

Application Note:

Polymer Capacitor in Intel IMVP9.x Designs

Introduction

KEMET's polymer capacitors (KO-CAP™ series and AO-CAP™ Series) offer low ESR to minimize power losses and unwanted noise and suitable for high switching frequency PWM technology PMIC. In the new Intel IMVP9.0 and 9.1, the maximum CPU application voltage is 2.74V and it is much higher than tradition CPU in IMVP8 1.52V. in order to meet this design change, 4V rated voltage Polymer Capacitor is suitable for this application, KEMET released SMD AO-CAP (Aluminum Polymer Capacitor) (LxWxH=7.3x4.3x2.1mm) A720V337M004APE4R5, A720V337M004APE006 for server and data center CPU Vcore output filtering and SMD KO-CAP(Tantalum Polymer Capacitor) (LxWxH=3.5x2.8x1.2mm and 3.5x2.8x1.0mm) T520T227M004ATE035 and T527K227M004ATE025, E035 for new generation Intel Tiger Lake Ultrabook computer CPU Vcore output filtering.

	IMVP8	IMVP9	IMVP9.1
VID Table	0-1.52V Vboot options: 0V, 1.05V	0.00V, 0.20 - 2.74V in 10mV steps.	0.00V, 0.20 - 2.74V in 10mV steps Vboot Options: 0V, 1.8V Max VID+Offset=3.05V

AO-CAP A720 Advantages

- Ultra low ESR. (4.5~6mohm), suitable for high switching frequency PMIC
- Low profile design (LxW= 7.3x4.3mm T=2.0mm),
- No acoustic noise, suitable replace Class II high capacitance MLCC
- High ripple current handling.
- No aging effects.

KO-CAP Advantages

- Low ESR (5~200mohm), suitable for high switching frequency PMIC
- Small size, low profile design (3.5X2.8mm T=1.0, 1.2mm), smallest size is P=2.0x1.2mm
- No Acoustic Noise, suitable replace Class II high capacitance MLCC
- No aging effects.

Voltage derating

KO-CAPs and AO-CAPs are solid state capacitors can be operated at full rated voltage, most circuit designers seek a minimum level of assurance in long term reliability, which should be demonstrated with data. A voltage derating can provide the desired level of demonstrated reliability based on industry accepted acceleration models. Since most applications do require long term reliability, KEMET recommends that designers consider a voltage derating.

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Series	Voltage Rating	Maximum Recommended Steady State Voltage	Maximum Recommended Transient Voltage	Surge Voltage
		-55°C to 105°C		
T520, T527 Series	2-10V	0.9V _R	V _R	1.3 V _R
A720 Ultralow ESR	2V-35V	V _R	V _R	1.3 V _R

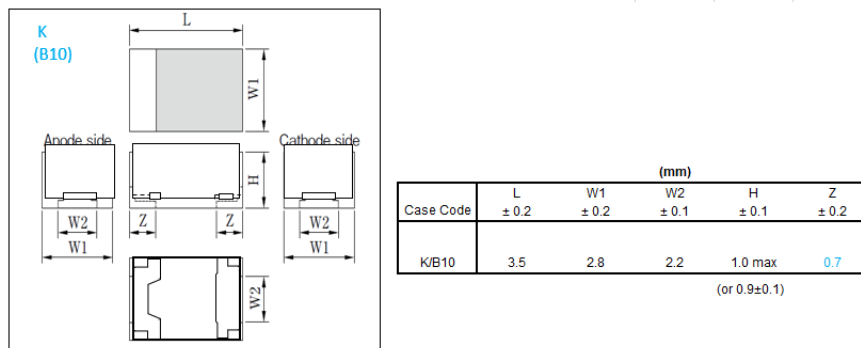
V_R: Rated Voltage

For 2.74V application voltage, KEMET recommends 4V KO-CAPs and 4V AO-CAPs. If the application voltage is less than 2V, choose 2.5V rated voltage is enough.

