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□ Confidential</td><td>C.H.Seok</td></tr>
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RN.2 Technologies

Datasheet

Delay Line 4

Rev. 1.0

Release Date 2017-04-28

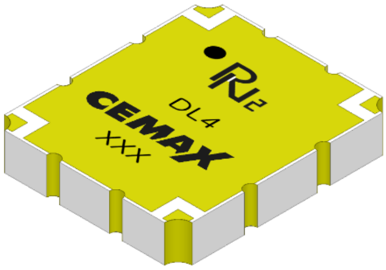
Revision History

Rev	Release Date	Description	Author
1.0	2017-04-28	• Initial release	C.H. Seok

Delay Line
with High-Power Capacity and Stable Performance based on RN2 LTCC Multilayer Technology
Model Name: Delay Line 4

KEY FEATURES

- Excellent high-power capacity up to average 100 watts
- Excellent stable performance at different temperatures
- Low insertion loss based on a LTCC base (Er = 6), high conductivity metal conductor (Ag), and gold (Au) plating
- Surface mount type
- RoHS compliance (Pb-Free)



APPLICATIONS

- Applications using GSM, UMTS, and LTE
- RF amplifiers
- Communications equipment

GENERAL DESCRIPTIONS

The DL4 is a Delay Line with high-power capacity and stable performance in different temperatures. The LTCC, high conductivity metal conductor (Ag), and gold (Au) plating enable the DL4 to minimize insertion loss and improve durability for thermal stabilization and electricity.

The DL4 is suited for applications using GSM, UMTS, and LTE and communications equipment, requiring low insertion loss and high power.

The DL4 supports up to average 100 watts. It is a SMD type product enabling Pb-Free solder and meets RoHS-6.

ELECTRICAL SPECIFICATIONS

Frequency (MHz)	Return Loss Min.(dB)	Insertion Loss Max.(dB)	Group Delay (nS)	Power Capacity (Watts)
300-700	20	1.9	3.95 ± 0.1	100
700-1000	20	2.3	3.95 ± 0.1	
1000-1400	20	2.8	3.97 ± 0.1	
1400-1800	17	3.4	4.03 ± 0.1	
1800-2100	18	3.8	4.11 ± 0.1	
2100-2800	15	4.6	4.20 ± 0.2	

NOTE: These electrical specifications are measured by using a RN2 test board.
Specifications subject to change without notice.

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PORT CONFIGURATIONS

Figure 1 shows the locations of the DL4 ports. The orientation marker is included to represent port 1.

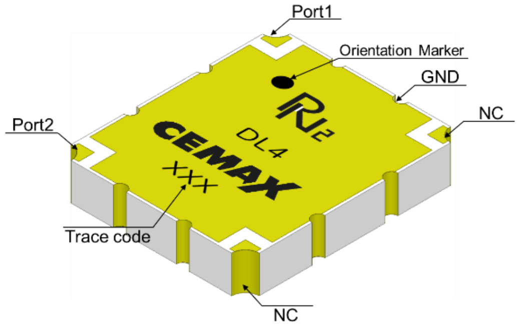


Figure 1. DL4 (Top View)

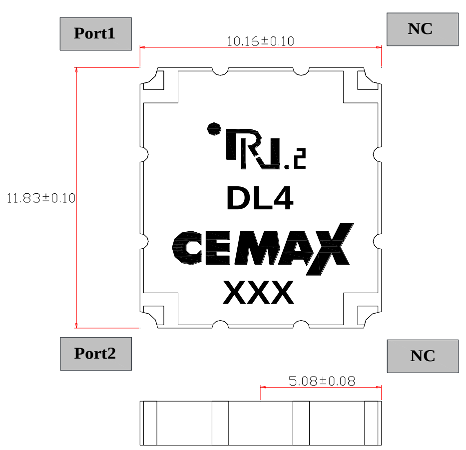
Table 1 describes the DL4 port configurations depending on how input signals are split. The Case 1 and Case 2 configurations mean that one input signal is split into two output signals. When port 1 is defined, the other ports are defined automatically.

