbi** in: Passives

Limited Capacity To Stack Ceramic Dielectric Will Extend MLCC Shortages To 2020 and beyond.

- Limited capacity expansion in the MLCC industry, specifically the ability to stack ceramic layers (limited capex in three-dimensional stacking capacity for barium titanate dielectric composition and nickel electrode paste) will extend shortages of MLCC to 2020 and beyond.
- As a result of expanding margins in ceramics- MLCC Manufacturers are NOT supporting low margin ceramic businesses, especially those that have exposure to precious metals such as ruthenium and palladium.

Figure 1. Examples of news in market related to MLCC shortage concerns – Source: TTI webpage

Due to this fact, R&D teams today call to action to access alternative solutions. But ***'what are the viable technical options?'***

The Capacitance and Voltage mapping for different capacitor technologies, as shown in *Figure 2a* guide us to Tantalum polymer electrolytic capacitors when engineers are limited to 75V and capacitance ranges between 1uF to 1mF. However, the process of converting from an MLCC to a Ta Polymer SMD component is not a one to one process and needs to follow several considerations that are schematically described in *Figure 2b*

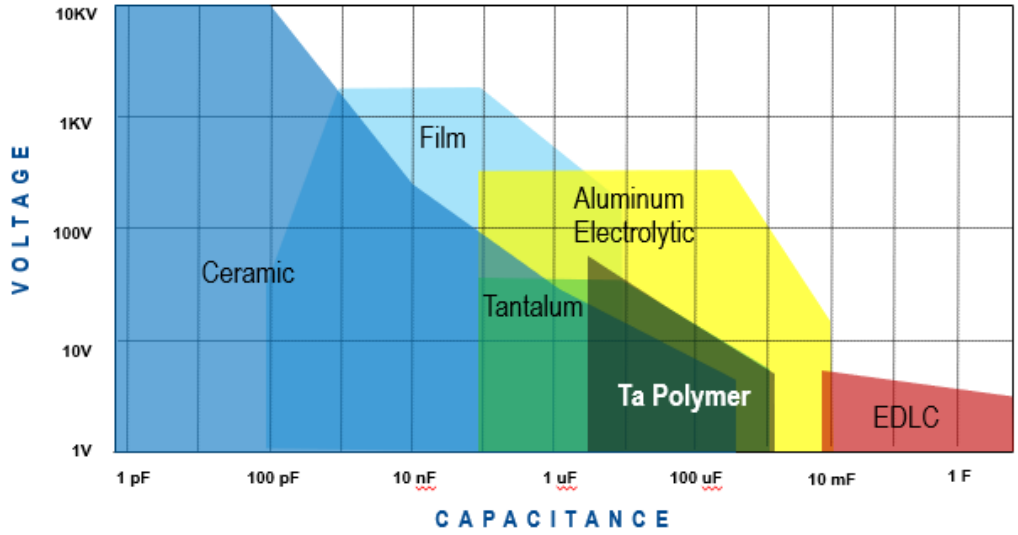


Figure 2a. Mapping of Capacitors Technologies

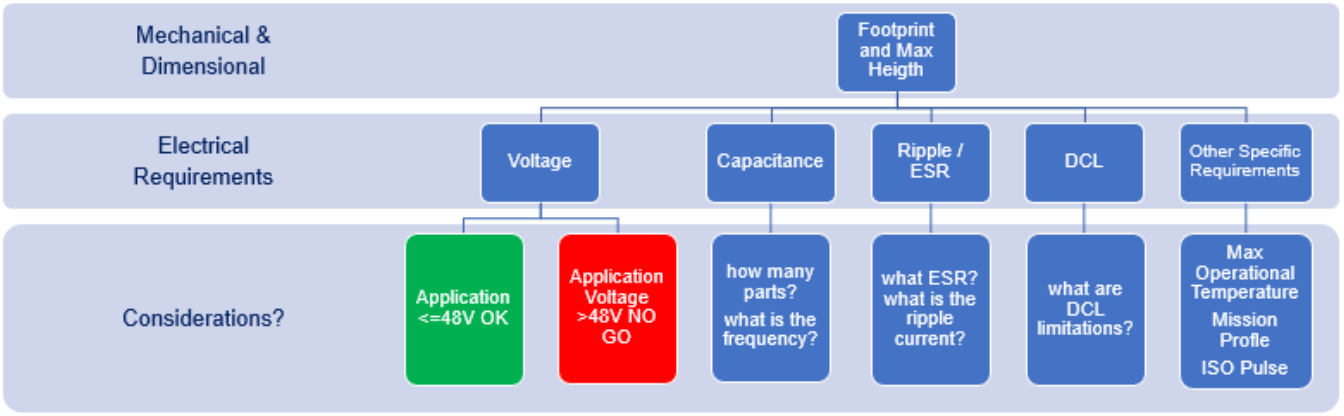


