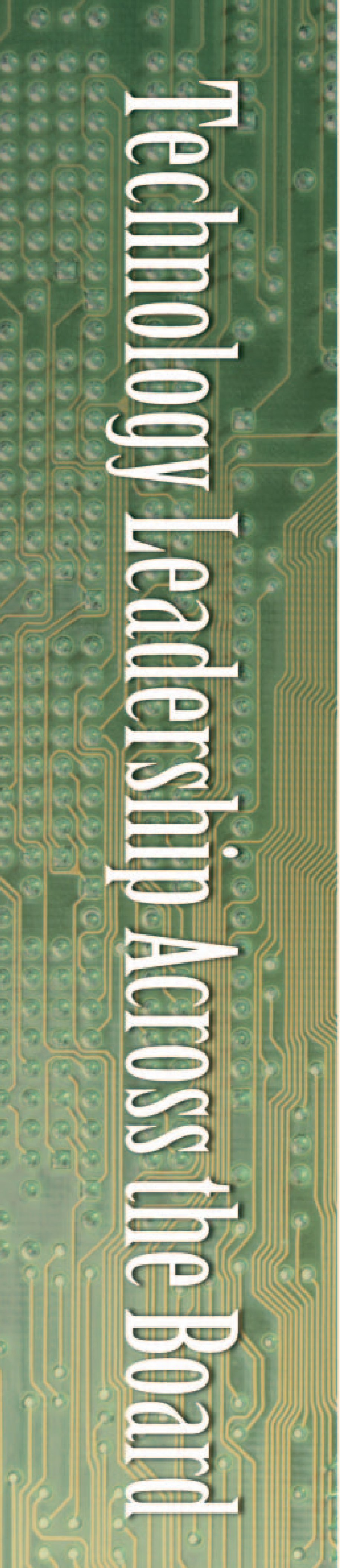


# Capacitor Array – An Integrated Passive Component Offering Benefits to the Automotive Sector


**ABSTRACT:**

By combining discrete capacitors into a multi-element package, AEC-Q qualified capacitor arrays offer automotive designers the opportunity to lower placement costs, increase assembly line output through lower component count per board and reduce real estate requirements.



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# Capacitor Array – An Integrated Passive Component Offering Benefits to the Automotive Sector

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The Integrated Passive Component (IPC) is an advancement in passive technology where more than one component is integrated into a single package. The capacitor array in one such IPC available from AVX. The smallest array option available from AVX is the 0405 2-element device, the 0508 4-element is one of the most popular and the 0612 4-element package gives the highest available capacitance values, all of which have received widespread acceptance in the marketplace.

AVX capacitor arrays are available in X5R, X7R and NP0 (C0G) ceramic dielectrics to cover a broad range of capacitance values. Voltage ratings from 6.3 Volts up to 100 Volts are offered. Key markets for capacitor arrays are mobile and cordless phones, digital set top boxes, computer motherboards and peripherals as well as automotive applications, RF modems, networking products, etc. They give the main advantages of saving board space, reducing the cost of placing multiple discrete components and giving increased throughput with faster board population. The capacitor array is also available with multi capacitance values in one package, and when connected in parallel can have lower ESR compared to an equivalent discrete component. All automotive capacitor arrays are qualified to the automotive AEC-Q standard.

## Space Saving

The miniaturization trend is very obvious in mobile phones and digital cameras where they are being offered to the marketplace in an ever-decreasing size. However, all areas of electronics even in the automotive sector have been affected by this trend as space and weight reduction becomes increasingly more important. Miniaturization has mostly been made possible through advancements in reducing the size of active components. But as integrated circuits (ICs) get smaller and more complex, there is an increasing need to also reduce the space required for the supporting passive components.

Increasing pressure for miniaturization of component size comes mainly from the telecommunications (cellular phones), computers (laptops) and instrumentation (handheld devices) industries as each application adds more functionality to the already reduced board space.

After introduction to these commercial users the miniaturized components are later used by those markets who require higher levels of reliability, such as the automotive sector in critical safety systems.

Reducing the package size of a Multi-Layer Ceramic Capacitor (MLCC) can be achieved by using ceramic materials with higher relative permittivity in conjunction with improved manufacturing processes. The MLCC package size, characterized using the Electronic Industries Association (EIA) standard, have reduced from 1210, 1206, 0805, and 0603 to 0402 and below. These very small chip sizes can challenge the users ability to process them and may require major upgrades in pick-and-place handling equipment that was built before their invention.