Table 1. DL4 Port Configurations

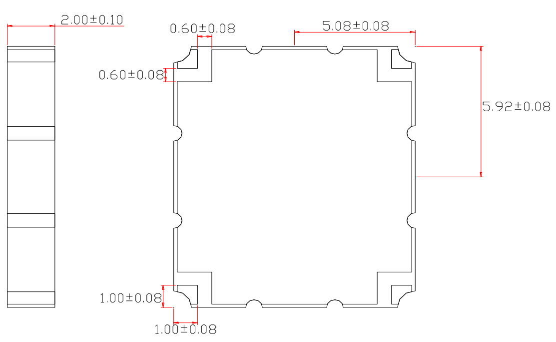
Configuration	Port 1	Port 2	N.C	N.C
Case 1.	Input	Output	N.C	N.C
Case 2.	Output	Input	N.C	N.C

MECHANICAL SPECIFICATIONS

Top View



Bottom View



- Weight: 0.70 grams
- Camber specifications: Less than ±0.08 mm

POWER DERATING CURVE

Figure 2 shows the maximum allowable average power (Maximum input power, CW) of the DL4 depending on base PCB temperature changes. The maximum allowable average power of the DL4 is limited by the following power derating curve.

The DL4 factors that determine the power derating curve are as follows:

- Internal circuit
- Thickness
- Thermal conductivity of materials
- Insertion loss
- Operating temperature
- Mounting interface temperature between the DL4 and the base PCB

The maximum operating temperature of the DL4 is 125 ºC. Therefore, when the base PCB temperature is over 125 ºC, the DL4 operates stably by decreasing its durable average input power. When the base PCB temperature reaches 200 ºC, the maximum allowable average power decreases to 0 watt.

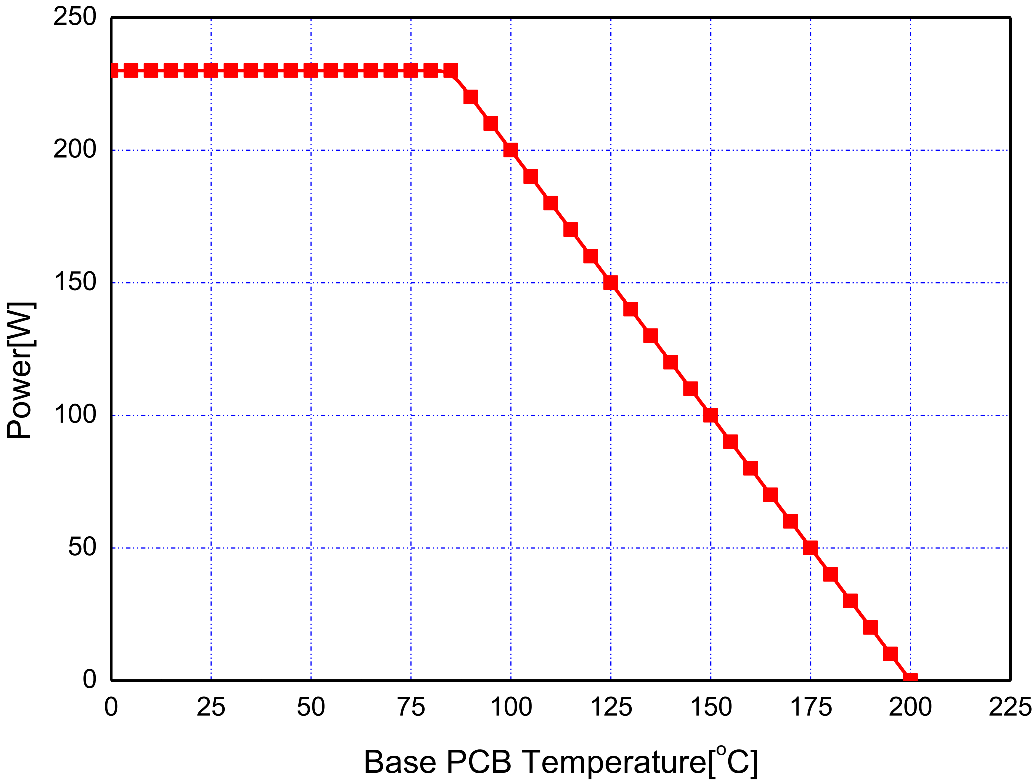


Figure 2. Power Derating Curve

RF PERFORMANCE CURVES: Return Loss and Insertion Loss (-55 ºC, 25 ºC, and 125 ºC)

Figure 3 shows the test plots of the return loss for the DL4. There are few variations for the specified frequencies and temperatures.

