Ansys

0201 AND 01005 ADOPTION IN INDUSTRY

First introduced in the year 2000, the 0201 package was sold in significant numbers in the electronics industry by 2003. According to some estimates, it currently accounts for approximately 20% of surface-mounted component (SMC) demand worldwide[1]. This puts consumption between 100-200 billion units per year. Despite these impressive numbers, the 0201 package and its smaller cousin, the 01005 package, have not yet achieved anything resembling widespread adoption in the overall electronics industry.

/ 1. INTRODUCTION

Pioneered for applications where volumetric efficiency is paramount, 0201 and 01005 components have been adopted in many mobile applications and, in limited form, specific defense applications. Issues related to the extremely small package size have limited wide-scale adoption.

The 0201 package measures 0.024" by 0.012" (0.6 mm by 0.3 mm) and is equivalent to the metric 0603 package. The 01005 package measures 0.016" by 0.008" (0.4 mm by 0.2 mm) and is equivalent to the metric 0402 package (see Figure 1). By comparison, a human hair is approximately 0.1 mm wide. This miniscule size leads to myriad issues involving manufacturability.

Many companies report difficulty in finding assemblers capable of reliably placing 0201 and 01005 components. Problems with misplacement appear to be somewhat common. Another issue is the difficulty of visually inspecting these components since inspection requires use of sophisticated optical or X-ray microscopy.

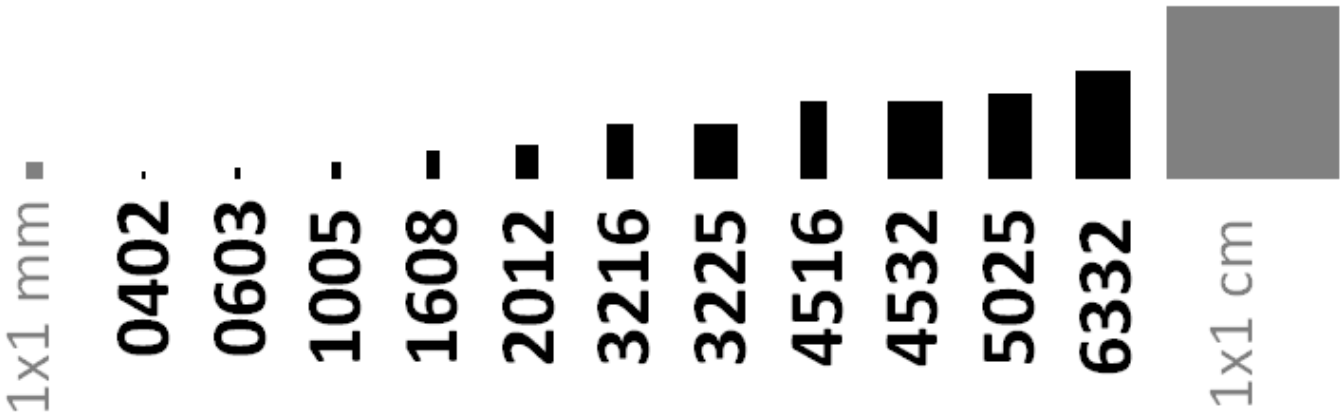


Figure 1: size comparison chart. U.S. 0201 and 01005 correspond to metric 0603 and 0402.

Ansys, in collaboration with Paumanok Group, performed a literature search, market research, and a survey of more than 100 people across the electronics industry in order to understand the adoption, use, understanding, and reliability of 0201 and 01005 components.

/ 2. MARKET RESEARCH AND LITERATURE ASSESSMENT

A thorough assessment was made of the current state of the market for 0201 multilayer chip capacitors (MLCCs) through publicly available information and literature.

