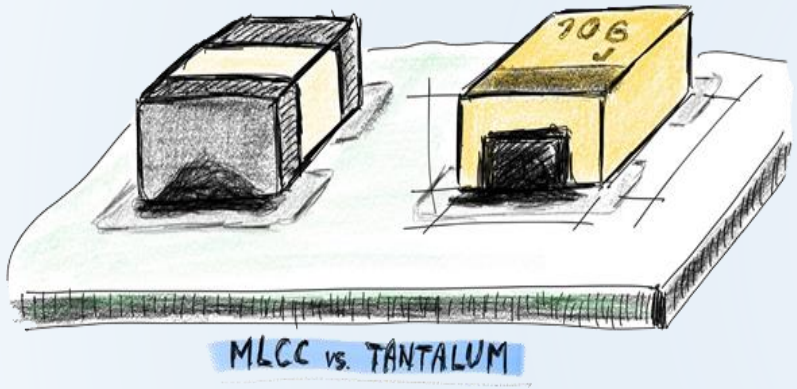
MLCC Capacitors Availability First Aid

Tantalum/NbO to MLCC Class II Replacement Guidelines

April 2018



Tomas Zednicek Ph.D.
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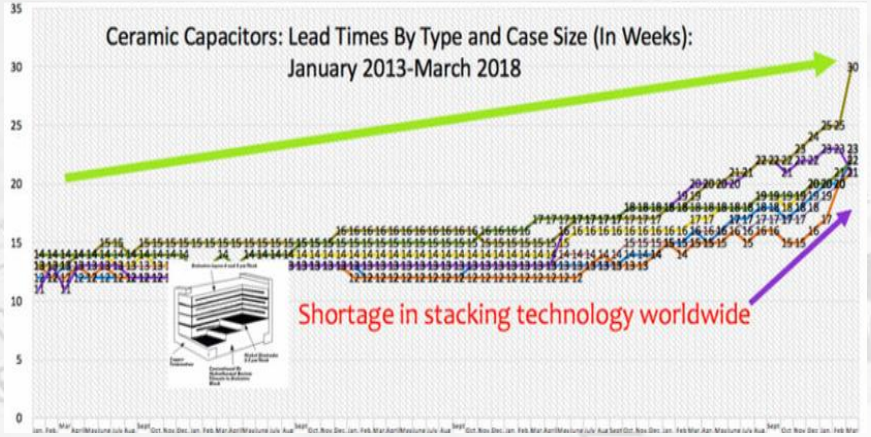

Source: Paumanok

Supply Issues & Headlines

An Update on Installed Global Capacitance in 2018
February 2018

MLCC Supply Remains Tight

April 18

MLCC Shortages and Why They Might Last Longer than Expected
June 2017

MLCC shortages are creating challenges in multiple end markets in 2018
March 2018

MLCC prices to rise 40-50% in 2Q18

March 18

tantalum capacitors are getting tight as well, but still it can offer better leadtimes depending to case sizes and Cap Volt type

Paumanok note on Tantalum Capacitors lead times continued to stretch March 18

click the headline for a link

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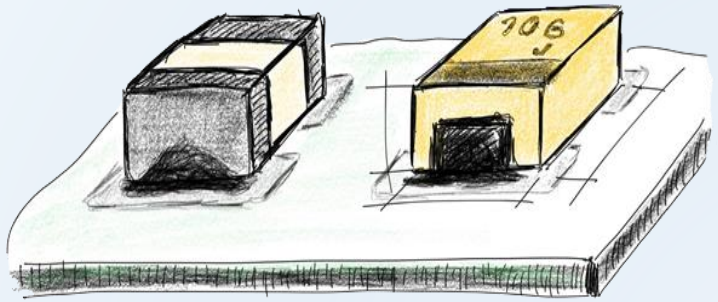
MLCC vs Tantalum



Case Sizes & Pad Dimensions

- basic PCB pad footprints 0603, 0805, 1206, 1210 are compatible with minor tolerance deviations
- case size height may by a type / CV specific

