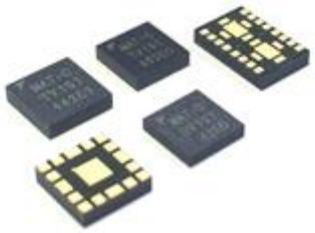
Aluminum Solid Electrolytic Capacitors [MAT-C]Series Compatible With Multi-Power SoC EMI

Introduction

Development of digital technologies driven by communication equipment and image processing equipment is spectacular. However improvement in digital processing capability is essential to further development. Clock frequency as the base of digital signal processing is increasing according to market requirement as well as development speed of semiconductor processing. Capacity of memory device for such digital signal processing is increasing and more access speed is required. In such circumstances, memory devices with new specifications are developed day after day.

The types of power supply for SoC (System on Chip) in the center of development in various devices have been getting wider, and the number of terminals on SoC is increasing. Withstand voltage of semiconductor device is reducing, so that lower power voltage requires more accuracy. These are the difficulties in designing power circuits. High clock frequency increases electromagnetic waves to be emitted from LSI, so as to make EMI measures difficult. Then many MLCCs (multi-layer ceramic capacitors) are connected to power terminals as one of such measures. However requirements of cost-cutting and higher quality in electronic equipment are getting higher, so that further improvements are sought.

MAT-C™(Multi Anode Terminal Capacitor) is a stack of multiple conductive polymer aluminum solid electrolytic capacitors, which realizes high capacitance, low ESL and low ESR. This capacitor is compatible with EMI measures to reduce number of parts and packaging cost.



Features

＜Construction＞
MAT-C uses multiple elements of PC-CON (conductive polymer aluminum solid electrolytic capacitor) in a stack. MAT-C with characteristic way of terminal extraction realizes inductance value lower than PC-CON.

Fig. 1 shows the appearance, internal equivalent circuit and construction of a MAT-C. Cathodes of multiple capacitor elements are connected with a through-hole in the center to make common terminal, so that negative terminals consists of 5 terminals including the common terminal. Anodes are laid on opposite sides of each capacitor and connected to 2

terminals on the same side with wire bonding. Then T60M capacitor compatible with 3 power lines, have 17 terminals in total, 12 positive terminals (4 terminals x 3 elements) and 5 negative terminals including a common GND terminal.

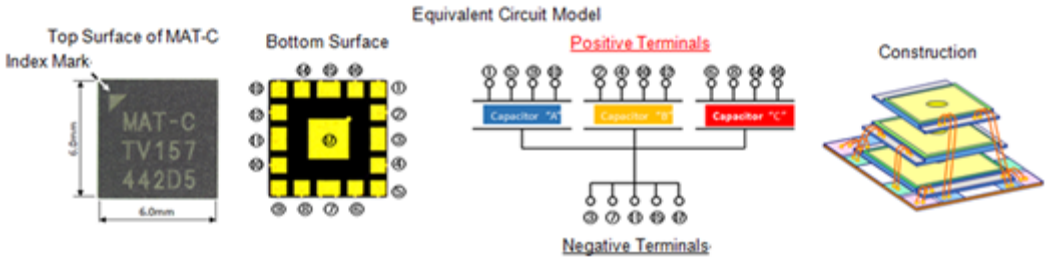


Fig. 1 Appearance, Construction and Equivalent Circuit of MAT-C

＜Compatibility with Multiple Powers＞

Recent SoC is miniaturized and power voltages for core, I/O and DDR are different according to semiconductor process. It is the reason why multiple powers such as POL (Point Of Load) are required. Each power uses decoupling capacitor. Further MLCC (multi-layer ceramic capacitor) is required to each power terminal as EMI measure. Then a big SoC uses more than 100 MLCCs. Use of 3-terminal capacitor is recently increasing to reduce number of capacitors, but it is yet insufficient.

MAT-C serves as decoupling elements for power lines, since it includes multiple capacitors of high capacitance. MAT-C is also suitable for impedance reduction in SoC, since it is superior in high frequency characteristics. A MAT-C together with a few MLCCs supersede many capacitors around power source.