Market Consumption
0201 and 01005 MLCCs are primarily consumed in modules for space-constrained end products. In 2010, the largest markets for these components were power amplifier and radio frequency modules for wireless handsets, followed by the defense circuit sector. 0201 and 01005 MLCCs were also used to a much lesser degree in hearing aids. A breakdown of global consumption of 0201 MLCCs in 2010 is below in Figure 2. FR4 modules are comprised of power amplifier and radiofrequency (RF) modules for handsets; while low-temperature co-fired ceramic (LTCC) modules are comprised of RF antenna and defense circuitry.

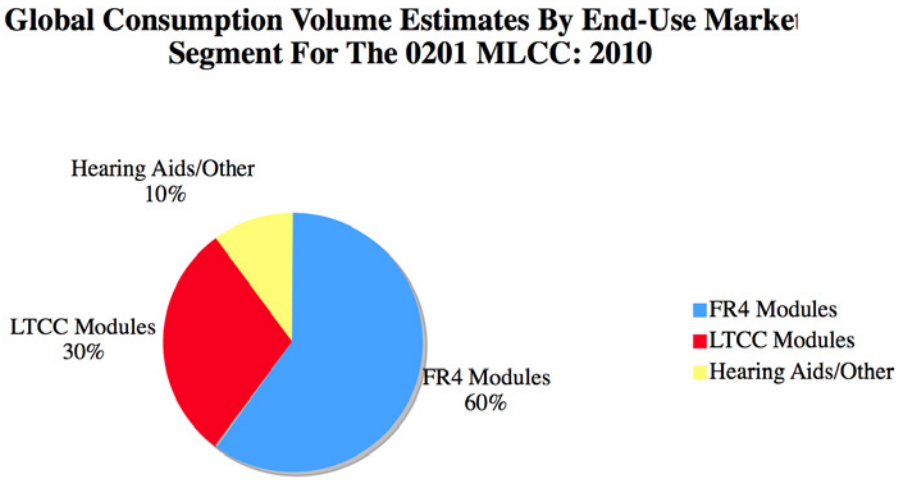


Figure 2. Global consumption of 0201 MLCCs in 2010

Market Volume
According to several estimates from major capacitor manufacturers, market volume for 0201 MLCCs is projected to be between 100-200 billion units in 2010. When actual manufacturing volumes are investigated from the major 0201 MLCC manufacturers, this can be further refined to 105-205 billion units. The most likely number is approximately 178 billion units, or 15-20% of the global MLCC market. At an estimated price of US$0.0085 per unit (though some units are sold for as much as US$0.025), this puts the size of the 0201 MLCC market at US$1.51 billion.

Performance
0201 MLCCs were sold in NP0, X7R, X5R, Y5V, and X6S performance types in 2010. Estimates for the volumes of each type are shown below in Figure 3.

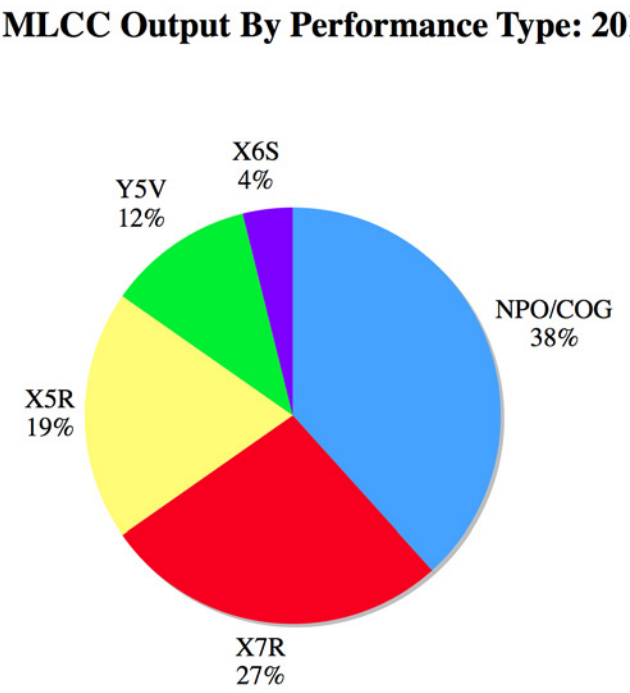


Figure 3. Worldwide 0201 output at different performance levels

Reliability
The large volume of the 0201 market and the development of the 01005 market appear to attest to a certain basic reliability in 0201 components. One vendor has claimed that 0201 components are actually more reliable than larger MLCCs using thousands of layers in high capacitance applications.