Figure 2b. Parameters to be consider during a process to convert from MLCC to a Ta Polymer SMD

The mechanical and dimensional characteristics are the first parameter to be validated. **Table 1** presents a dimensional comparison between MLCC and Ta Polymer: MLCC EIA codes 0805 and 1206 have direct dimensional footprint alternative with metrics P-2012 and A-3216 footprints. The larger MLCC EIA codes 1210 and 2220 have a potential alternative with metrics B3528 and D7343 footprints, althouth the replacement is not direct.

The electrical characteristics need additional comparison efforts in order to determine the adequate solution. MLCC technology is characterized with capacitance drop biased effect, temperature capacitance drop effect and ultimately the aging effect in life. The schematic effects are described in *Figure 3*; the other side MLCC technology has extremely low leakage current, with an insulation resistance range of 100 to 1000Megohm. The Ta polymer capacitors have a DCL specification define ar 0,1xCxV uA.

MLCC's - Surface Mount		Ta Surface Mount		
EIA size code	Metric Size Code	Metric Size Code	Letter	Comment / max H
0805	2012	2012	P	1,0mm max H
1206	3216	3216	A	1,8mm max H
1206	3216	3216	S	1,2mm max H
1206	3216	3216	I	1,0mm max H
1210	3225			
		3528	B	2,1mm max H
1808	4520			
1812	4532			
1825	4564			
		6032	C	2,8mm max H
2220	5650			
2225	5664			
		7343	X	4,3mm max H
		7343	Y	4,0mm max H
		7343	D	3,1mm max H
		7343	V	2,0mm max H

