Yageo Chip-Resistor Introduction

R-Chip PM Team

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Introduction

Purpose
• To familiarize the customer with Yageo’s chip resistors and their manufacturing process

Objectives
• Provide basic explanation of how the chip resistors are made
• Introduction to their Thin and Thick Film product offering
• Provide an overview of their resistor networks and low ohm current sense resistors
• Explore Yageo’s part number breakdowns and RoHS labeling

Content
• 32 pages

Leaning Time
• 15 minutes
Introduction to Chip-Resistor

SMT: Surface Mounted Technology

SMD: Surface Mounted Device
Chip Resistor Fabrication Process

C2 Back Conductor Print  →  C1 Front Conductor Print  →  Conductor Firing  →  Resistor Print

In Process QC  →  Laser Trim  →  Glass Firing  →  1st Glass Print  →  Resistor Firing

2nd Epoxy Print  →  Epoxy Curing  →  Marking  →  In process QC
Chip Resistor Fabrication Process
Resistance Trimming Process
Yageo Chip Resistor Overview - Thick Film

**Discrete**
- **RC Series**
  - 01005 to 2512
- **RE Series**
  - 0201 to 1206
- **AC Series**
  - 0402 to 2512
- **AF Series**
  - 0402 to 1206

**Specific Application**
- **AR** (Gold Termination)
- **RV** (High Voltage)
- **TR** (Trimmable)
- **SR** (Surge)
- **ATV** (Attenuator)

**Arrays/Network**
- **YC (convex) / TC (concave) Series**
  - YC102/104
  - YC122 TC122
  - YC124 TC124
  - YC162 TC164
  - YC164
  - YC248
  - YC324

**Network**
- **YC 158 Series**
- **YC 358 Series**

[Diagram showing RC, RE, AC, AF series, specific applications, arrays/network, and network variants with YC and TC series numbers.]
Yageo Chip Resistor Overview – Thin Film

Thin Film

Discrete

RT Series
Tol: ±0.05 ~ 1%,
TC: 0±10 ~ 50ppm/K

• RT0402
• RT0603
• RT0805
• RT1206
• RT1210
• RT2010
• RT2512

Arrays/Network

TA Series
• TA122
• TA124
• TA162
• TA164

On request

TD Series
(multi-value)
• TD164
On request
Yageo Chip Resistor Overview – Low Ohmic

Low ohmic – Current sensing

Thick Film

- **RL Series**
  - Standard TCR
  - RL0402
  - RL0603
  - RL0805
  - RL1206
  - RL1210
  - RL1218
  - RL2010
  - RL2512
  - RL0805 double power
  - RL1206 double power

- **PT Series**
  - Low TCR
  - PT0201* 200
  - PT0402* 200
  - PT0603 200
  - PT0805 200
  - PT1206 75
  - PT2010 75
  - PT2512 75
  - PT0815 100

  PT is double power
  * Triple power available

Metal Foil

- **PF/PE Series**
  - 0603 2512
  - 0805 4520
  - 1206 4527
  - 2010

- **PH Series**
  - 0603 1206

  PF Series
  - Wide terminal
  - 0508 0612 0815
  - 0830 1225

Metal Strip

- **PR Series**
  - PR1206
  - PR2010
  - PR2512

- **PS Series**
  - 4 - Terminal
  - 0612 1225
Thick Film Resistor – General Purpose


- Package / Case: 01005 – 2512
- Resistance Range: 1Ω to 22MΩ, Jumper
- Tolerance: 0.5%, 1%, 5%
- Temperature coefficient: ± 200 ppm/°C, ± 100 ppm/°C
Automotive Grade Thick Film Resistors

Series: AC0402, AC0603, AC0805, AC1206, AC1218, AC2010, AC2512
• Package/Case: 0402~2512
• Resistance Range: 1 Ω~10MΩ
• Tolerance: 1%, 5%
• Temperature coefficient: ±100 ppm/°C, ±200 ppm/°C
• AEC-Q200 compliant
• 8,000 hours operational life test
• 100% AOI prior to taping
• Stable process control including narrow specification and Cpk monitor