/ 3.SURVEY

A survey was sent to a cross-section of potential users across the electronics industry. It asked a wide range of questions about adoption of 0201 and 01005 components, validation and usage, and attitudes about reliability. The survey flow is outlined in Appendix A, and the actual questions are in Appendix B. One hundred and two responses were received from 14 major industry sectors including, automotive, military, aerospace, mobile communications, and utilities.

Selected Survey Results (% of Total Respondents)
Figures 4-8 show a selection of responses to five of the more demonstrative questions asked in the survey. Some of the comments sent by respondents are also discussed in Section 4 below.

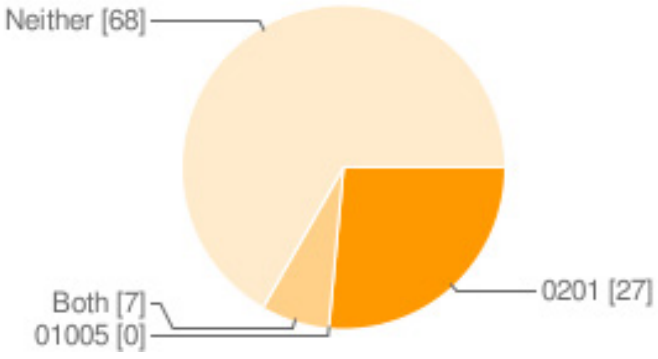


Figure 4. "Do you use 0201 or 01005 components in your product line?" (%)

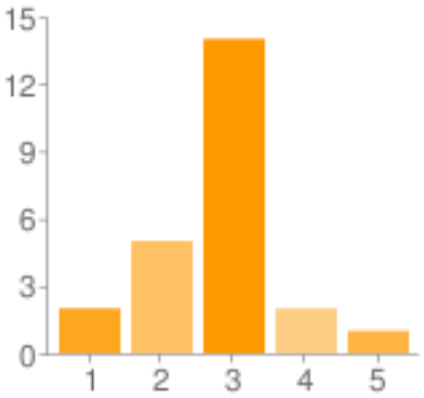


Figure 5. "Do you believe that 0201 resistors are more or less reliable than 0402 resistors?" 1 is less reliable, 3 is as reliable, and 5 is more reliable. Only people who said they use 0201 resistors were asked this.

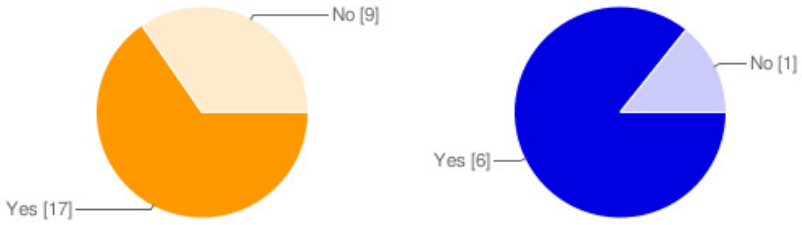


Figure 6. "Do you plan on increasing the number of 0201 or 01005 components in the next generation of your product line?" Only people who said they use 0201 or 01005 components were asked this. 0201 components are on the left, 01005 components on the right.