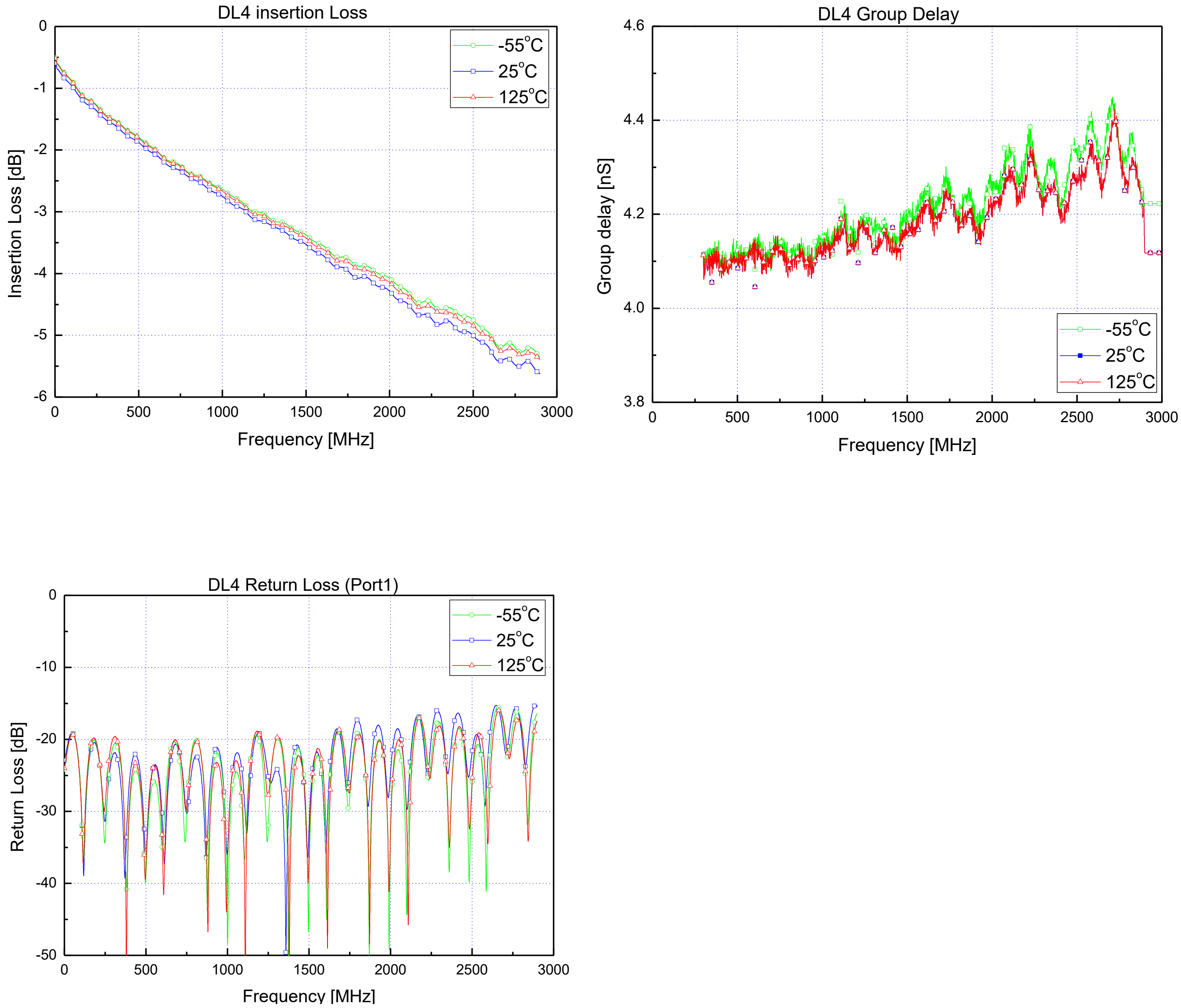


Figure 3. Test Plots of Insertion Loss, Group Delay and Return Loss (-55 ºC, 25 ºC, and 125 ºC)

RF TEST METHODS

This section describes how to test the DL4 RF performance. To ensure s-parameters reliability, we follow our internal test procedures by using the RN2 bare test board, RN2 test board, Vector network analyzer, and test fixture. In addition, we use the Automatic Port Extensions (APE) function of the Vector network analyzer to obtain accurate s-parameters.