Applications:
• Infotainment– dashboard, ETC, navigation, audio/video
• Comfort/Security- HVAC system, power window, keyless entry system, indoor lighting, central door locking, and wiper modules
• Power management - BMS (Battery Management System), Battery Charger DC/DC Converter, PLC (Power Line communications)
Anti-Sulfurated Chip Resistors

Series: AF0402, AF0603, AF0805, AF1206
- Package/Case: 0402~1206
- Resistance Range: 1 Ω~22MΩ
- Tolerance: 1%, 5%
- Temperature coefficient: ±100 ppm/°C, ±200 ppm/°C
- Superior resistance against sulfur containing atmosphere

Applications:
- All general purpose applications
- Car electronics
- Industrial and communication applications
High Voltage Chip Resistor – for High Voltage Circuit

Series: RV series

- **SMD Type**: 0805 / 1206 / 2512
- **Power Dissipation**: 0.125W to 1W
- **Resistance Range**: 100KΩ to 27MΩ
- **Tolerances**: ± 1%, ± 5%
- **Max. working voltage**: 400V / 500V
- **Max. overload voltage**: 800V / 1kV

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RESISTANCE RANGE</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rated Power</td>
</tr>
<tr>
<td>RV0805</td>
<td>5% (E-24) 100KΩ to 10MΩ</td>
<td>1/8 W</td>
</tr>
<tr>
<td>RV1206</td>
<td>5% (E-24) 100KΩ to 27MΩ</td>
<td>1/4 W</td>
</tr>
<tr>
<td>RV2512</td>
<td>5% (E-24) 4.7MΩ to 16MΩ</td>
<td>1 W</td>
</tr>
</tbody>
</table>
Surge Chip Resistor – For Snubber Circuit

Series : SR series

- SMD Type : 0805 / 1206 / 1218 / 2010 / 2512
- Power Dissipation : 0.125W to 1W
- Resistance Range : 1Ω to 100KΩ; E24 series
- Tolerances : ± 5%, ± 10%, ± 20%
- TCR : ± 200ppm/°C

(A) Single Pulse Function
Resistor Arrays
8P4R (0402 x 4) – Convex Termination

Series : YC124

- Package / Case : 0402 x 4 Convex
- Resistance Range : 10Ω to 1MΩ, Jumper
- Tolerance : 1%, 5%
- Power dissipation (70° C) : 1/16 W
- Temperature coefficient : ± 200 ppm/°C
Resistor Arrays
4P2R (0402 x 2) – Convex Termination

Series: YC122

- Package/Case: 0402 x 2 Convex
- Resistance Range: 10 Ω to 1M Ω, Jumper
- Tolerance: 1%, 5%
- Power dissipation (70°C): 1/16 W
- Temperature coefficient: ± 200 ppm/°C
Resistor Arrays
8P4R (0603 x 4) – Convex/Concave Termination

Series: YC164, TC164

- Package / Case: 0603 x 4 Convex / Concave
- Resistance Range: 10 \( \Omega \) to 1M\( \Omega \), Jumper
- Tolerance: 1\%, 5\%
- Power (70° C): 1/16 W
- Temperature coefficient: \( \pm 200 \) ppm/°C
Resistor Arrays
8P4R (1220~1206 x 4) – Convex Termination

Series: YC324

- Package / Case: 8P4R (1220 ~1206 x 4)
  Convex
- Resistance Range: 10Ω to 1MΩ, Jumper
- Tolerance: 1%, 5%
- Power (70°C): 1/8 W
- Temperature coefficient: ± 200 ppm/°C
Resistor Arrays
16P8R (0616) – Convex Termination

Series: YC248

- Package / Case: 16P8R (0616 ~ 0602 x 8) Convex
- Resistance Range: 1Ω to 100KΩ
- Tolerances: ± 1 and ± 5%
- Power (70°C): 1/16 W
- TCR: ±200ppm/°C
10P8R Resistor Network