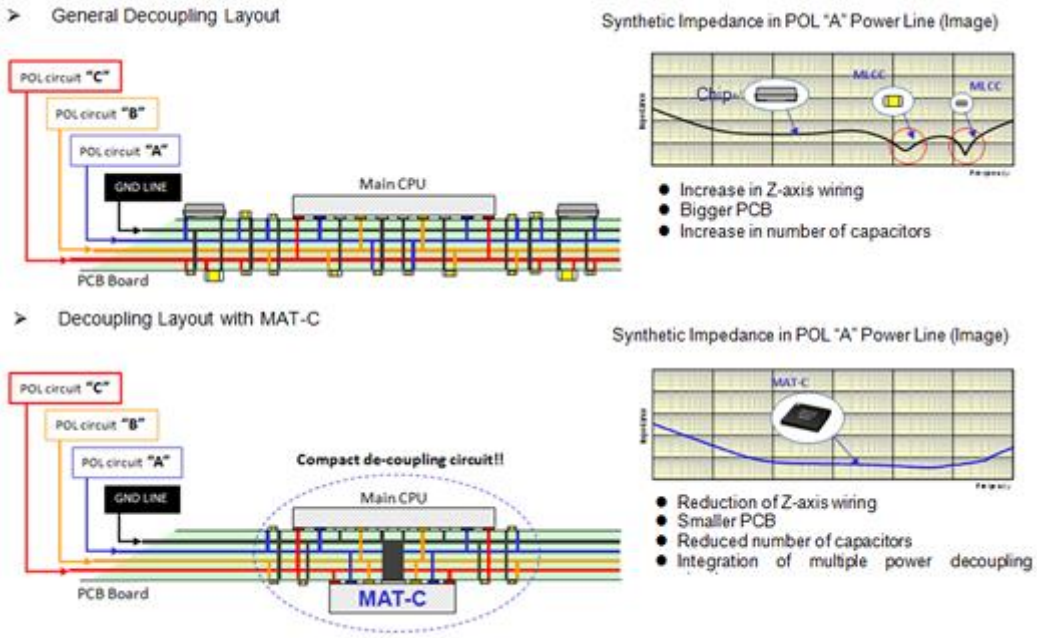


Fig. 2 Layout Image and Impedance-Frequency Curve

＜Low Impedance over Wide Frequency Range＞

MLCC and 3-terminal capacitor are used as decoupling capacitors in EMI measure of SoC, but

it is necessary to connect multiple capacitors with different frequency characteristic in parallel, in order to realize low impedance in power circuit over wide frequency range including low frequency range. In such case, it is concerned that aintiresonance between capacitance and parasitic inductance of each capacitor produces points of high impedance at specific frequencies.
On the other hand, MAT-C has both of high capacitance and low ESL to realize low impedance over wide frequency range, so that it supersedes multiple capacitors. It means no necessity to consider antiresonance and easiness in circuit designing.

Fig. 3 shows bandpass characteristic of 4 ports of Capacitor A on the bottom of MAT-C. The capacitor has the capacitance as high as 60µF so as to realize low impedance over wide frequency range from low to high frequencies. Bandpass characteristic includes 3 curves, since the capacitor is rectangular so as to make 3 distance values are included between internal terminals.

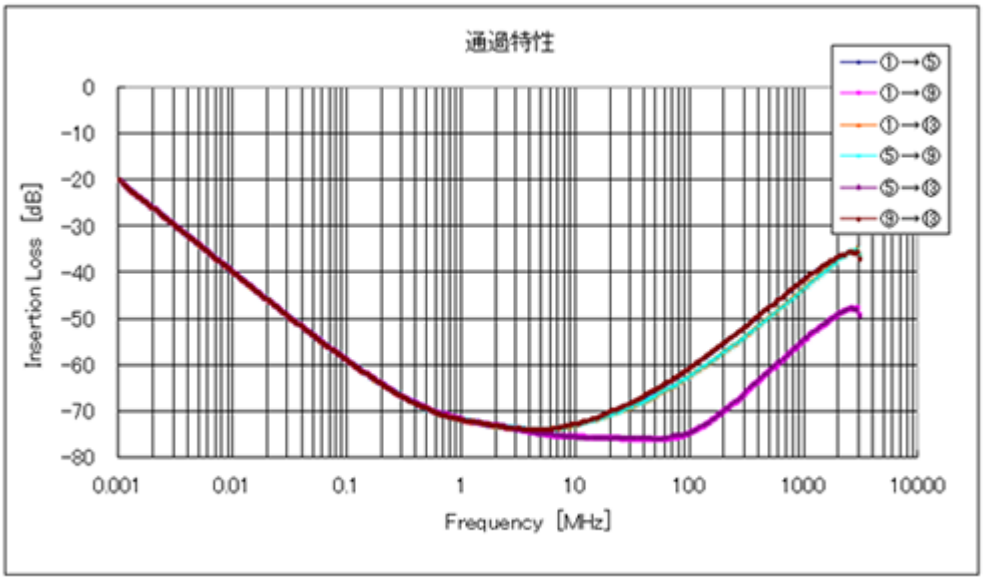


Fig. 3 Bandpass Characteristics

Electric Characteristics

MAT-C has the category temperature range between -55°C and 105°C, and stable characteristics over the temperature range. Temperature characteristics of capacitor depend on dielectric material and properties of electrolyte. MAT-C using polypyrrole working with electronic conduction as the electrolyte has less capacitance change over the temperature range than aluminum electrolytic capacitor using liquid electrolyte working with ion conduction (Fig. 4). Aluminum oxide as the dielectric has small change in permittivity under electrification, so that MAT-C realizes small change in impedance and capacitance under DC bias (Fig. 5). These features contribute to easiness in designing circuits as well as improvement in reliability of the final product.

Table 1 shows electric values of T60M.