Check the following sections for more details:

- RF TEST PROCEDURES
- RN2 TEST BOARD LAYOUT
- AUTOMATIC PORT EXTENSIONS (APE) FUNCTION

RF TEST PROCEDURES

To test the DL4 RF performance, we perform the following steps:

1. Preparing the Test Equipment
2. Performing the Automatic Port Extensions (APE) Function of the Vector Network Analyzer
3. Measuring the S-parameters (Coupling, Transmission Loss, Isolation, and Return Loss)
4. Obtaining the Characteristic Parameters (Amplitude Balance, Isolation, Insertion Loss, Return Loss, and Phase Balance)

STEP 1: Preparing the Test Equipment
The following test equipment is prepared to test the DL4 RF performance.

- RN2 bare test board
- RN2 test board
- Vector network analyzer
- Test fixture

STEP 2: Performing the Automatic Port Extensions (APE) Function of the Vector Network Analyzer
The APE function is used with the RN2 bare test board to correctly check the DL4 RF performance. This reduces or eliminates both electrical delay and insertion loss of the test fixture.

The detailed steps are as follows:

1. Place the RN2 bare test board on the text fixture.
2. Click the **Cal** button of the Vector network analyzer to calibrate it.
3. Connect the four ports of the test fixture into the fours ports of the Vector network analyzer.
4. Click the **Port Extensions** button of the Vector network analyzer to measure the data of the RN2 bare test board.

STEP 3: Measuring the S-parameters (insertion Loss, Group delay, and Return Loss)
After performing the APE function, the DL4 s-parameters are measured through the following steps:

1. Place the RN2 test board on the text fixture.
2. Apply pressure to the text fixture using a pneumatic piston.
3. Connect the four ports of the test fixture into the fours ports of the Vector network analyzer.
4. Set port1 as Case 1 configuration in *'Table 1. DL4Port Configurations'*.
5. Calibrate the Vector network analyzer.
6. Measure the insertion Loss and Group delay value from port 1 to port 2 (S21).
7. Measure the return loss value from port 1 to port 1 respectively (S11).

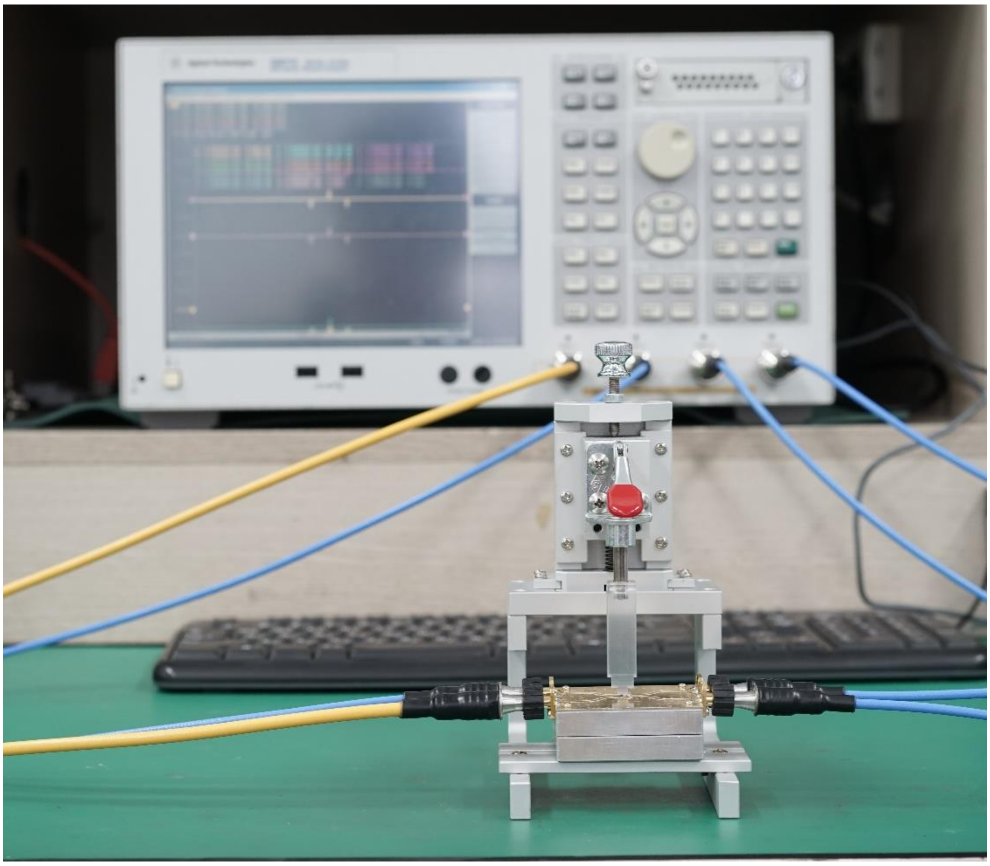


Figure 4. Test Setting to Measure the DL4 S-parameters

STEP 4: Obtaining the Characteristic Parameters (Amplitude Balance, Isolation, Insertion Loss, Return Loss, and Phase Balance)

The s-parameters are calculated by using the formula in ***Table 2*** to obtain the characteristic parameters, such as insertion loss and return loss.