Table 1 . Dimensions Comparison between MLCC and Ta Polymer

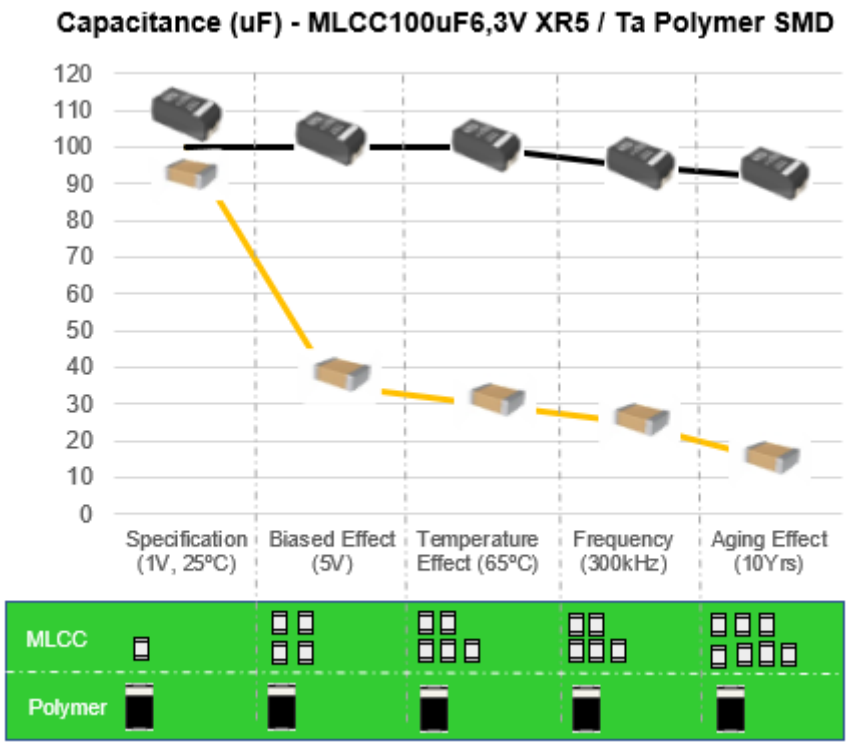


Figure 3. Schematic Representation of Capacitance Effects at MLCC and Ta Polymer Technologies

In order to support the designers; the replacement examples in the next pages are organized by low voltage power rails and 12V input power rail as described in the schematic below *(Figure 4)*

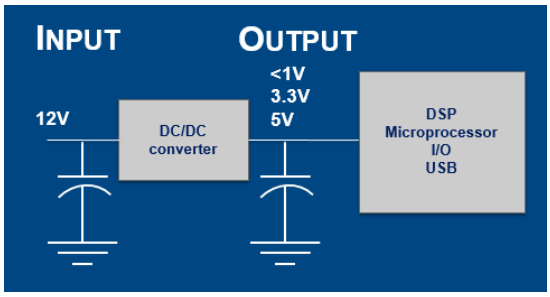


Figure 4. DC/DC Schematic Example (input, output)

A. **Low Voltage Power Rails – output**

a.1) <2V power rails - Board Saving when replacing X7R 47uF6,3V 1210 in a output buffering using a ultra low ESR Ta polymer part.

In the actual solution a bulk of 10 MLCC capacitors can be replaced with 2 Ta Polymer, 220uF, 2.5V rated voltage capacitors. *Figure 5* shows the capacitance in frequency at 85ºC and 1,1V application voltage. The applications require a maximum operational temperature of 105ºC and an ESR (Equivalent Series Resistance) <5mOhm. In *Figure 6* we show the ESR frequency behavior at 85ºC and 1,1V application conditions and demonstrate that the solution as an ESR inside the customer requirements. In this case, the board design needs to be adjusted, although a reduction of 21% board space area is achieved.