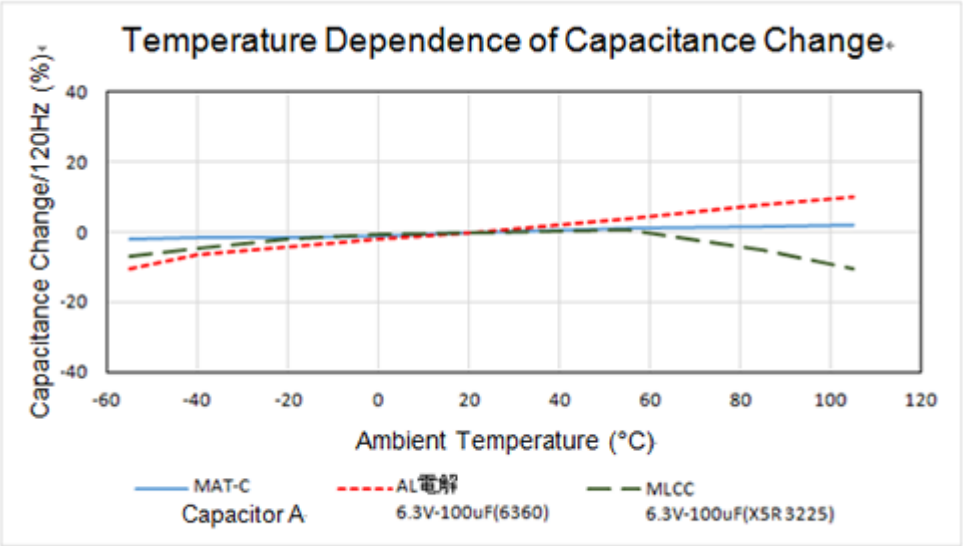


Fig. 4 Temperature Characteristic

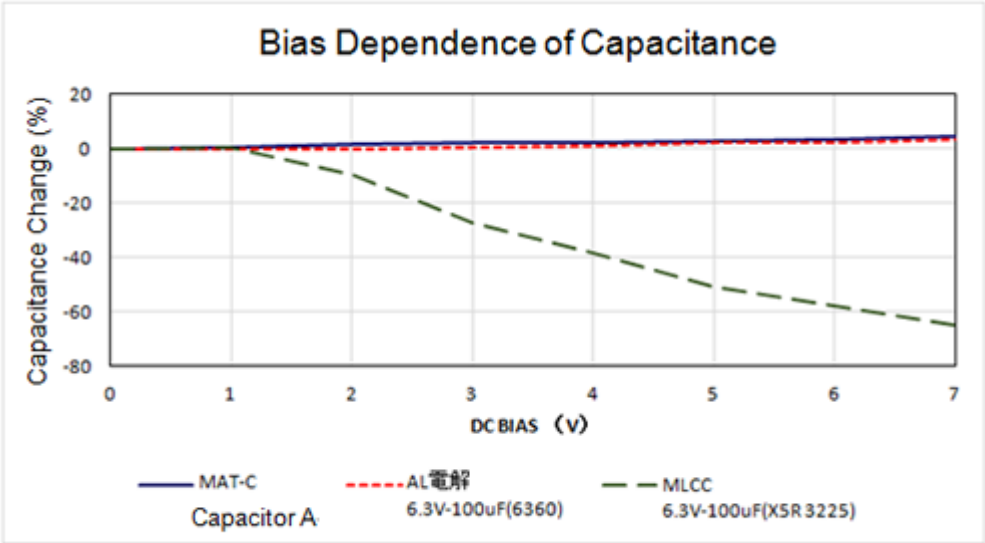


Fig. 5 Bias Dependence

Table 1 Electric Values of MAT-C

	Max Voltage (V D.C.)	Nominal Cap. (μF)	Cap. Tolerance	tanδ (Max.)	L.C. (μA / WV / 5min) (Max.)	E.S.R. (mΩ/100kHz) (Max.)	Max Allowable Ripple Current (mArms/100KHz)
Capacitor A	2.0	60	±25%	0.10	60.0	18	1000
Capacitor B	3.5	50	±25%	0.10	87.5	30	1000
Capacitor C	4.0	40	±25%	0.10	80.0	40	1000

Advantages to Use MAT-C

In use of system LSI having high digital processing capability, Many MLCCs are required to use so as to reduce EMI arising from many power terminals. Then assembly of such circuit requires much man-hour (costs) to mount parts and to control such parts. Use of MAT-C

reduces number of parts so as to cut costs. Less parts also reduce soldering points, resulting in reduction of soldering failure and degradation of reliability.

In an actual case using Image Processing LSI to car navigation system, one MAT-C together with 6 MLCCs supersede MLCCs more than 100pcs to attain equal EMI performance. It is drastic cost cutting. Packaging area is further reduced by 75%.

Future Technology Trend

In MAT-C Series, optimal capacitors can be selected according to application. For example in a 6-square-millimeter product, multiple capacitors, at most 100µF at the rated voltage of 2.5 or at most 50µF at the rated voltage of 6.3V, can be built in. It is available to develop and produce MAT-Cs with multiple rated voltages according to customer requirement. We are going to bring MAT-C ideal for new system SoC to the market. We will further develop advanced products with lower impedance in much higher frequency range as well as with improved resistance to higher temperature and humidity, in order to expand lineup of MAT-C and the market.

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