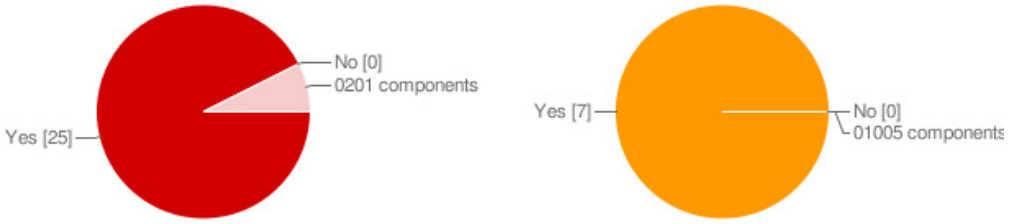


Figure 7. "If such small components were not necessary to your application, would you use larger components instead?" Only people who said they use 0201 or 01005 components were asked this. They were given the options"yes," "no," and "such small components are not necessary to my application." 0201 components are on the left, 01005 on the right.

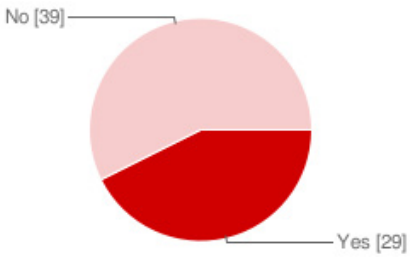


Figure 8. "Do you plan to use 0201 components in your product line within the next three years?" Only people who said they do not use 0201 or 01005 components were asked this.

/ 4. DISCUSSION

The survey and research performed allowed a certain amount of insight into 0201 and 01005 components and how they are currently used in the electronics industry.

Despite the fact that 0201 components are used in significant volumes, the high usage applications are concentrated in ultra-small modules and in high-frequency and microwave applications. As noted above, the single largest market for 0201 components is in modules for wireless handsets. So, despite the high volume of 0201 components produced in 2010, the components are actually used by a small percentage of companies in very high volume niches.

It is not surprising that the majority of respondents indicated they are not yet using 0201 or 01005 components. As a whole, the survey population is more conservative in adopting new technologies, preferring to let other sectors resolve reliability issues in "next-generation" technologies. However, the actual factors limiting more widespread adoption of 0201 and 01005s were overwhelmingly reported as design, manufacturability, and quality rather than reliability.

One third of survey respondents indicated usage of 0201 components. Approximately 7% of these respondents indicated that they also use 01005 components. Considering the limited market penetration of 0201 and 01005 components and the high reliability needs of the respondents, this is a significant percentage.

Most respondents felt that the reliability was as good or better than parts currently in use. So, reliability concern is not a primary limiting factor. However, some respondents were still concerned about the relative lack of reliability data on these components. Thirty percent of the survey takers do expect to be using 0201s within three years as design drives the need for these small components. These users are highly concerned about the ability to successfully place and inspect these small components. The survey response comments indicated some universal concerns and some very specific industry and design specific (see Table 1).

Table 1: Concerns over adopting usage of 0201 and 01005 components

Common Concerns	Unique Concerns
Lack of contract manufacturer (CM) capability	Capacitors in this form factor do not provide the necessary voltage ratings required by system design margins.
Too hard to test and debug products using this technology	Safety applications require spacings that prevent use of these parts in sections of the circuit. Line spacings and traces using these violate minimum guidelines for long-field-life designs.
General manufacturability issues — placement, repair, inspection, equipment upgrades, feeders, cost	Specific concerns about leakage resistance and contaminations issues due to small distance between pads
Solder paste print and deposit issues due to varying part sizes; how to combine with other components that will require more solder for reliable solder joints.	Usage limited for automotive because of very limited thermal derating and creepage/ clearance rules.
General Reliability concerns, lack of reliability data.	

Survey respondents also mentioned the key limiting and driving technical factors in adoption of 0201 and 01005 components (Table 2). Driving factors were primarily related to the benefits of compactness in certain applications, with some respondents also noting the reduced parasitism in small components.