MLCC Case Size			Tantalum Case Sizes		
Metric	EIA	Thickness [mm] max	Metric	Thickness [mm] max	Letter Code*
1608	**[0603]**	**0.85**	**1608-09**	**0.9**	**J, L or M**
2012	**[0805]**	**1.1**	**2012-12**	**1.2**	**R or P**
			2012-10	*1.0*	S,M,N
			2012-15	*1.5*	*R or P*
3216	**[1206]**	**1.35**	**3216-18**	**1.8**	**A**
			3216-10	*1.0*	*K*
			3216-12	*1.2*	*S, A*
			3216-15	*1.5*	*G*
3225	**[1210]**	**1.35**	**3225-21**	**2.1**	**B**
			3225-10	*1.0*	*L*
			3225-12	*1.2*	*T, B*
			3225-15	*1.5*	*H*

Table 1. MLCC versus case size comparison, source: EPCI, manufacturers datasheets

** letter code may be manufacturer specific*

MLCCs are good in making parts physically smaller tantalums answer better the needs for thin and flat designs.

For example, if the task is to get maximum capacitance within 1.0mm max height, tantalum capacitors can make easier larger thin part with high capacitance in a mechanically strong body, unlike the MLCCs that could lead to a fragile design with risk of cracking.

In reality, tantalum capacitors are available in more thickness and low profile case options as seen in Table 1. On the other hand, MLCC technology can go to much smaller dimensions and make smallest capacitors available

Cost Matters

- In a "stable" market environment, technology based cost for **1206 case MLCC class II and Tantalum capacitors can be very close** (depending on capacitance and voltage value).
- The **1206 case size is a cost down sweet-spot case size for a standard tantalum capacitors** and it can be in price competitive position to MLCC class II.
- Tantalum smaller case sizes 0805 and 0603 may be **more expensive** than 1206.
- MLCC smaller case sizes 0805 and 0603 may be **cheaper** than 1206.
- 0402 and 0201 tantalum case sizes are existing as well as larger case MLCCs, howeve,r these are more niche products our of high volume and mass volume pricing.
- The actual cost vs performance value may be application specific due to a different parameters stability and features.

MLCC vs Tantalum

Construction & Key Features

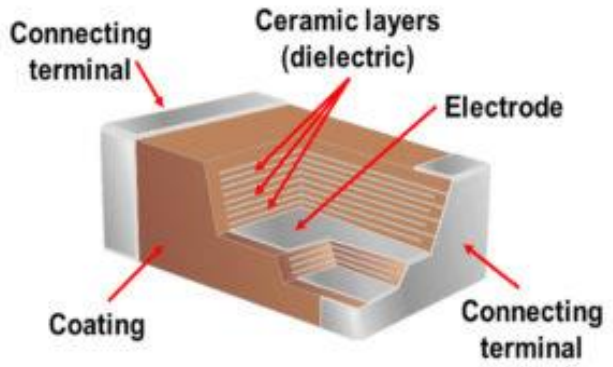


Fig.1. MLCC capacitor construction, image credit: Wikimedia

Tantalum/NbO advantages

- no piezo noise
- stable capacitance with voltage BIAS and temperature
- high mechanical strength, robustness and vibration resistance

Common strong points

- lead-free standard design and reflow compatibility
- ROHS friendly standard design
- wide temperature range (-55/+125C basic range)
- relatively very good basic reliability
- high capacitance in small dimensions

MLCC class II advantages

- low ESR
- high ripple load
- non-polarized
- low DCL

MLCC class II issues

- capacitance dependency to AC/DC voltage and temp
- piezzo noise
- mechanical robustness