The real goal in miniaturization is not just to make smaller components, but to achieve board-area savings and overall volumetric reduction. Even the smallest components still require placement clearances and board-mounting pads. Combining the discrete passives into arrays before mounting them addresses these limitations. The AVX capacitor array can combine 2 or 4 discrete components into a single multi-element package (Figure 1).

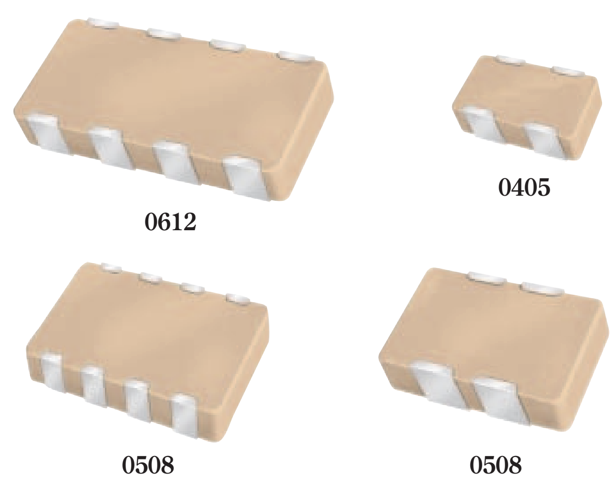
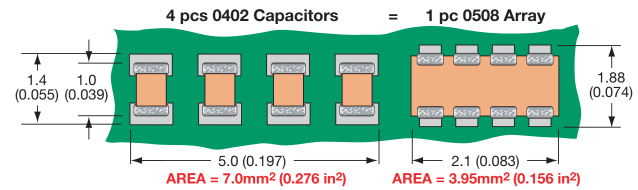
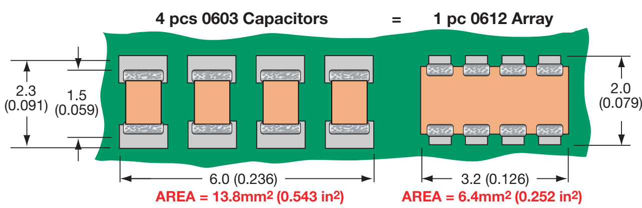



Figure 1. Capacitor Array Available Case Sizes

Space savings from a capacitor array can be quite dramatic when compared to the use of discrete chip capacitors. As an example in Figure 2, the 0508 4-element array offers a space reduction of >40% vs. 4 x 0402 discrete capacitors and of >70% vs. 4 x 0603 discrete capacitors. (This calculation is dependent on the spacing of the discrete components.)




The 0508 4-element capacitor array gives a PCB space saving of over 40% vs. four 0402 discretes and over 70% vs. four 0603 discrete capacitors.




The 0612 4-element capacitor array gives a PCB space saving of over 50% vs. four 0603 discretes and over 70% vs. four 0805 discrete capacitors.

Figure 2. Space Saving with Capacitor Array versus 4% Discrete Components

## Increased Throughput

Assuming that there are 220 passive components placed in a mobile phone; a reduction in the passive count to 200 (by replacing discrete components with arrays) results in an increase in throughput of approximately 9%. A reduction of 40 placements increases throughput by 18%.

For high volume users of cap arrays using the very latest placement equipment capable of placing 10 components per second, the increase in throughput can be very significant and can have the overall effect of reducing the number of placement machines required to mount components. If 120 million 2-element arrays or 40 million 4-element arrays were placed in a year, the requirement for placement equipment would be reduced by one machine.

For examples, during a 20 hour operational day a machine places 720,000 components. Over a working year of 167 days the machine can place approximately 120 million. If 2-element arrays are mounted instead of discrete components, then the number of placements is reduced by a factor of two and in the scenario where 120 million 2-element arrays are placed there is a saving of one pick and place machine. Smaller volume users can also benefit from replacing discrete components with arrays. The total number of placements is reduced thus creating spare capacity on placement machines. This in turn generates the opportunity to increase overall production output without further investment in new equipment.