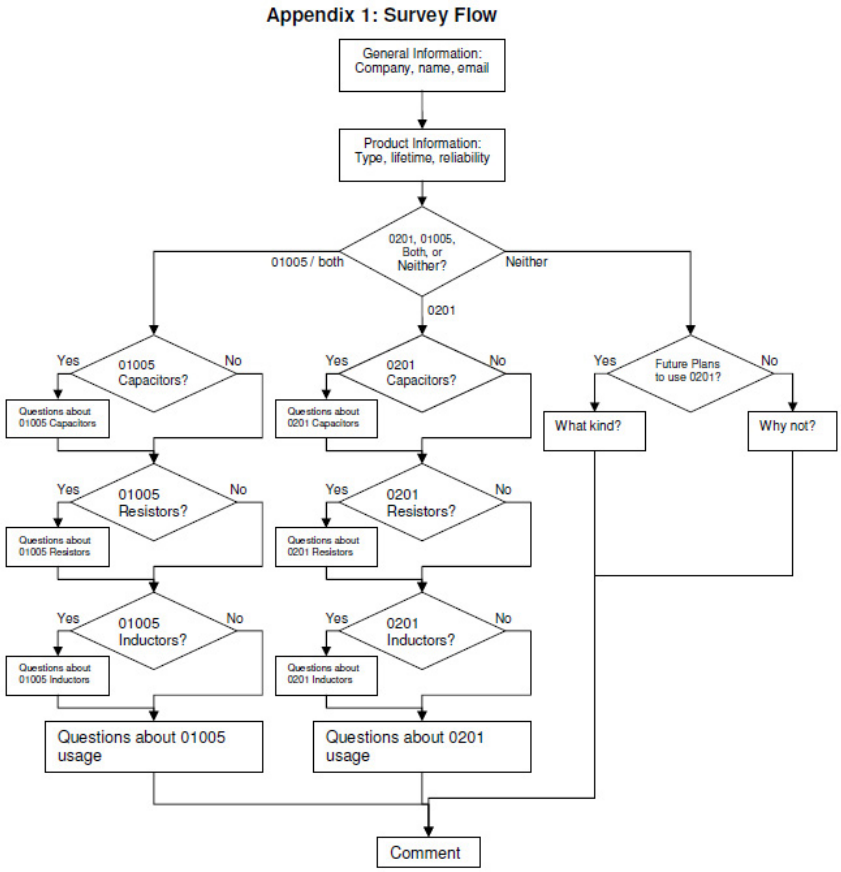
Limiting technical factors centered around the limits and difficulties faced by the small sizes, the increased cost of buying and using these components, and the relative scarcity of reliability data.

Table 2: The most commonly noted driving and limiting technical factors in the adoption of 0201 and 01005 components, in descending order of occurrence

Driving Technical Factors	Limiting Technical Factors
Large, fine-pitch BGAs are driving use of 0201s; otherwise using 0402s would be preferred.	The product line does not require components that small.
Need for space: reduced end product size, high-density needs (mobile devices, hearing aids)	201 and 01005 components do not have the reliability data the product line requires.
Very high speed applications — driven by reduced parasitics in these small components.	Increased cost
	CM does not support them.
	0402s are a good size because microvias fit in the pads.

/ 5. CONCLUSIONS

0201 and 01005 components have grown to represent a large portion of the modern component market and will continue to increase as time goes on. Currently, issues with manufacturability, cost of use, and inspection limit wider adoption of these components. The trend for smaller products in certain industries will drive an increase in adoption that will necessarily result in improved practices in manufacturing. As the market matures and more reliability data becomes available, even the applications where reliability is paramount will begin to see adoption of these small parts. Indeed, the majority of respondents to Ansys' survey expect to be using 0201 components within the next three years.



Appendix 2: Survey Questions

Adoption of 0201 and 01005 Components in Industry

Thank you for filling out our survey on the adoption of 0201 and 01005 components in industry. All participants will get a copy of the survey results when it is complete.