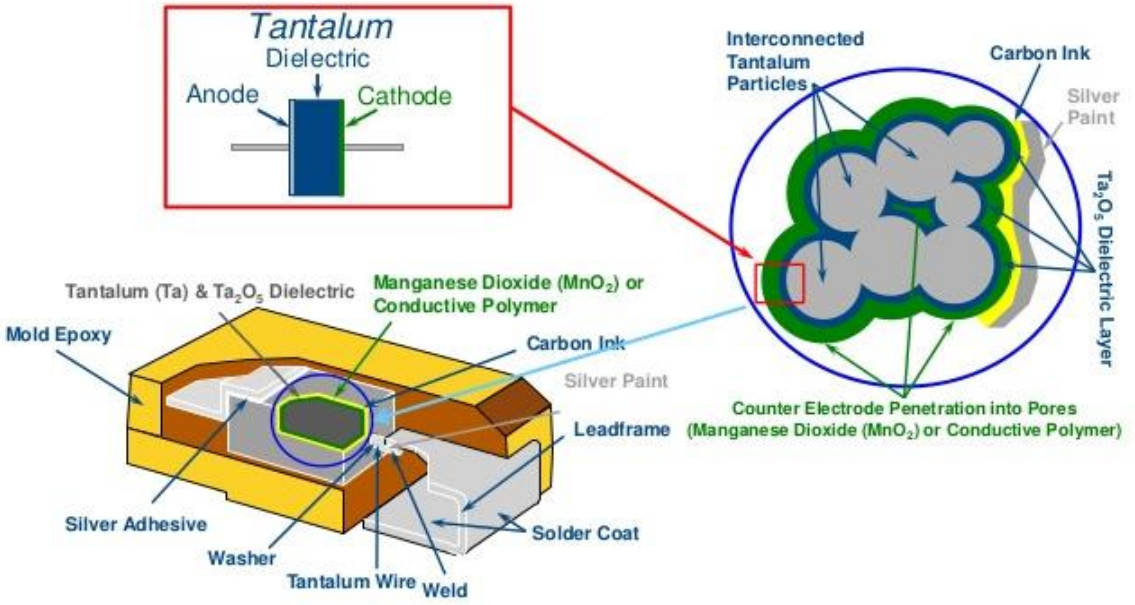


Fig.2. Tantalum capacitor construction, image credit: Kemet

Ta/NbO issues

- high current surge sensitivity
- derating rules (depending to technology and application different rules may apply)
- conflict-free tantalum source (addressed by leading mfgs)

Key Features – Details I.

Temperature Dependency

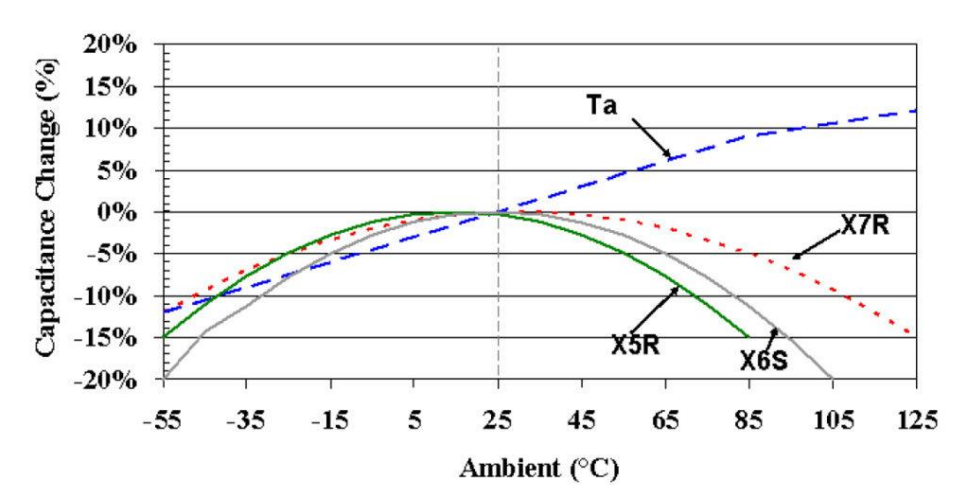


Figure 3. Capacitance versus temperature behavior by different dielectric types, chart credit: Kemet