Dimension and popular case size

KO-CAPs has volume efficiency advantage, the smaller case size KEMET can offer today is P size, 2.0x1.2x1.0mm. Popular case size for computer application are V size(7.3x4.3x2.0mm) B size(3.5x2.8x2.0mm) and T size(3.5x2.8x1.2mm). in 2019, KEMET offer first to market T case, 220uF/4V/ max ESR =35mohm for Tiger lake CPU Ultrabook compute (KEMET P/N:

T520T227M004ATE035), this capacitor replaced many X6S MLCC in CPU cores to reduce X6S MLCC acoustic noise. In 2020, KEMET developed first T=1.0mm K case(3.5x2.8x1.0mm), 220uF/4V/max ESR=25 or 35mohm. it can be mounted on Ultrabook



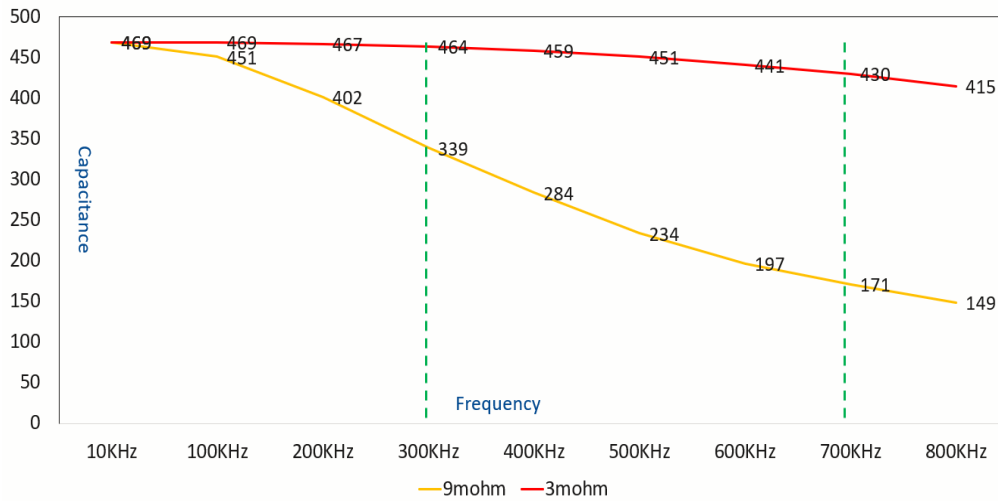
mainboard PCB top side to save the bottom side (component side) board space.

Figure 1. New K case KO-CAP dimension

KEMET Case Size Code	EIA Case Size Code (LXW-H)	Rated Voltage (Volt)	Capacitance (uF)	Max ESR @100KHz (mohm)	Ripple Current @45C, 100KHz	KEMET P/N
K	3528-10	4.0	220	25 35	TBD	T527K227M004ATE025 T527K227M004ATE035
T	3528-12	4.0	220	35	1.46A	T520T227M005ATE035
V	7343-20	4.0	330	4.5 6.0	9.54A 8.26A	A720V337M004APE4R5 A720V337M004APE006