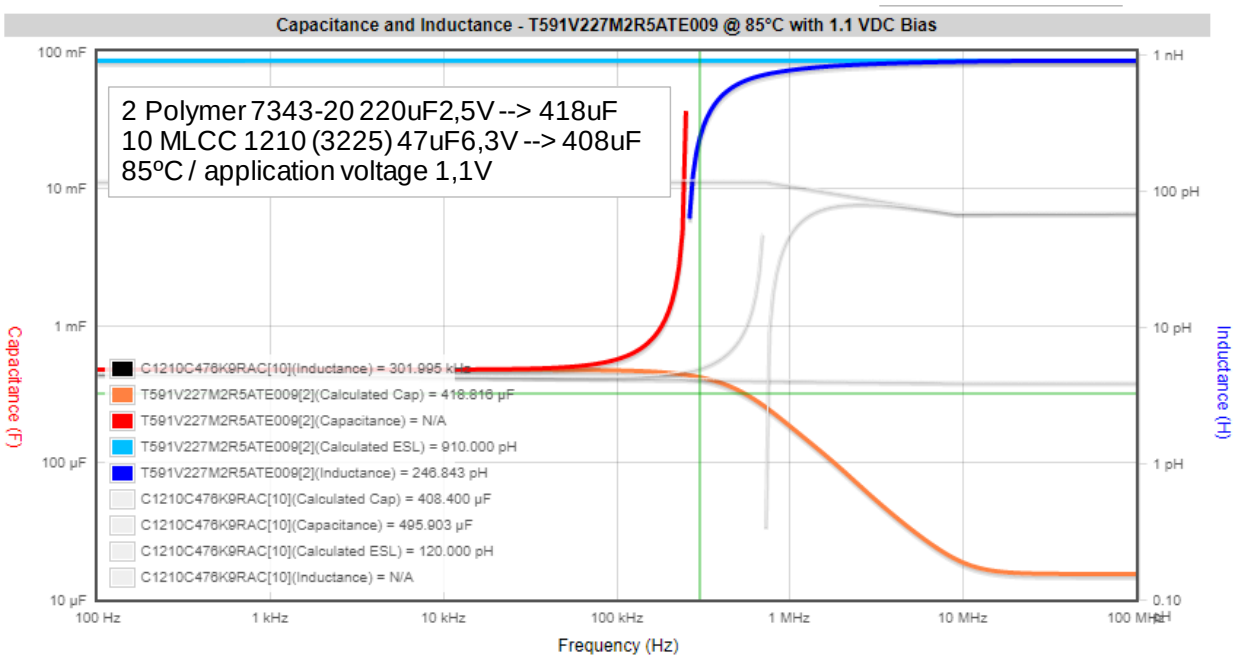


Figure 5. Capacitance in frequency comparison – http://ksim.kemet.com/

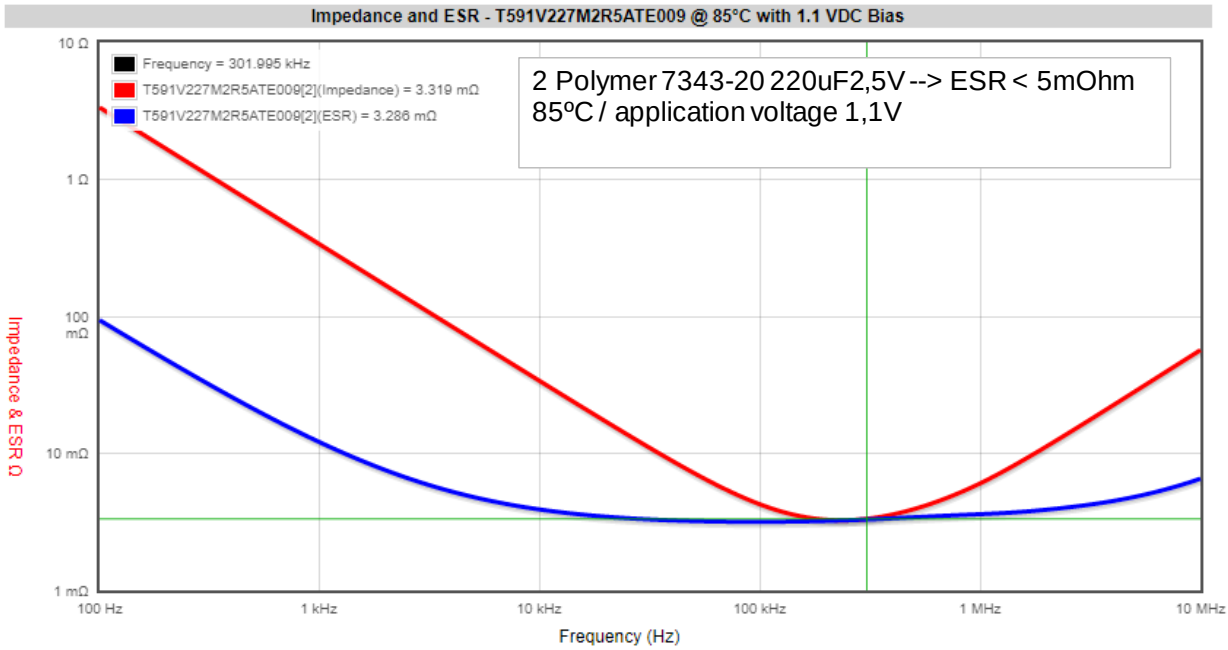


Figure 6. ESR in frequency -verification of <5mOhm – – http://ksim.kemet.com/

a.2) 5V power rails - Board saving in ultra miniturization ADAS application as front and rear camera.

In this type of application, the usage of 0805 and 1206 MLCC with 10uF and 22uF is common. The maximum operational temperature is limited to 105ºC. An alternative with Ta Polymer SMD can be considered by applying the highest capacitance in P2012-10 (same as 0805) and S3216-10 (same as 1206). In an Automotive Grade solution, KEMET is developing with samples available (contact your sales representative for samples). *Figure 7* presents the capacitance in frequency and demonstrates that a large number of components can be replaced with equal footprint, or that 2 components can be replaced by only 1 Ta Polymer with smaller foot print.