Tantalum/NbO advantages and MLCC Issues

- stable capacitance with DC/AC voltage BIAS and temperature

Capacitance vs DC Voltage

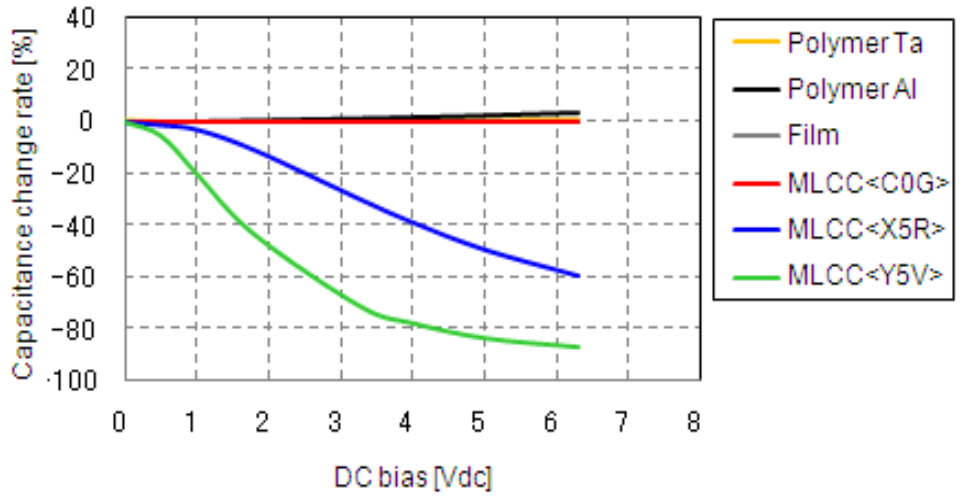


Figure 4. Cap versus DC Bias behavior by different dielectric types, chart credit: Murata

Capacitance vs AC Voltage

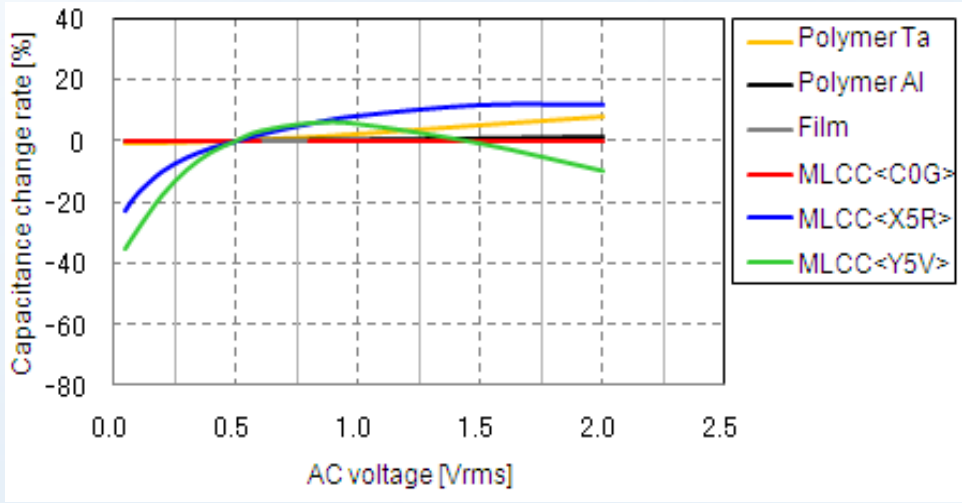


Figure 5. Cap versus AC voltage behavior by different dielectric types, chart credit: Murata

Key Features – Details II.

IMP, ESR vs Frequency

MLCC advantages and Tantalum General Issues

- Low ESR and High ripple load (at high "switching" frequency)

Nevertheless, **! Watch for Working Frequency !**

MLCC's ESR may be even higher than tantalum at low frequencies (sub 1kHz)