Participant Information — Tell us about yourself or your company.

What is your email address? * — This information will not be shared.

What is your name? — This information is optional, and will not be shared.

What is the name of your company? — This information is optional, and will not be shared.

Product Line Information — Please tell us a little about one of your company's product lines. Please focus on one specific product line. We encourage you to fill out this survey multiple times for different product lines.

What type of product line is this? — Please choose the option that best fits your product line. Please choose only one of your company's product lines for this survey.

Appliances
Automotive – Safety
Automotive – Under-Hood
Automotive – Other
Avionics – Commercial/Military
Computer – Business
Computer – Consumer
Computer – Server
Computer – Storage
Computer – Other
Consumer Electronics
HVAC
Industrial Control
Lighting
Military – Missiles
Military – Other
Mobile – Consumer
Mobile – Industrial
Networking
Power – Distribution
Power – Monitoring/Metering
Power – Solar
Rail Transportation
Space Systems
Test Equipment
Utilities – Distribution
Utilities – Monitoring/Metering
Utilities – Other
Other

Product Lifetime Information
What is the desired lifetime of your product line?
Enter the desired lifetime in years.
What is the desired end-of-life reliability for your product?
Enter the desired EOL reliability in %.

0201/01005 Component Usage
*Does this product line have 0201 or 01005 components? **
0201
01005
Both
Neither

0201 Capacitor Usage
*Do you use 0201 capacitors? **
Yes
No

0201 Capacitor Reliability
Did you perform any additional qualification activities before accepting 0201 capacitors into your design?

Please select all relevant activities

No additional activities

Aging Studies (i.e., drift)

HTOL (not to failure)

HTOL (to failure)

Manufacturing Process Qualification

Ongoing Screening Auditing

Parametric Measurements (capacitance, resistance, inductance, etc.)

Supplier Quality Audit

Supplier Technical Audit

Temperature/Humidity/Bias (not to failure)

Temperature/Humidity/Bias (to failure)

Other:

Do you believe that 0201 capacitors are more or less reliable than 0402 capacitors?

	1	2	3	4	5	
Less Reliable						More Reliable

0201 Resistor Usage
*Do you use 0201 resistors? **
Yes
No

0201 Resistor Reliability

Did you perform any additional qualification activities before accepting 0201 resistors into your design?

Please select all relevant activities.

No additional activities

Aging Studies (i.e., drift)

HTOL (not to failure)

HTOL (to failure)

Manufacturing Process Qualification

Ongoing Screening Auditing

Parametric Measurements (capacitance, resistance, inductance, etc.)

Supplier Quality Audit

Supplier Technical Audit

Temperature/Humidity/Bias (not to failure)

Temperature/Humidity/Bias (to failure)

Other:

Do you believe that 0201 resistors are more or less reliable than 0402 resistors?

	1	2	3	4	5	
Less Reliable						More Reliable

0201 Inductor Usage

*Do you use 0201 inductors? **

Yes

No

0201 Inductor Reliability

Did you perform any additional qualification activities before accepting 0201 inductors into your design?

Please select all relevant activities.

No additional activities.

Aging Studies (i.e. drift)

HTOL (not to failure)

HTOL (to failure)

Manufacturing Process Qualification

Ongoing Screening Auditing

Parametric Measurements (capacitance, resistance, inductance, etc.)

Supplier Quality Audit

Supplier Technical Audit

Temperature/Humidity/Bias (not to failure)

Temperature/Humidity/Bias (to failure)

Other:

Do you believe that 0201 inductors are more or less reliable than 0402 resistors?

	1	2	3	4	5	
Less Reliable						More Reliable

Planned 01005 Component Usage
*Do plan to use 01005 components in your product line within the next three years? **
Yes
No

What 01005 components do you plan to use in this product line?
Please check all that apply.
Capacitors
Resistors
Inductors

0201 Usage
Do you plan on increasing the number of 0201 components in the next generation of your product line?
Yes
No

If 0201 components were not necessary to your application, would you use 0402 components instead? *
Yes
No
0201 components are not necessary to my application.