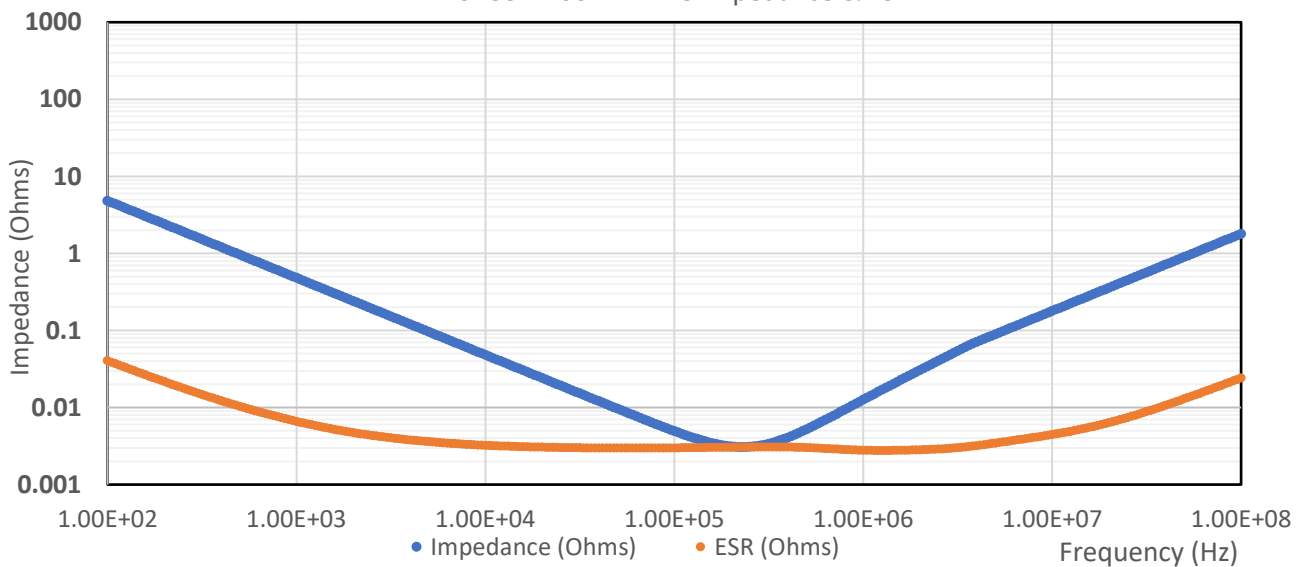
Table 1. new 4V AO-CAP and KO-CAP Part Numbers

Capacitance and ESR performance.



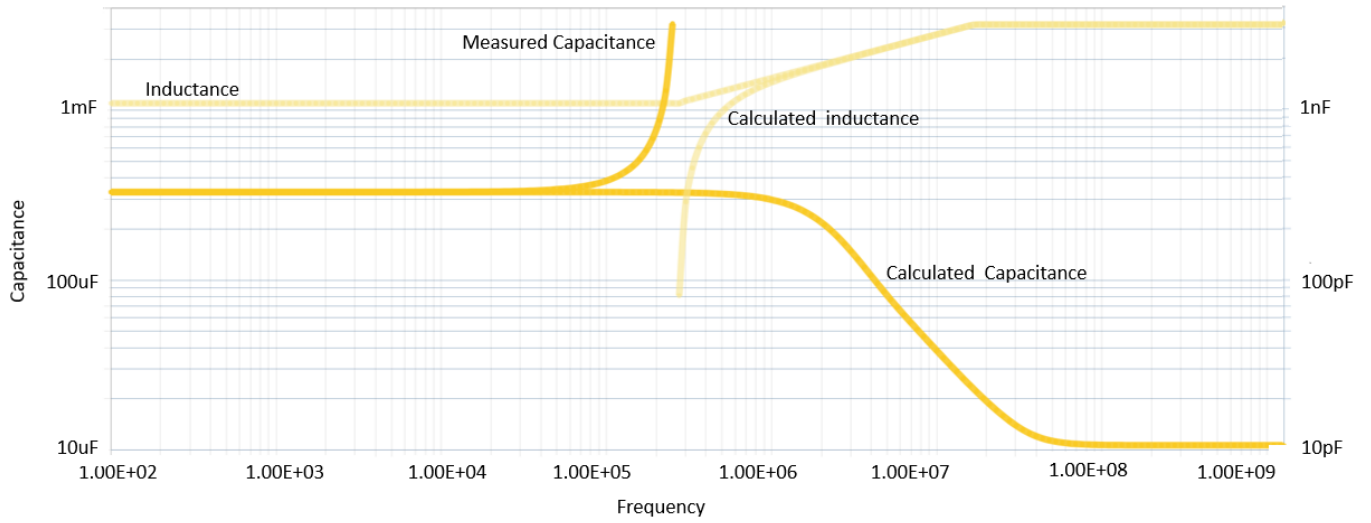
For modern DC/DC PWM PMIC, the switching frequency from 300kHz to 700kHz or higher, low ESR is very important for output filtering capacitor. Above plot shows two different ESR Capacitor capacitance vs. frequency, both capacitors are 470uF, but ESR=9mohm capacitor lose 130uF(27%) @300kHz and lose 298uF(63%)@700kHz. ESR=3mohm capacitor only lose 5uF(1%) @300kHz and 39uF(8.3%)@700kHz. One 470uF, ESR=3mohm capacitor cap replace 2.5pcs 470uF ESR=9mohm capacitor @700kHz.(430uF/171uF=2.51), KEMET A720 new 4V 330uF Capacitor can offer very stable low ESR over frequency, it is suitable for >300kHz switching frequency PMIC and maintain high capacitance.