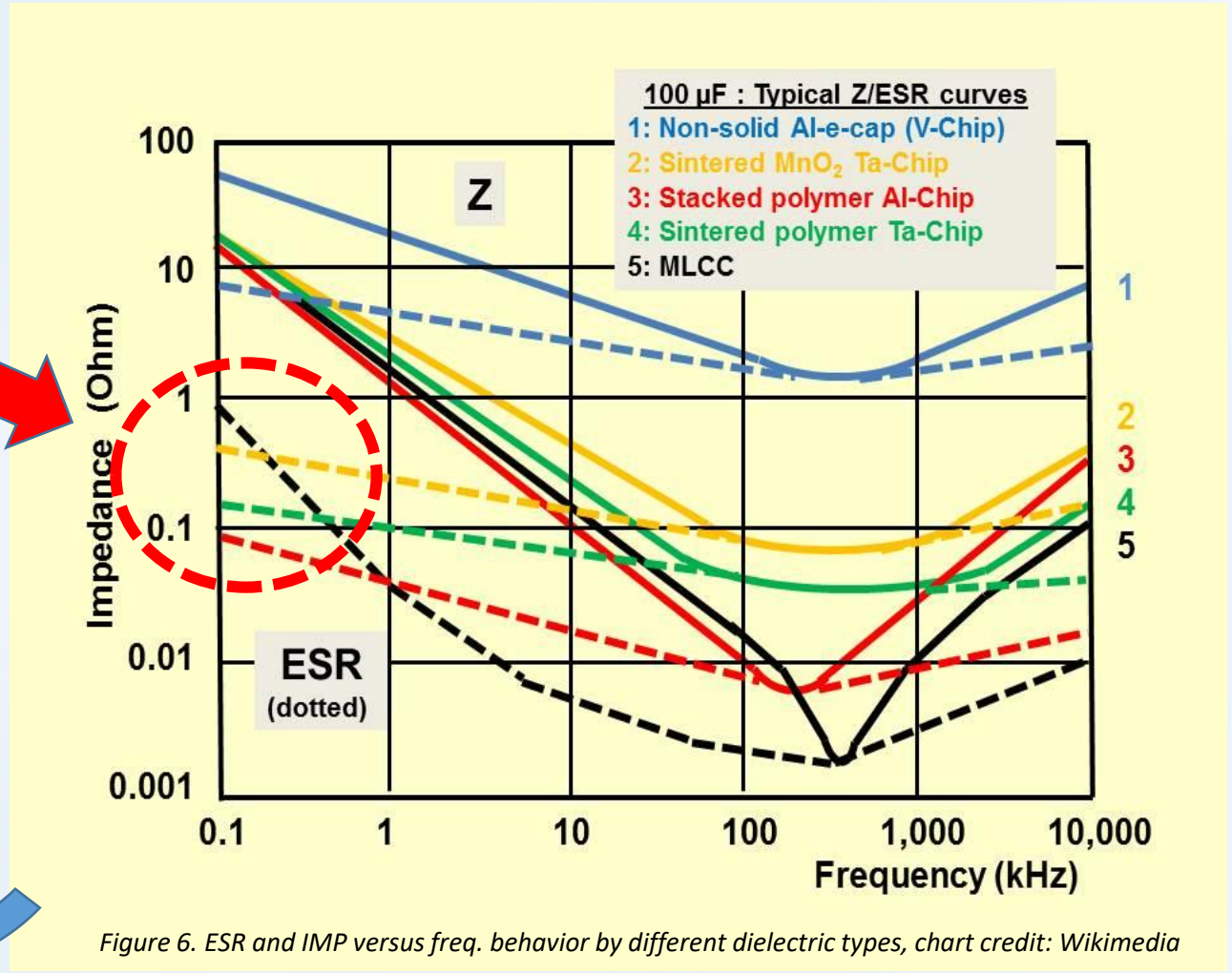


Figure 6. ESR and IMP versus freq. behavior by different dielectric types, chart credit: Wikimedia

This is then reflected into the capacitors' power dissipation and ripple current load capability

Ripple Current

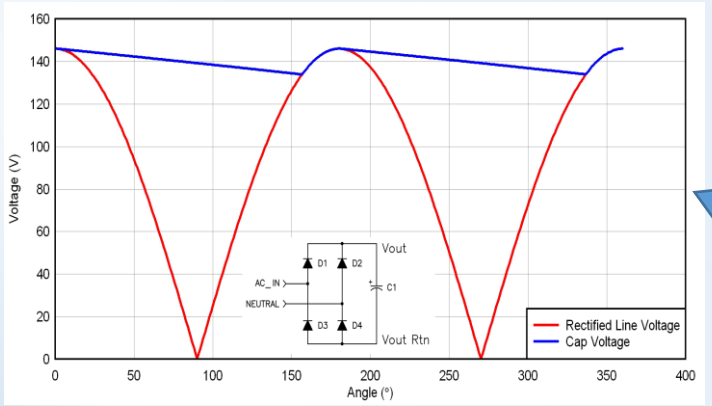


Fig 7. Capacitor smoothing function in a rectifier circuit.