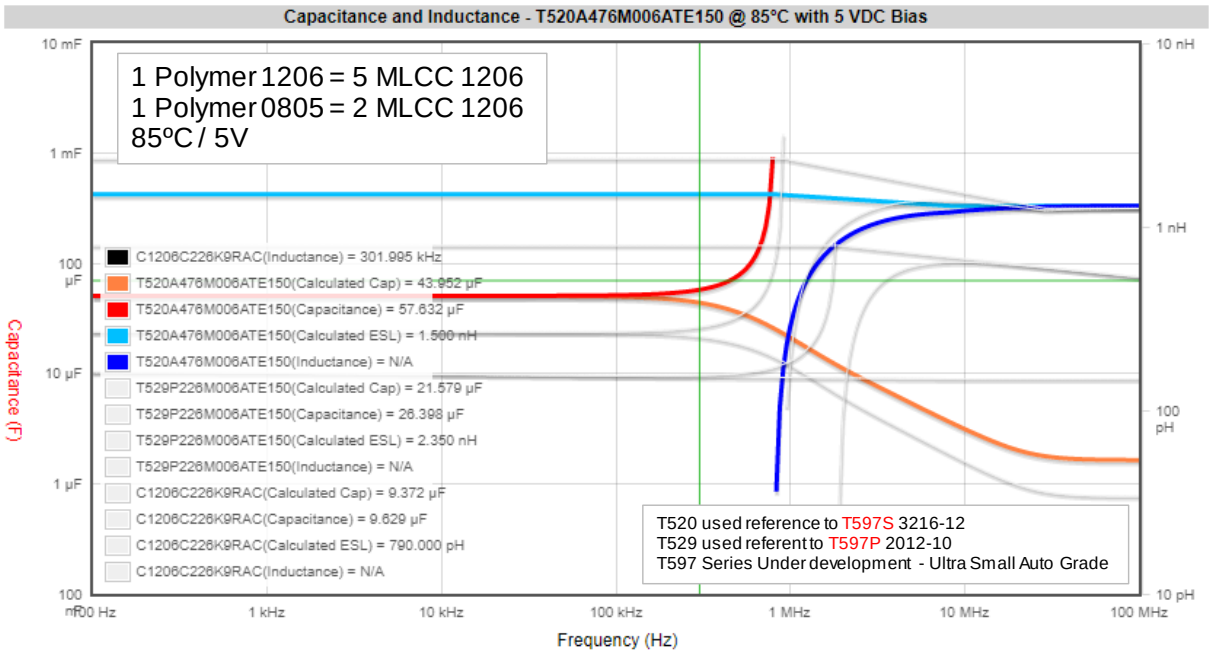


Figure 7. Capacitance in frequency comparison – Small case size solutions – http://ksim.kemet.com/

B. **High Voltage Power Rails - input**

b.1) 12V power rails - Board Saving and Piezo Noise Issue Fixing

In this example a 12V rail application, that operates at 85ºC, used 3 MLCC components of 1210 10uF 50V X7R, the customer was seeking for an alternative to (1) safe board space and (2) piezo noise-free.
The total capacitance required can be replaced by 1 Polymer component T598D226M035ATE065, *Figure 8.*