A720V337M004APE4R5 Impedance & ESR

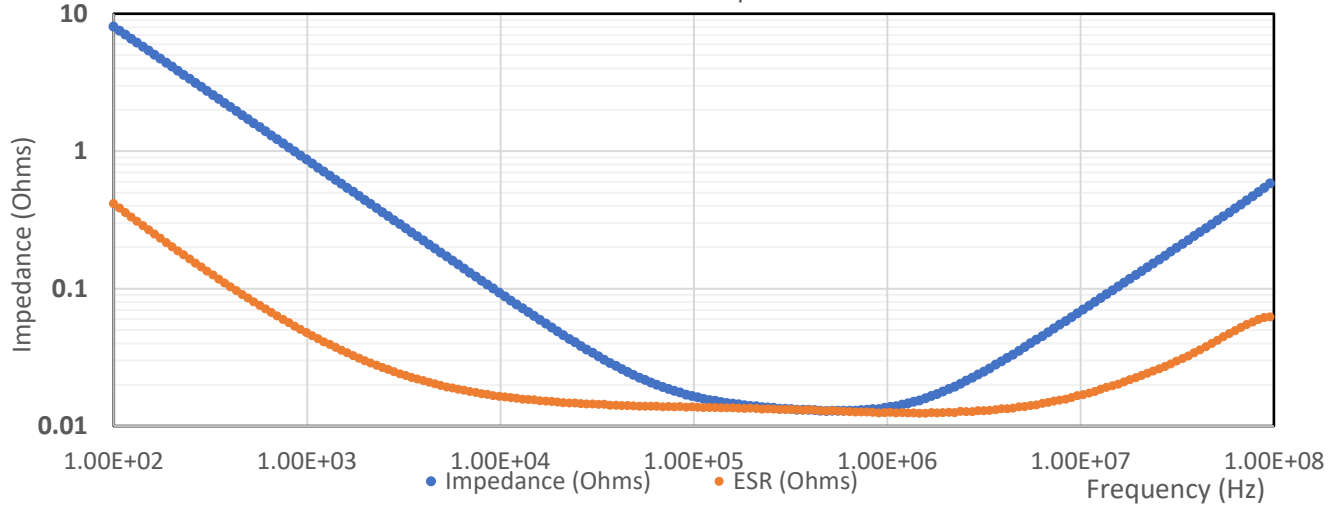


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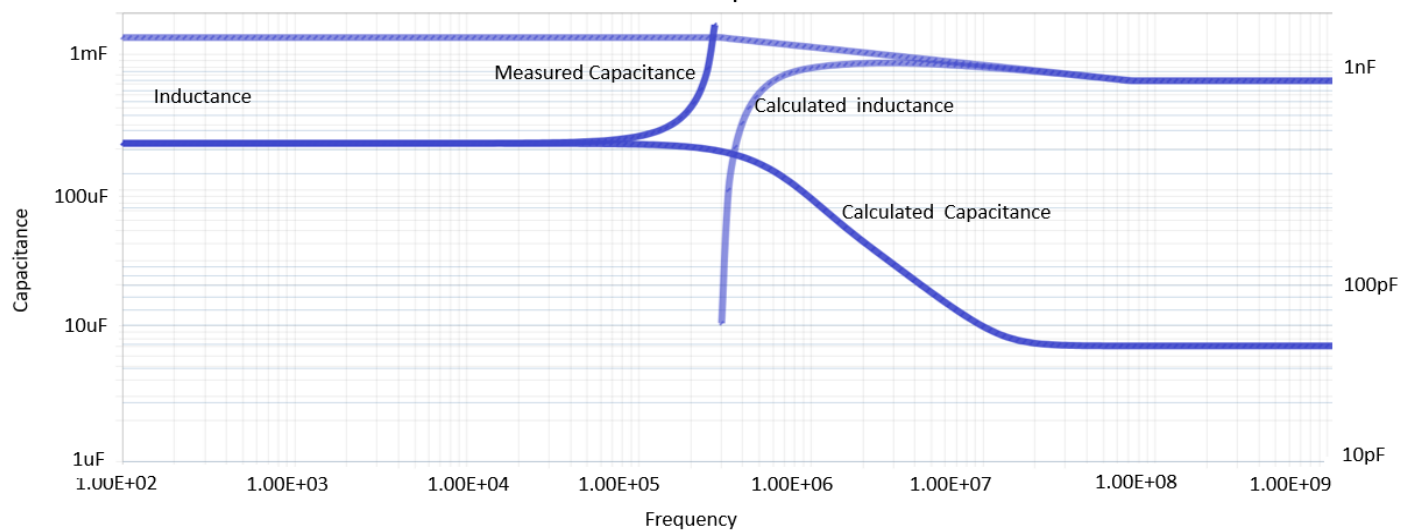
A720V337M004APE4R5 Capacitance & Inductance