## Reduced Costs

In terms of cost savings, it is very important that the difference between the price of a component and its cost when placed and soldered onto a PCB is recognized. Also, inventory levels are lowered and further savings can be made on solder materials, etc. Because ceramic capacitors are already very low in price, the potential for achieving savings by means of price reduction are extremely limited. However, the conversion cost cc (cc = cost of placement, soldering and inspection) is typically some $0.022, made up of the cost of the pick n' place machine, its downtime, labor and overhead. Therefore, when placing a 4-element array at a cost of $0.022 vs. the $0.088 it would cost to place the 4 discrete capacitors, a saving of some $0.066 is achieved, which is typically more than the price of the 4 separate capacitors! So, logically, even if the customer were to be offered free capacitors by their supplier, these would be too expensive compared to the savings available from changing to arrays.

## High Frequency Filtering Capacitor Array

The NP0 (C0G) capacitor array is an ideal solution for high frequency filtering. For example from the S21 parameter plot in Figure 3 the 4-element 10pF 0405 array is well suited to filtering noise generated at the 1800MHz GSM frequency. Lower capacitance arrays are being introduced for filtering applications at higher frequencies above 1800MHz. These 4-element capacitor arrays are ideal for applications where it is essential to filter problematic electromagnetic interference (EMI) caused by mobile telephone transmissions. In many such applications the capacitor array can provide filtering to multiple data lines providing a solution of reduced board space and cost.

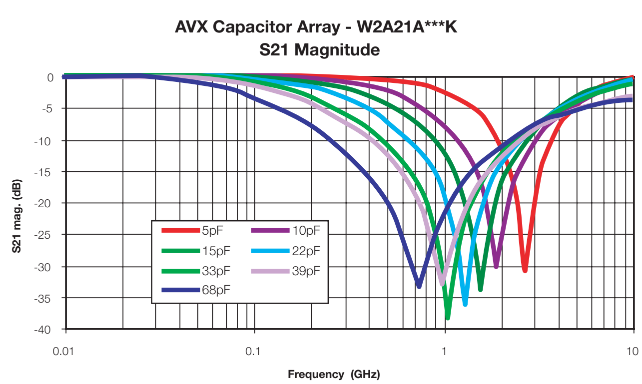



Figure 3. High Frequency S-Parameter Plot for 0508 4% element Capacitor Array

## Multi-Value Capacitor Array

An addition to the array product range is the Multi-Value Capacitor Array. These devices combine two different capacitance values in standard 'Cap Array' packages and are available with a maximum ratio between the two capacitance values of 100:1. The multi-value array is currently available in the 0405 and 0508 2-element styles and also in the 0612 4-element style.

Whereas to date AVX capacitor arrays have been suited to applications where multiple capacitors of the same value are used, the multi-value array introduces a new flexibility to the range. The multi-value array can replace discrete capacitors of different values and can be used for broadband decoupling applications. The 0508 x 2 element multi-value array would be particularly recommended in this application.

## Multi-Value Capacitor Array - Enhanced Performance Due to Reduced Parasitic Inductance

When connected in parallel, not only do discrete capacitors of different values give the desired self-resonance, but an additional unwanted parallel resonance also results. This parallel resonance is induced between each capacitor's self-resonant frequencies and produces a peak in impedance response. For decoupling and bypassing applications this peak will result in a frequency band of reduced decoupling and in filtering applications reduced attenuation. The multi-value capacitor array, combining capacitors in one unit, virtually eliminates the problematic parallel resonance, by minimizing parasitic inductance between the capacitors, thus enhancing the broadband decoupling/filtering performance of the part.

Figure 4 illustrates the impedance performance for a 10nF and 100nF discrete component connected in parallel compared to a Multi-Value Capacitor Array of the same value. The parallel resonance induced by the discrete components is virtually eliminated when the Multi-Value Capacitor Array is used.