Table 2. Mathematical Formula for the DL4 Parameters

Parameter	S-Parameter	Power Method
Insertion Loss	S21	
Return Loss	S11 S22	$10 \cdot \log\left(\frac{P_{in}}{P_{back}}\right)$

NOTE

- P_{in} : Power of Input Port
- P_{back} : Return Power of Input Port

RN2 TEST BOARD LAYOUT

Figure 5 shows the RN2 test board layout used for testing the DL4 RF performance. The RN2 test board is based on the Taconic RF35 board with the dielectric constant of 3.5, board thickness of 0.8 mm, and copper of 1 Oz.

We recommend that you use the same material and design layout, as shown in ***Figure 5***, to meet the specifications in this datasheet. However, if you use different materials, you must follow the basic guildelines. See *'RECOMMENDED PCB LAYOUT AND SOLDER MASK PATTERN'* for more details.

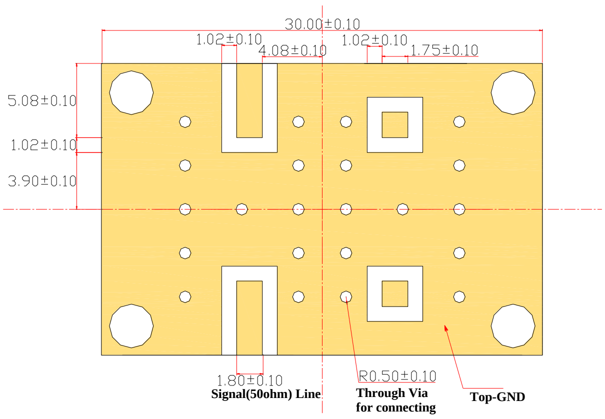


Figure 5. RN2 Test Board Layout

AUTOMATIC PORT EXTENSIONS (APE) FUNCTION

To accurately measure the DL4 s-parameters, we use the Automatic Port Extensions (APE) function of the Vector network analyzer. The APE function is used for reducing or eliminating both electrical delay and insertion loss of test fixtures. It provides a convenient, automated way to calculate the insertion loss and electrical delay terms by a simple measurement of an open or short circuit, which is easy to do in test fixtures.

We consider the transmission lines of the RN2 bare test board as extensions of the coaxial test cables that are between the Vector network analyzer and the DL4. With the APE function, we extend the coaxial test ports so that our calibration plane is right at the terminals of the DL4, and not at the connectors of the RN2 bare test board.