Series: YC358

- **Package / Case**: 10P8R (0612 / 1225)
- **Resistance range**: 10 Ω to 330K Ω
- **Tolerances**: ± 1 and ± 5%
- **Power dissipation (70°C)**: 1/32 W, 1/16W
- **Temperature coefficient**: ±200 ppm/°C
Low Ohmic Resistors -- RL / PT / PF / PR Series

- Application Fields
  - <10mR for high current sensing
    - Server main board (high end MB), NB, Networking, high current battery pack (100A)
  - 10mR ~ 50mR for DC/DC Converter circuit or battery current sensing
    - NB, Battery of NB, Networking, PC power peripheral
  - 50mR~270mR for estimating the rotation speed of a motor
    - HDD, Micro-Motor, stepper motor
  - >270mR, general power management
    - Mobile, Power supply, Projector, LED lighting driver

- Why users looking for Low ohmic - Low TCR
  - Current sensing with low power dissipation = low ohmic value!
  - low TCR to get low temperature depending sensor
  - excellent stability with high current consumption
Yageo Low Ohmic Series – RL, PT

Thick Film Technology

- **RL** Price Competitive
- **PT** TCR enhanced

**Application**: middle/low voltage power supply (<700W)

**Runner Item**: 0805~2512, 0R1~0R91, x1~3
Yageo Low Ohmic Series – PR, PF

Metal Technologies

- ✓ Metal Strip
- ✓ Metal Foil
  - PR Low TCR
  - PF Low TCR

Application: middle/high voltage power supply (>700W)
Runner Item: 1206~2512, 0R001~0R1, x1~3
**PE Series**  Current Sensing, Low Ohmic, Low Thermo EMF

- **Case Size:**
  - 0603, 0805, 1206, 2010, 2512

- **Features:**
  - **Low thermo-EMF** < 0.03μV/°C, Mn-Cu Alloy
  - **Range**
    - 0603: 10 mΩ ~ 100 mΩ, 0805: 2 mΩ ~ 100 mΩ
    - **Low TCR:** ±50 ~ ±100 ppm/°C
  - **Power enhancement**
    - 0603: 0.5 W
    - 0805: 0.125, 0.25, 0.33, 0.5, 0.7 W
    - 2010: 2W
  - **Part number:** PEXXXXXXFXXXXXZ

<table>
<thead>
<tr>
<th>PE</th>
<th>1206</th>
<th>1/2W</th>
<th>(P×R)^(1/2)</th>
<th>-55°C to 155°C</th>
<th>3mΩ ≤ R ≤ 100mΩ</th>
<th>±1%</th>
<th>±2%</th>
<th>±5%</th>
<th>3mΩ ≤ R ≤ 9mΩ</th>
<th>10mΩ ≤ R ≤ 100mΩ</th>
<th>±100 ppm/°C</th>
<th>±75 ppm/°C</th>
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</thead>
<tbody>
<tr>
<td>PE1206xRx07xxxxxx</td>
<td>1206</td>
<td>1W</td>
<td>(P×R)^1/2</td>
<td>-55°C to 155°C</td>
<td>3mΩ ≤ R ≤ 100mΩ</td>
<td>±1%</td>
<td>±2%</td>
<td>±5%</td>
<td>3mΩ ≤ R ≤ 9mΩ</td>
<td>10mΩ ≤ R ≤ 100mΩ</td>
<td>±100 ppm/°C</td>
<td>±75 ppm/°C</td>
</tr>
<tr>
<td>PE1206xRx7Wxxxxxx</td>
<td>2512</td>
<td>1W</td>
<td>(P×R)^1/2</td>
<td>-55°C to 155°C</td>
<td>1mΩ ≤ R ≤ 100mΩ</td>
<td>±1%</td>
<td>±2%</td>
<td>±5%</td>
<td>1mΩ ≤ R ≤ 9mΩ</td>
<td>10mΩ ≤ R ≤ 100mΩ</td>
<td>±100 ppm/°C</td>
<td>±75 ppm/°C</td>
</tr>
</tbody>
</table>
Thin Film Resistor Introduction