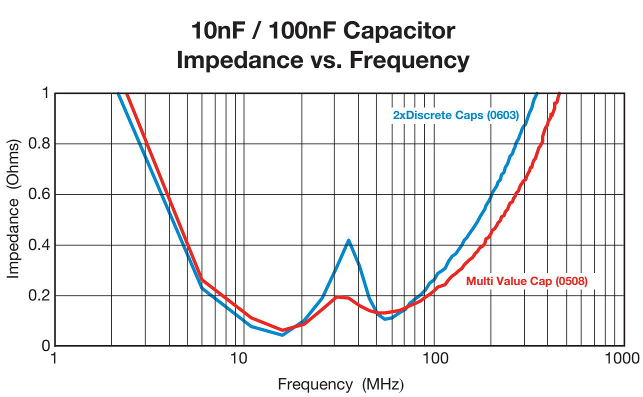



Figure 4. The Multi-Value Capacitor Array Increasing the Effective Decoupling Range

## Automotive Qualified Capacitor Array

AVX has a long-term commitment to automotive with more than 10 years history producing both discrete and capacitor array products for the industry. All automotive products offered by AVX are AEC-Q200 qualified; AVX in fact was the first MLCC manufacturer to achieve AEC qualification.

The Automotive Electronics Council (AEC) was originally established by Chrysler, Ford, and GM in 1993. They are essentially a standardization body for establishing standards for automotive electronic components. Components meeting these specifications are seen to be suitable for use in the harsh automotive environment without additional component-level qualification testing. This means when AVX supplies a customer with an AEC-Q200 qualification package they do not require their own lengthy testing program.

## The Capacitor Arrays Resistance to Mechanical Board Flex Damage

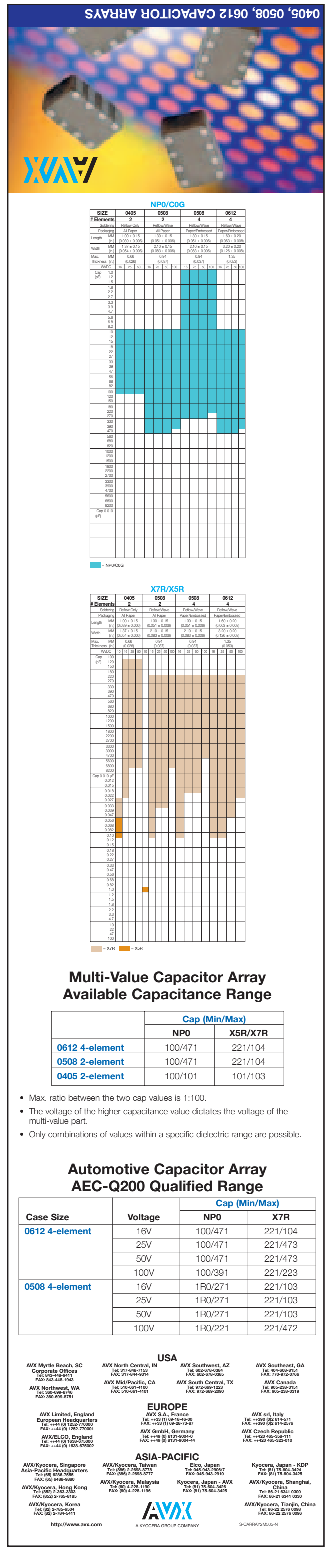
The vast majority of failures caused in discrete MLCC components are mechanical in nature, generally due to placement or handling issues caused during component population and handling of the PCB. To improve the cap arrays mechanical resistance to damage AVX has added a flexible termination to the automotive grade X7R cap arrays. This, along with the longer side connection to the PCB board, means that mechanical failures in capacitor arrays are drastically reduced compared to discrete components. In fact, in a standard automotive bend board test, automotive X7R cap arrays can survive a 5mm bending test, this is more than twice the automotive specification requirement of 2mm.

## Future Developments

The new X8R range of discrete ceramic capacitors are currently being released for 150°C applications, such as under the hood, these are specifically aimed for hybrid circuits where a ceramic is used for the circuit substrate. These developments will be transferred to the capacitor array range and in time will be realized for the automotive and other markets that require components to operate in high temperature conditions.

# Latest Capacitor Array Flyer

An updated capacitor array flyer was published in May 2005 and available now from your local AVX representative. This provides the latest capacitance range matrix for the NP0, X5R and X7R components. How to order information, pad layout and component dimensions are all provided in this simple to use reference flyer.