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Summary & Recommendations

Tantalum to MLCC replacement possible:

A. AT LOW RISK:

all applications, where very low ESR and high ripple current load is not a prime requirement, such as circuit functions - coupling/decoupling including audio circuits, selected filtering, timing etc.

Checklist:
a) low ESR requirements and high ripple current load Yes/No/Level
b) DCL leakage level in case of battery operated circuit

Tantalum or NbO capacitors in these applications are representing even more stable, reliable solution that may be even superior compare to the original MLCC capacitor.

B. MORE DETAILED EVALUATION NEEDED:

smoothing applications typically at DC/DC converters with high power load requirements.

Checklist:
a) smoothing frequency required **! not a general specification table parameter !** - at low frequencies ESR of MLCC capacitors may be even higher than tantalum. Use of tantalum capacitors is thus possible with even improved performance.
b) beware of the required low ESR and ripple load specification values as the critical characteristics as the low ESR may be the main limiting factor for the circuit operation.
c) return to b) and check the low ESR / ripple load requirements in the entire end device operating temperature range
d) consider appropriate derating rules for tantalum, NbO and polymer capacitors. Follow manufacturers recommendations Kemet [18], AVX [19], Vishay [20]

related technical papers on capacitors selection for DC/DC converters can be found in [13] and detailed technical paper from AVX on DC/DC capacitor benchmarking [14].

The Final Word & References

The Final Word

Situation on the market is rather dynamic, thus it can not be guaranteed that tantalum or NbO capacitor alternatives will be available with shorter leadtime than MLCC, nevertheless the main purpose of these guidelines is to provide a basic info on possible replacement considerations to be flexible with some more choices on mind to avoid line stops.

References

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[6] AVX technical paper, 2005 " New Tantalum Technologies Tantalum Polymer and Niobium Oxide Capacitors", link here
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[16] D.Zogbi, Paumanok, March 17, :"Paumanok note on Tantalum Capacitors lead times continued to stretch", link here
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[19] AVX Technical paper:"Voltage Derating Rules for Solid Tantalum and Niobium Capacitors", link here
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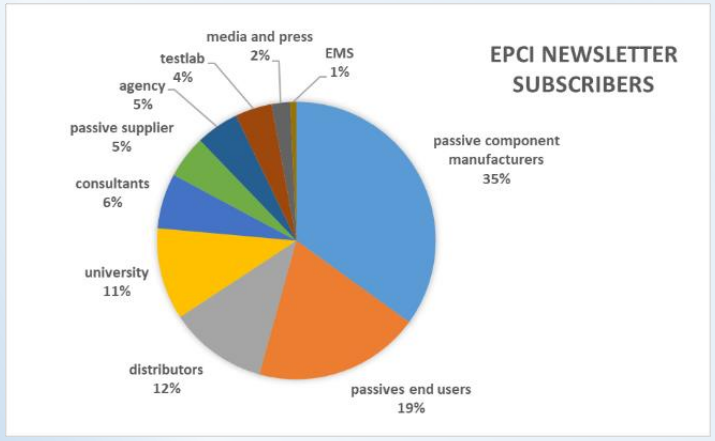

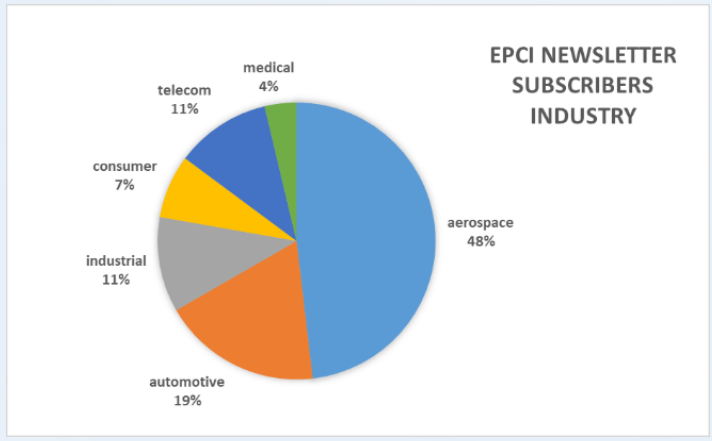

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