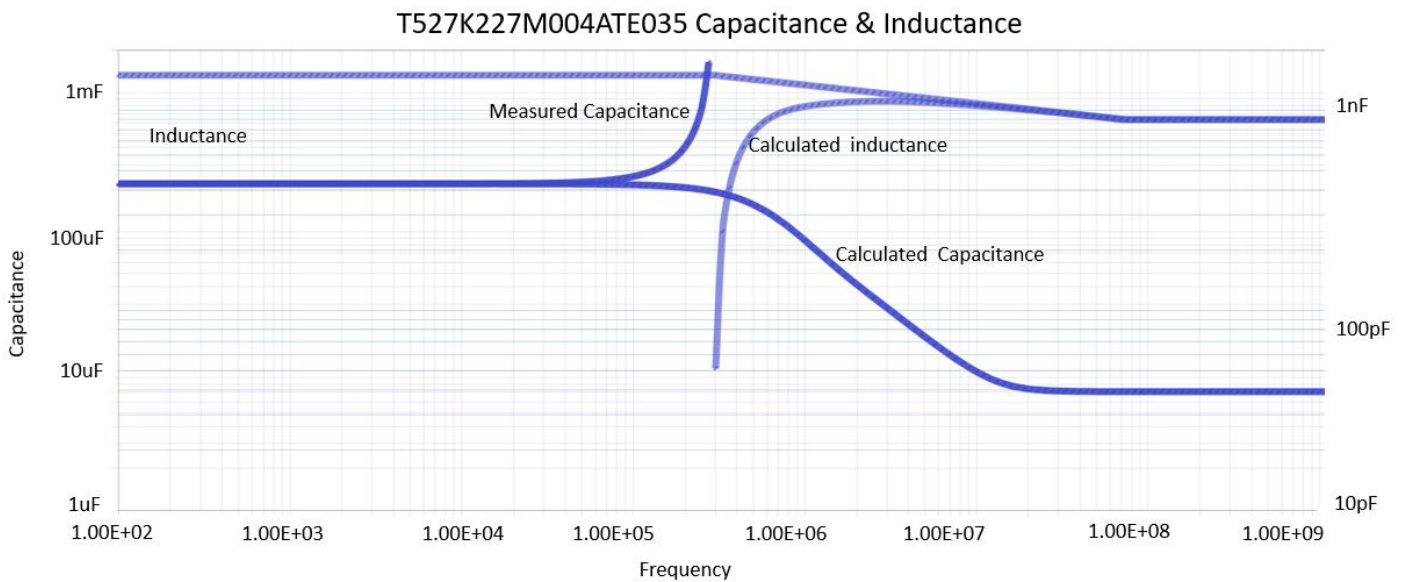
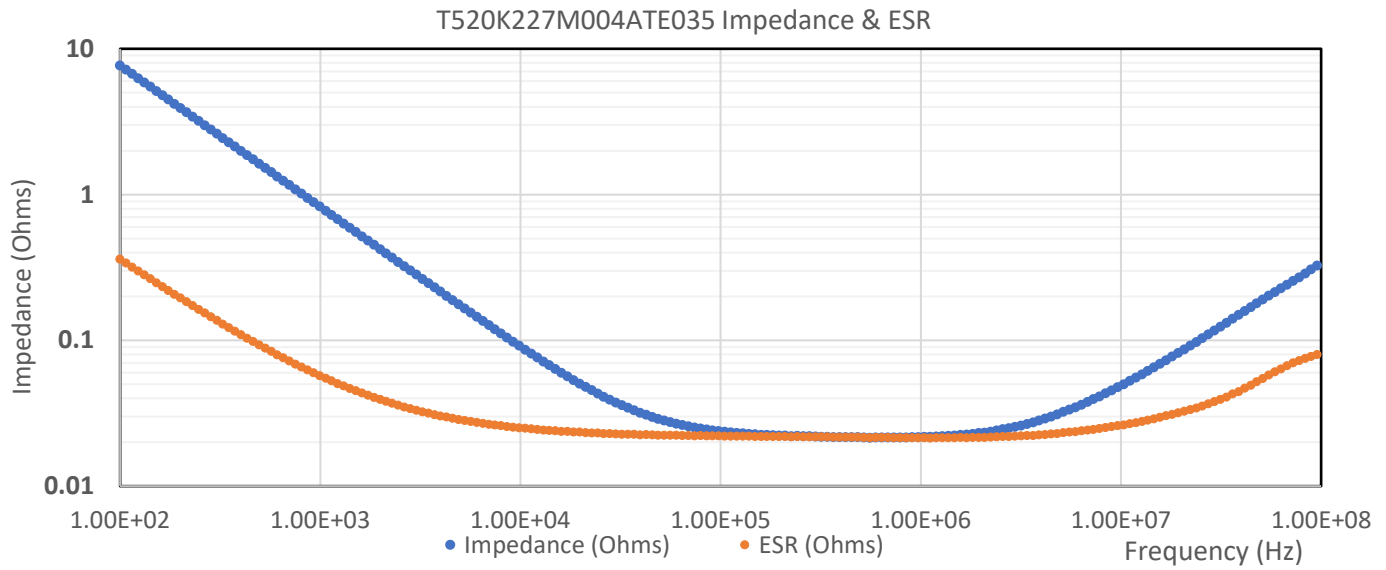
T520T227M004ATE035 Impedance & ESR



T520T227M004ATE035 Capacitance & Inductance



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Ripple Current capability

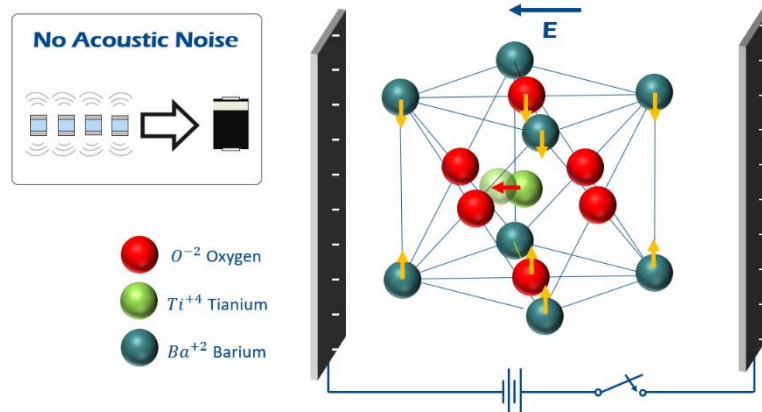
KEMET recommend A720 for high speed CPU Core filtering and decoupling application. ESR 4.5mohm capacitor can handle 9.54A @45C(temperature rise 30°C). ESR 6mohm capacitor can handle 8.26A, Since high speed server and data center CPU, the output power may more than 100A, the filtering capacitor ripple current capability should more than 8A.