0405, 0508, 0612 CAPACITOR ARRAYS

NP0/C0G

X7R/X5R

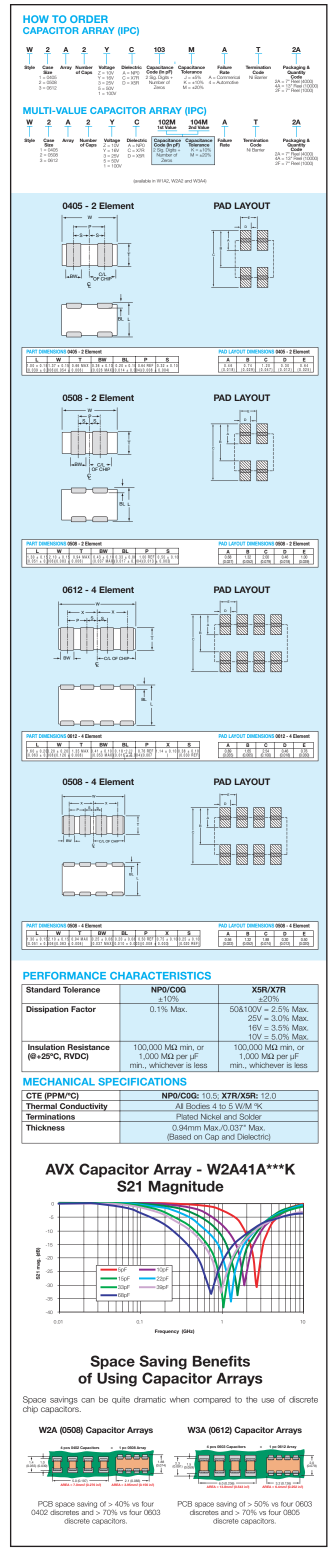
## Multi-Value Capacitor Array Available Capacitance Range

| | Cap (Min/Max) | |
|---|---|---|
| | NP0 | X5R/X7R |
| 0612 4-element | 100/471 | 221/104 |
| 0508 2-element | 100/471 | 221/104 |
| 0405 2-element | 100/101 | 101/103 |

- Max. ratio between the two cap values is 1:100.
- The voltage of the higher capacitance value dictates the voltage of the multi-value part.
- Only combinations of values within a specific dielectric range are possible.

## Automotive Capacitor Array AEC-Q200 Qualified Range

| Case Size | Voltage | Cap (Min/Max) NP0 | Cap (Min/Max) X7R |
|---|---|---|---|
| 0612 4-element | 16V | 100/471 | 221/104 |
| | 25V | 100/471 | 221/473 |
| | 50V | 100/471 | 221/473 |
| | 100V | 100/391 | 221/223 |
| 0508 4-element | 16V | 1R0/271 | 221/103 |
| | 25V | 1R0/271 | 221/103 |
| | 50V | 1R0/271 | 221/103 |
| | 100V | 1R0/221 | 221/472 |



HOW TO ORDER CAPACITOR ARRAY (IPC)

MULTI-VALUE CAPACITOR ARRAY (IPC)

0405 - 2 Element — PAD LAYOUT

0508 - 2 Element — PAD LAYOUT

0612 - 4 Element — PAD LAYOUT

0508 - 4 Element — PAD LAYOUT

### PERFORMANCE CHARACTERISTICS

| Standard Tolerance | NP0/C0G ±10% | X5R/X7R ±20% |
|---|---|---|
| Dissipation Factor | 0.1% Max. | 50&100V = 2.5% Max.<br>25V = 3.0% Max.<br>16V = 3.5% Max.<br>10V = 5.0% Max. |
| Insulation Resistance (@+25ºC, RVDC) | 100,000 MΩ min, or 1,000 MΩ per μF min., whichever is less | 100,000 MΩ min, or 1,000 MΩ per μF min., whichever is less |

### MECHANICAL SPECIFICATIONS

| | |
|---|---|
| CTE (PPM/ºC) | NP0/C0G: 10.5; X7R/X5R: 12.0 |
| Thermal Conductivity | All Bodies 4 to 5 W/M ºK |
| Terminations | Plated Nickel and Solder |
| Thickness | 0.94mm Max./0.037" Max. (Based on Cap and Dielectric) |

AVX Capacitor Array - W2A41A***K S21 Magnitude

Space Saving Benefits of Using Capacitor Arrays

Space savings can be quite dramatic when compared to the use of discrete chip capacitors.

W2A (0508) Capacitor Arrays — PCB space saving of > 40% vs four 0402 discretes and > 70% vs four 0603 discrete capacitors.

W3A (0612) Capacitor Arrays — PCB space saving of > 50% vs four 0603 discretes and > 70% vs four 0805 discrete capacitors.

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