Series: RT/RJ

- Package / Case: 0402 – 2512
- Resistance Range: 1Ω to 1.5MΩ
- Tolerance: ±0.05%, ±0.1%, ±0.25%, ±0.5%, ±1%
- Temperature coefficient: ±10, ±15, ±25, ±50 ppm/°C
Technical Information
Basic Theorems - TCR

Calculate the Temperature Coefficient of Resistance (TCR) as follows:

\[
T.C.R. = \frac{R_2 - R_1}{R_1 (t_2 - t_1)} \times 10^6 \text{ (ppm/°C)}
\]

- \( R_1 \) = resistance at reference temperature in ohms
- \( R_2 \) = resistance at test temperature in ohms
- \( t_1 \) = +25 °C or specified room temperature
- \( t_2 \) = -55 °C or +155 °C test temperature
# Chip Resistor Product Segment Mapping

<table>
<thead>
<tr>
<th>Alternative Energy</th>
<th>Power</th>
<th>Computing</th>
<th>Lighting</th>
<th>Medical</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC Series 0603~2512</td>
<td>RC Series 0402~2512</td>
<td>RC Series 01005~1206</td>
<td>RC Series 0402~1206</td>
<td>RC Series 0402~0805</td>
</tr>
<tr>
<td>PT, RL Series 1206/2010/2512</td>
<td>PF, PR Series 2512</td>
<td>RL, PT, PR, PF, PE Series 0201~0603</td>
<td>RL, PT, PR, PF Series 0805~2512</td>
<td>RL, PF, PT, PR Series Full size</td>
</tr>
<tr>
<td>RT Series 0603~1206</td>
<td>RT Series 0603~1206</td>
<td>RT Series 0603~1206</td>
<td>RT/RE Series 0603~1206</td>
<td>RT/RE Series 0603~1206</td>
</tr>
<tr>
<td>SR/RV Series 0805~2512</td>
<td>SR/RV Series 0805~2512</td>
<td>SR/RV Series 0805~2512</td>
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<td></td>
</tr>
<tr>
<td>AF Series 0402~1206</td>
<td>AF Series 0402~1206</td>
<td>AF Series 0402~1206</td>
<td>YC Series YC102/104 to YC 124</td>
<td>Array YC Series YC124, 164</td>
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<td>Array YC Series YC124, 164</td>
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</table>
## Yageo Part Number Information
### Single Chip Resistor

<table>
<thead>
<tr>
<th>Series Name</th>
<th>Size code</th>
<th>Resistance Tolerance</th>
<th>Packing style</th>
<th>TCR</th>
<th>Reel Type</th>
<th>Resistance</th>
<th>Terminations</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC = Thick film resistor</td>
<td>0201</td>
<td>±0.1%</td>
<td>Paper Tape</td>
<td>C = ±15ppm/°C</td>
<td>07 7 inch</td>
<td>100R</td>
<td>Lead Free</td>
</tr>
<tr>
<td>RT = Thin film high precision – high stability</td>
<td>0402</td>
<td>±0.25%</td>
<td>Embossed Plastic Tape</td>
<td>D = ±25ppm/°C</td>
<td>10K 10 inch</td>
<td>1K</td>
<td></td>
</tr>
<tr>
<td>RJ = Thin film general purpose</td>
<td>0603</td>
<td>±0.5%</td>
<td>B = Bulk Bag</td>
<td>E = ±150ppm/°C</td>
<td>1R 13 inch</td>
<td>100K</td>
<td></td>
</tr>
<tr>
<td>RL = Low ohmic resistor</td>
<td>0805</td>
<td>±1%</td>
<td></td>
<td>M = ±75ppm/°C</td>
<td>10R 13 inch</td>
<td>1M</td>
<td></td>
</tr>
<tr>
<td>PR = current sensor – low</td>
<td>1206</td>
<td>±5%</td>
<td></td>
<td>F = ±100ppm/°C</td>
<td>100R 13 inch</td>
<td>10K</td>
<td></td>
</tr>
<tr>
<td>TCR</td>
<td>1210</td>
<td>±0.02%</td>
<td></td>
<td>G = ±200ppm/°C</td>
<td>100M 13 inch</td>
<td>10M</td>
<td></td>
</tr>
<tr>
<td>TR = Trimmable</td>
<td>1218</td>
<td>±0.05%</td>
<td></td>
<td>I = ±300ppm/°C</td>
<td>100R 13 inch</td>
<td>1K</td>
<td></td>
</tr>
<tr>
<td>SR = Surge</td>
<td>2010</td>
<td></td>
<td></td>
<td>– – Base on Spec.</td>
<td>10R 13 inch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR = Fusible</td>
<td>2512</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part Number Example
- **RC**: Series Code
- **0201**: Size Code
- **J**: Option Code
- **R**: Prefix Code
- **-**: Option Code
- **07**: Reel Code
- **100R**: Resistance
- **L**: Option Code
## Yageo Part Number Information
### Array and Network Resistors

