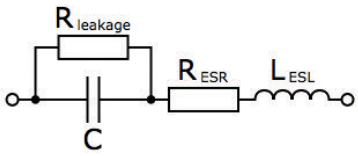
ZAPCO Electrolytic Capacitors
used for Z-LX and other amplifiers
(APEX, 07 June 2017)

Critical to the development of Zapco products is the continuous search for new technologies and better components to enhance sonic performance. Zapco's engineers are also audiophiles, with experience not only in amplifier design, but also in car audio competition as both participants and judges in the US and in Europe. Components are evaluated first on the relative specifications, and then the components are evaluated in listening tests. All parts are tested to verify the reliability of published specifications, but final choices made from actual tested data and the listening tests.
One of the most important components for the audio amplifiers are the capacitors, especially the electrolytic capacitors. There are many factories In the market producing electrolytic capacitors, some old and well known, some new and un-known. We look at, and test, them all, and we continuously look for any better that come along.

From Wikipedia about comparing capacitors:
Comparison of electrical parameters of electrolytic capacitors

In order to compare the different characteristics of the different electrolytic capacitor types, capacitors with the same dimensions and of similar capacitance and voltage are compared in the following table. In such a comparison the values for ESR and ripple current load are the most important parameters for the use of electrolytic capacitors in modern electronic equipment. The lower the ESR, the higher the ripple current per volume and better functionality of the capacitor in the circuit. However, better electrical parameters come with higher prices.

Series-equivalent circuit

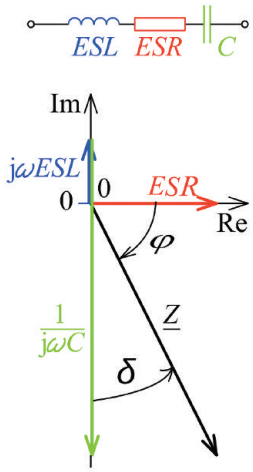


Series-equivalent circuit model of an electrolytic capacitor

The electrical characteristics of capacitors are harmonized by the international generic specification IEC 60384-1. In this standard, the electrical characteristics of capacitors are described by an idealized series-equivalent circuit with electrical components which model all ohmic losses, capacitive and inductive parameters of an electrolytic capacitor:

- C, the capacitance of the capacitor
- RESR, the equivalent series resistance which summarizes all ohmic losses of the capacitor, usually abbreviated as ESR
- LESL, the equivalent series inductance which is the effective self-inductance of the capacitor, usually abbreviated as ESL
- Rleak, the resistance representing the leakage current of the capacitor

Impedance



Simplified series-equivalent circuit of a capacitor for higher frequencies (above); vector diagram with electrical reactances XESL and XC and resistance ESR and for illustration the impedance Z and dissipation factor tan δ

Generally, a capacitor is seen as a storage component for electric energy. But this is only one capacitor function. A capacitor can also act as an AC resistor. Especially aluminum electrolytic capacitors in many applications are used as decoupling capacitors to filter or bypass undesired biased AC frequencies to the ground or for capacitive coupling of audio AC signals. Then the dielectric is used only for blocking DC. For such applications the AC resistance, the impedance, is as important as the capacitance value.

So the most important factors for considering an electrolytic capacitor are:

- Operating Temperature (for car use it should be at least -40~+85 degrees C) **Higher temperature range is better**
- Capacity Tolerance (normally is -20% + 20%) **Tighter tolerance is higher quality**
- Max Resistance and Impedance (ESR and dissipation factor tan δ) **Lower number is higher quality**
- Max Ripple current (the maximum current the capacitor can support) **Higher value is higher quality**
- Max Leakage current (the maximum DC current through the capacitor) **Lower number is higher quality**
- Endurance **Life of the capacitor at the maximum declared values. After that limit the capacity can decrease up to 20% at lower values**
- Dimensions **Usually, with the same value, a better cap will be smaller in size**

Below, we take some the known capacitors we have been using, and we make the comparison with the capacitors used in the newest production of amplifiers in the Z-LX series. For comparison we will take four capacitor values (from small to high values). Note that we are comparing to the top three brands. The chart below shows the numbers:

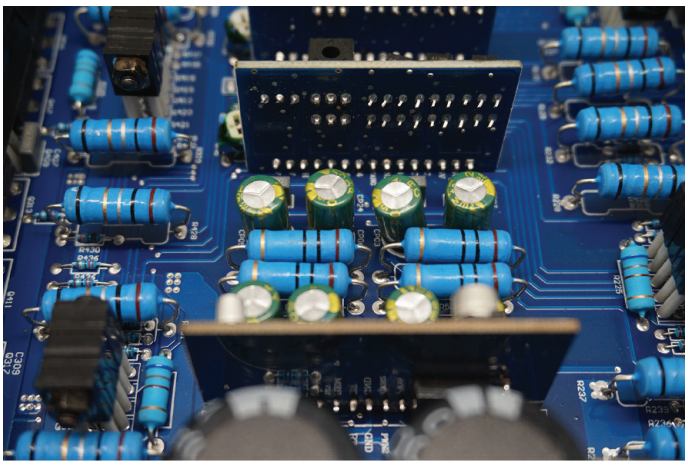
Capacity & Voltage	Type		Operating temperature	Capacitance Tollerance 120Hz 20 °C	Max ESR 100 KHz, 20 °C	Dissipation Factor max 20°C 120Hz	Max. Ripple current 85/105 °C	Max. Leakage current after 2 min.	Endurance	Dimen. (DxL)
uF/V			-°C + °C	-%~+ %	mΩ	tanδ	mA	µA	hours	mm
4.7uF/50V	ELNA RFS code: RFS50V417ME3		-55+85°C		not declared	0.08	35	2.35	1000	5/11
100uF/50V	ELNA RFS code: RFS50V101MH3		-55+85°C	-20%~+20%	not declared	0.08	380	50	1000	12.5/20
3,300uF/25V	Panasonic code: EEU-FC1E332		-55+105°C	-20%~+20%	18	0.18	3010	825	5000	16/31.5
4,700uF/50V	Nichicon code: LKS1H472MESB		-40+85°C	-20%~+20%	not declared	0.3	2550	2350	1000	30/25

Capacity & Voltage	Type	Declared & measured values on 10 pcs average	Operating temperature	Capacitance Tollerance 120Hz 25 °C	Max ESR 100 KHz, 25 °C	Dissipation Factor max 20°C 120Hz	Max. Ripple current 105 °C 100KHz	Max. Leakage current after 2 min. 20 °C	Endurance	Dimen. (DxL)
uF/V			-°C + °C	-%~+ %	mΩ	tanδ	mA	µA	hours	mm
4.7uF/50V	Zapco code: ZC288H1H4R7T	Decl.	-40+105°C	-10%~+20%	3000	0.08	92	2.35	1000	5/11
		Meas.		4.6~4.7	960	0.029		0.7		
100uF/50V	Zapco code: ZC288H1H101T	Decl.	-40+105°C	-10%~+20%	400	0.08	649	50	1000	8/12
		Meas.		97.4~99.1	158	0.032		7.3		
3,300uF/25V	Zapco code: ZC288H1E332T	Decl.	-40+105°C	-10%~+20%	50	0.16	2560	825	1000	16/26
		Meas.		3249~3258	24	0.085		51.5		
4,700uF/50V	Zapco code: ZC2931H471M	Decl.	-40+105°C	-10%~+20%	ND	0.2	2400	2350	1000	30/30
		Meas.		4677~4706	18	0.116		360		

These tests by Zapco's Engineer Department (APEX Group) show the new Zapco capacitors to be superior to what we have been using in the past as below:

- **Higher operating temperature: Up to 105°C instead of 85°C** (only Panasonic matched that value)
- **Better capacitance tolerance than the others: -10%~+20% instead of -20%~+20%**
- **ESR and dissipation factors are the same**
- **Max Ripple: better value than Elna capacitors, similar the other two**
- **Max leakage current: same in declared values, but much lower in actual testing**
- **Endurance the same (1000 hours) except the Panasonic that is 5000 hours**
  Note: the value of the endurance is with capacitor at the maximum rated data: ie. temperature, voltage, ripple current, etc. In with normal use the average endurance is up to 5 times more
- **The new Zapco capacitors are little smaller than all but the Nichicon**

https://en.wikipedia.org/wiki/Electrolytic_capacitor#Comparison_of_electrolytic_capacitor_types
http://www.elna.co.jp/en/capacitor/index.html (Catalog No.2017 / 2018E ALL (7.2MB)
https://industrial.panasonic.com/ww/products/capacitors/aluminum-capacitors/aluminum-cap-lead/fc/EEUFC1E332
http://www.datasheet-pdf.com/PDF/LKS1H472MESB-Datasheet-Nichicon-858018



The Z-SP Series with the new Zapco capacitors inside.