KEMET P/N	$P_{max}=I_{rms}^2 \times ESR$ (Temperature rise 30°C)
A720V337M004APE4R5	$9.54^2 \times 4.5 = 410mW$
A720V337M004APE006	$8.26^2 \times 6.0 = 410mW$

In above table, these two A720 capacitors' $P_{max} > 400mW$. Compare with other higher than 10mohm Capacitors these two capacitors not easy to heat up. It can help to extend capacitor lifetime with lower capacitor temperature.

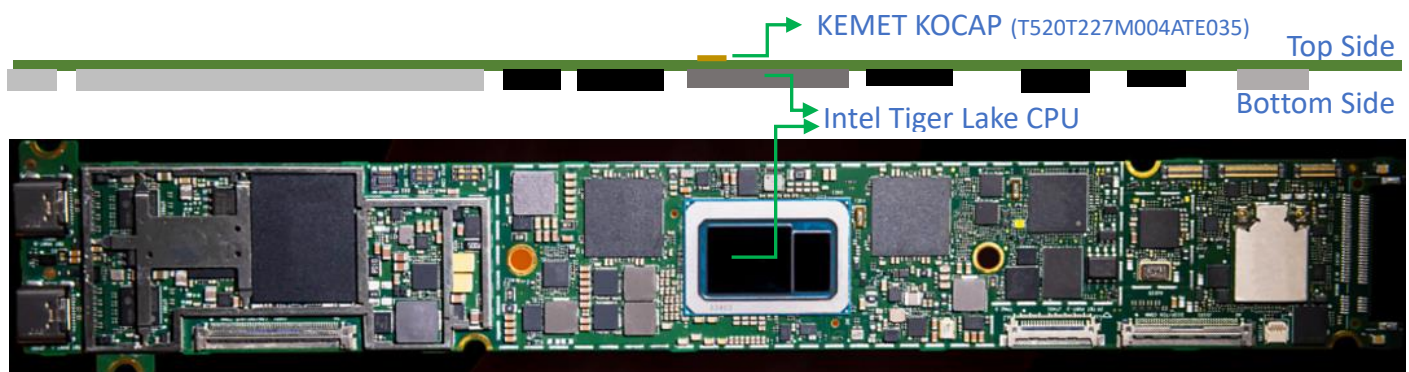
Replace Class II MLCC

In the Intel reference design, there are many high Capacitance X6S ceramic capacitor capacitors connected in parallel to the DC/DC output. Due Class II MLCC use $BaTiO_3$ ferroelectric dielectric material has piezoelectric effect, in the range of 20Hz-20KHz, it could be audible to humans, it is so called acoustic noise and some engineers call it singing capacitor. In order to solve this issue, KEMET recommend KO-CAPs or AO-CAPs to replace Class II MLCC. For Ultrabook CPU, 1pcs KEMET T520T227M004ATE035 or T523K227M004ATE035 can replace many MLCCs, in Tiger lake laptop CPU V core, we saw 1pcs



KOCAP can replace more than 10pcs 10uF/X6S MLCC without problem.

T520T227M004ATE035 or T523K227M004ATE035 component height only 1.2mm and 1mm. with low profile design, engineers can mount this capacitor on the backside of PCB to save component side space. It also suitable for next generation Intel Alder lake CPU.



Conclusion

For Server and data center CPU Vcore, consider KEMET A720 4V series. KEMET can offer A720V337M004APE4R5 and E006 today.

For Ultrabook Laptop, KEMET recommends T520T227M004ATE035 and T527K227M004ATE025 or E035. T520T227M004ATE035 is in mass production today and T527K227M004ATE025 or E035 will be ready in Q1/2021.