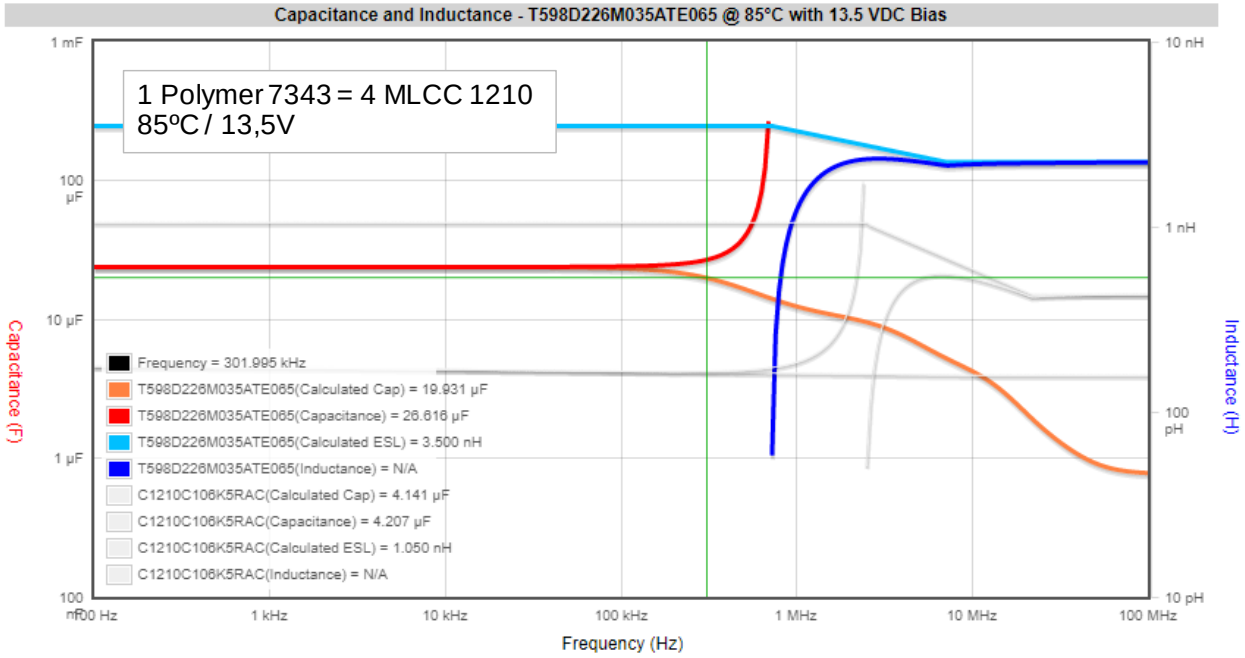


Figure 8. Capacitance and Indudance in frequency at 80ºC and 12V - – http://ksim.kemet.com/

The design of Ta Polymer in input side requires an explanation of technological differences with the old Ta-MnO_2 products. Over the past few years, KEMET has done efforts to clarify that Ta Polymer capacitors offer a benign failures mode, not generating ignition due to the absence of oxygen. In addition, the fact that Ta Polymer T598 Series is fully AEC-Q200 qualified, the usage of these components require some performance evidence of transient capabilities.

KEMET has performed the *ISO7637-2 Road vehicles — Electrical disturbances from conduction and coupling — Part 2: Electrical transient conduction along supply lines only* pulse tests and concluded that the 35V rated voltage products fully comply with pulse1, 2a,2b,3a,3b, 4 and 5b(suppressed at 13,5+40V) and show limitation at 5a pulse. The 5a pulse limitation requires up-front definition of the pulse shape and parameters for an alternator with centralized load dump suppression or not is use. In most new alternators, the load dump amplitude is suppressed (clamped) by the addition of the limiting diodes.

The usage of Ta polymer as alternative relatively to the high CV MLCC 1210 need special evaluations. In addition KEMET performed the Special Load Dump testing E05 according the VW80000, issue 06-2013 – Electric and Electronics Components in Motor Vehicles up to 3,5t . The summary of the results are shown in **Table 2**

ISO7637-2 VW80000 (E05)	Pulse 1	Pulse 2		Pulse 3		Pulse 4	Pulse 5a unsupressed		Pulse 5b suppressed (13,5+40V)		Load Dump E05	
		a	b	a	b		Ri=0,5Ohm	Ri=4Ohm	Ri=0,5Ohm	Ri=4Ohm	Ri=0,5Ohm	Ri=4Ohm
Severity Level 3												
Severity Level 4												