<table>
<thead>
<tr>
<th>YC</th>
<th>15</th>
<th>8</th>
<th>L</th>
<th>J</th>
<th>R</th>
<th>-</th>
<th>07</th>
<th>100R</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
<td>(9)</td>
<td>(10)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series Name</th>
<th>Size code</th>
<th>Number of resistor</th>
<th>Schematic</th>
<th>Tol.</th>
<th>Packing style</th>
<th>TCR</th>
<th>Reel Type</th>
<th>Resistance</th>
<th>Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>YC = convex</td>
<td>12 = 0402x2. x4 15 = 0612 for 10P8R 16 = 0603 x4 24 = 0616 for 16P8R 32 = 1220 for 8P4R 35 = 1225 for 10P8R</td>
<td>2 = 2 resistor 4 = 4 resistor 8 = 8 resistor</td>
<td>L = L-Type T = T-Type J=±5%</td>
<td>F=±1% R = Paper Tape K = Embossed Plastic Tape B = Bulk Bag</td>
<td>– = Base on spec.</td>
<td>07= 7 inch 13=13 inch</td>
<td>Example 1R 100K 10R 1M 100R 10M 1K</td>
<td>L = Lead Free</td>
<td></td>
</tr>
</tbody>
</table>
Yageo Part Number Information
Power Rating Upgrade

Series name (code 1~2)
- RL = Low ohmic
- PR/PF = Current sensor - Low TCR

Dimensions (case size / mm) (code 3~6)
- 0805 = 2.0 x 1.25
- 1206 = 3.2 x 1.6
- 2010 = 5.0 x 2.5
- 2512 = 6.35 x 3.2

Tolerance (code 7)
- F = ±1%
- G = ±2%
- J = ±5%

Packing style (code 8)
- R = Paper Tape Reel
- K = Embossed Plastic Tape Reel

Optional code (code 17)

Resistance (code 12~16)
- 0R01 = 0.01Ω
- 0R1 = 0.1Ω
- 1R = 1Ω

Taping Reel (code 11)
- W = 2 x standard power
- 7 = 7 inch Dia.Reel

TCR (code 9)
- M = ±75ppm/°C
- F = ±100ppm/°C
- G = ±200ppm/°C

"—" = Based on Spec.
  ( — for RL Film only)

Example: Current Sensor TC100 2512 2W 1% 5m Ohm 7inch reel
Yageo PN is PR2512FKF7W0R005L
Available Series : RL0805, RL1206, PRPF
Lead Free Products

- Products with Lead-free termination are available & ready to meet CUSTOMERS request

GREEN SUPPLIER for all your PASSIVE COMPONENTS
Lead Free, Label for Identification

Since 01/01/2004 All Yageo R-Chips become fully lead free, with RoHS 6/6 compliance.

Old label format for Pb containing termination

Label format for Pb-free termination
Summary

• Provide a basic explanation of how the chip resistors are made
• Introduced their Thin and Thick Film product offering
• Provide an overview of their resistor networks and low ohm current sense resistors
• Explored Yageo’s part number breakdowns and RoHS labeling
Innovative Service Around the Globe

Thank you