01005 Capacitor Usage
*Do you use 01005 capacitors? **
Yes
No

01005 Capacitor Reliability
Did you perform any additional qualification activities before accepting 01005 capacitors into your design?
Please select all relevant activities.
No additional activities
Aging Studies (i.e., drift)
HTOL (not to failure)
HTOL (to failure)
Manufacturing Process Qualification
Ongoing Screening Auditing
Parametric Measurements (capacitance, resistance, inductance, etc.)
Supplier Quality Audit
Supplier Technical Audit
Temperature/Humidity/Bias (not to failure)
Temperature/Humidity/Bias (to failure)
Other:

Do you believe that 01005 capacitors are more or less reliable than 0201 capacitors?

	1	2	3	4	5	
Less Reliable						More Reliable

01005 Resistor Usage
*Do you use 01005 resistors? **
Yes
No

01005 Resistor Reliability
Did you perform any additional qualification activities before accepting 01005 resistors into your design?

Please select all relevant activities.

No additional activities

Aging Studies (i.e. drift)

HTOL (not to failure)

HTOL (to failure)

Manufacturing Process Qualification

Ongoing Screening / Auditing

Parametric Measurements (capacitance, resistance, inductance, etc.)

Supplier Quality Audit

Supplier Technical Audit

Temperature/Humidity/Bias (not to failure)

Temperature/Humidity/Bias (to failure)

Other:

Do you believe that 01005 resistors are more or less reliable than 0201 resistors?

	1	2	3	4	5	
Less Reliable						More Reliable

01005 Inductor Usage
Do you use 01005 inductors? *
Yes
No

01005 Inductor Reliability
Did you perform any additional qualification activities before accepting 01005 inductors into your design?

Please select all relevant activities.

No additional activities.

Aging Studies (i.e. drift).

HTOL (not to failure)

HTOL (to failure)

Manufacturing Process Qualification

Ongoing Screening / Auditing

Parametric Measurements (capacitance, resistance, inductance, etc.)

Supplier Quality Audit

Supplier Technical Audit

Temperature/Humidity/Bias (not to failure)

Temperature/Humidity/Bias (to failure)

Other:

Do you believe that 01005 inductors are more or less reliable than 0201 inductors?

	1	2	3	4	5	
Less Reliable						More Reliable

01005 Usage

Do you plan on increasing the number of 01005 components in the next generation of your product line?
Yes
No

*If 01005 components were not necessary to your application, would you use 0201 components instead? **
Yes
No
01005 components are not necessary to my product line.

No 01005 Components

Why do you not use 01005 components in your product line? Choose all that apply.

The product line does not require components that small.

01005 components are too expensive.

01005 components do not have the reliability my product line requires.

*Do you have any comments on the subject of 0201 or 01005 components that you would like to share? **
Yes
No

Planned 0201 Component Usage

*Do plan to use 0201 components in your product line within the next three years? **
Yes
No

What type of 0201 components do you plan to use in your product line? Please check all that apply.

Capacitors

Resistors

Inductors

*Do you have any comments on the subject of 0201 or 01005 components that you would like to share? **
Yes
No

No 0201 or 01005 Components

Why do you not use 0201 or 01005 components in your product line?

Choose all that apply.

The product line does not require components that small.

0201 and 01005 components are too expensive.

0201 and 01005 components do not have the reliability my product line requires.

Comments
Do you have any comments on the subject of 0201 or 01005 components that you would like to share?

For more information and to request a quote from our Ansys Reliability Engineering Services Team, visit: https://upl.inc/a5b0679

/ REFERENCES:

1. *Assessing The World Market For The 0201 MLCC*, Paumanok Publications, 2010.

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