All Pass Limiting Failures

Table 2. *Summary Results – ISO 7637-2 and VW80000 (Load dump E05)*

b.2) 12V power rails in a Power Train application with 150ºC requirement

In this example, a 12V rail power train actuator, that operates with a maximum operating temperature of 125ºC and max 13,5V, requires 60uF. The initial evaluations with MLCC 1210 XR7 10uF 50Vparts determine the need for 10 components with the total board are required of 120mm2. Based on the Ta Polymer Automotive technology KEMET has extended the capability to 150ºC by focusing on new conductive layers enablers. The new T599 Series in this example allows the designer to use 2 components of T599 (150ºC) 7343-43 33uF 35V and achieved the required 60uF. This action reduces the space board area to 63mm2, *Figure 9*.

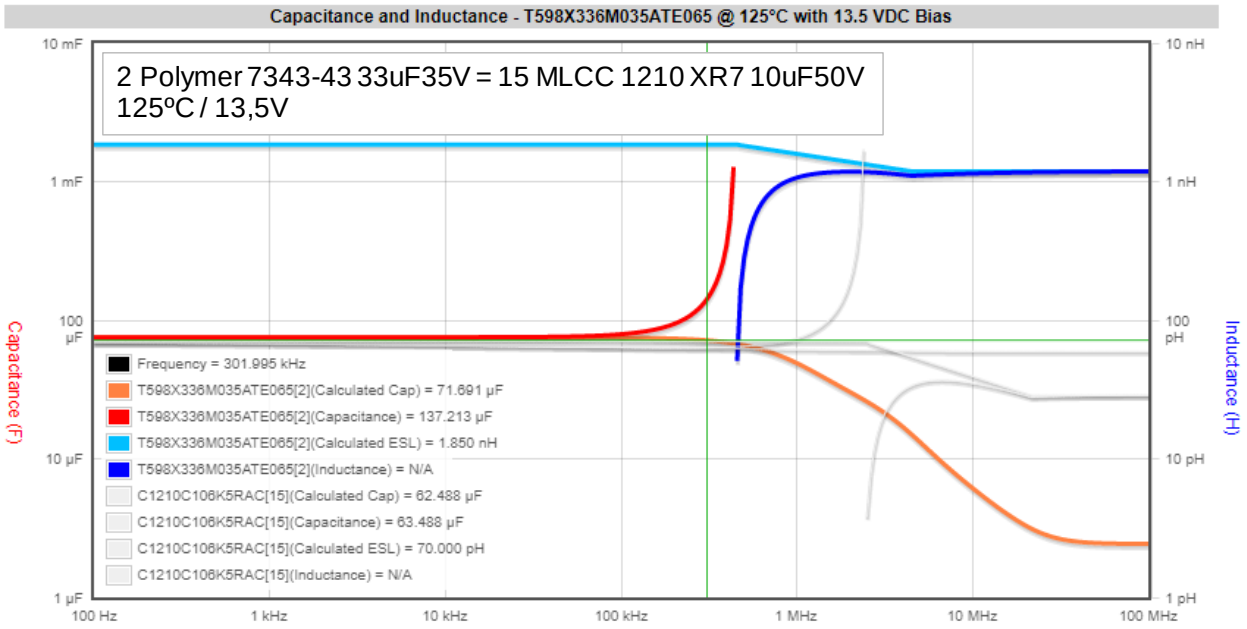


Figure 9. Capacitance in frequency at 125ºC and 13,5V – K-SIM

The new T599 Series offers designers a new type of solution. The new series is fully AEC-Q200 qualified and was subject to rigorous ISO Pulses and Load dump evaluation during the development phase.

Conclusions

With an actual shortage of MLCC components in the market, Ta Polymer product offers new potential solutions to automotive designers where space board saving, piezo noise free solution, and miniaturization are required. The examples described in this document focuses on boundaries where a polymer is a viable alternative and in the main parameters that must be taken into consideration. If in any cases a direct dimensional replacement can be used, the fast majority of solutions requires re-design activity. In the commercial side, the total cost of the solution is the main driver and not the cost per piece. Please contact KEMET sales representative to support you in your challenges!

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