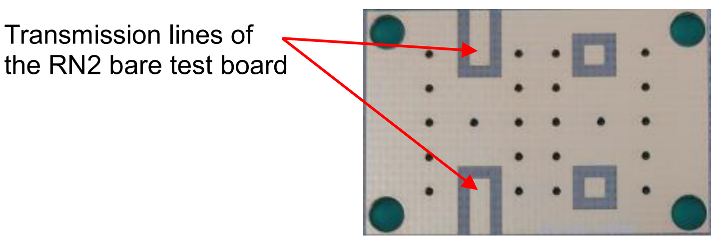


Figure 6. Performing the APE Function Test

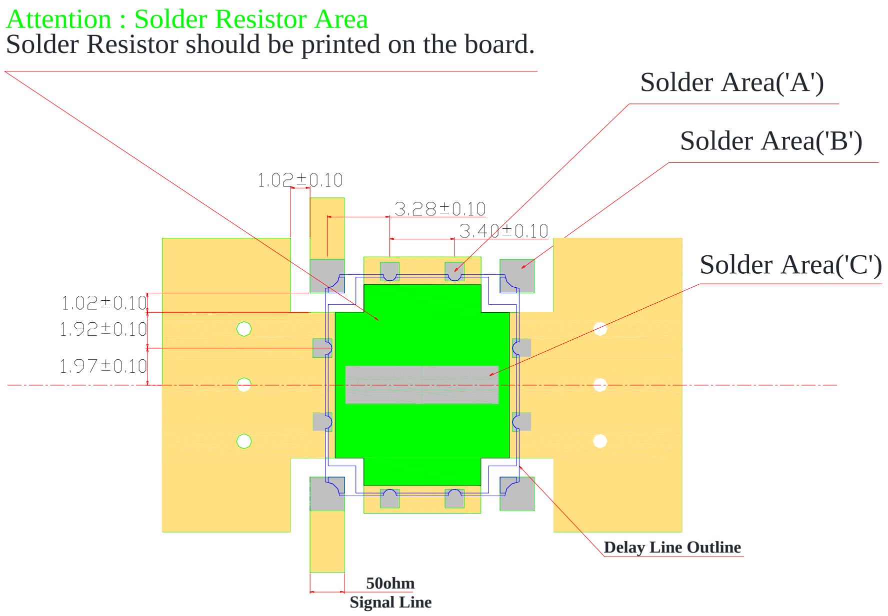
RECOMMENDED PCB LAYOUT AND SOLDER MASK PATTERN

Figure 7 shows the recommended PCB layout and solder mask pattern to meet the specifications in this datasheet. When you use different materials other than the RN2 test board, you must follow the basic guidelines at minimum.

Basic Guidelines

- Place GND more than 30% of the DL4 GND dimension regardless of a via size.
- Appropriately increase via sizes and numbers to allow low impedance ground connection and good thermal conductivity.
- Align the DL4 ground plane with the solder to have good connection to ground.
- Fill the via holes under the DL4 with the solder for thermal emission.

NOTE: Contact the RN2 Technologies sales team for more detailed PCB layout and solder mask pattern information.



NOTE

- Test Solder Cream: SAC-305 (Alpha Metal)
- Pb-Free Solder Alloy: Sn/Ag/Cu Ratio of 96.5/3.0/0.5
- Solder Area ('A') Dimension : 1.0 mm by 1.0 mm
- Solder Area ('B') Dimension : 1.8 mm by 1.8 mm
- Solder Area ('C') Dimension : 8.0 mm by 2.0 mm

Figure 7. Recommended PCB Layout and Solder Mask Pattern

SOLDERING PROCESS

The DL4 soldering steps are as follows:

1. Cleaning the PCB
2. Applying solder paste to the PCB
3. Placing the DL4 on the PCB
4. Reflowing the DL4 to the PCB
5. Cleaning and inspecting the soldered PCB with the DL4

STEP 1: Cleaning the PCB
Carefully clean the PCB surface where the DL4 is soldered.
Particles must not be placed on the PCB surface where the DL4 is soldered.

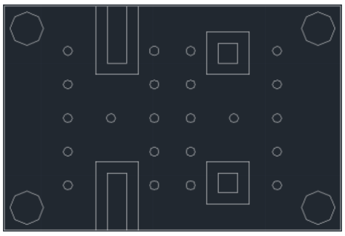


Figure 8. Cleaning the PCB Surface Where the DL4 is Soldered

STEP 2: Applying the Solder Paste to the PCB
Apply the solder paste to the 13 points on the PCB surface.
It enables good thermal conductivity because the DL4 is firmly attached to the PCB surface without air.

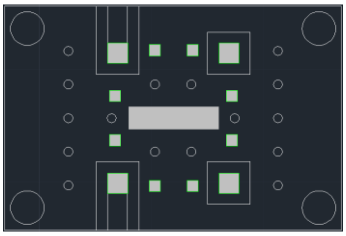


Figure 9. Applying the Solder Paste to the 13 Points on the PCB Surface

STEP 3: Placing the DL4 on the PCB
Correctly place the DL4 on the 13 points of the PCB surface.
Applying the solder paste to the 13 points helps you firmly attach the DL4 to the PCB surface.

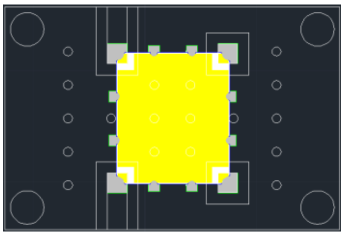


Figure 10. Placing the DL4 on the 13 Points of the PCB Surface

STEP 4: Reflowing the DL4 to the PCB
We recommend both manual soldering and PCB surface pre-heating methods when reflowing the DL4 to the PCB surface. Be careful NOT to touch the iron tip to the DL4 when you use the manual soldering method.
See *'REFLOW PROFILE'* for more details.

REFLOW PROFILE

Figure 11 shows the thermal reflow profile of the SAC-305 (Alpha metal), which is a test solder cream we used.

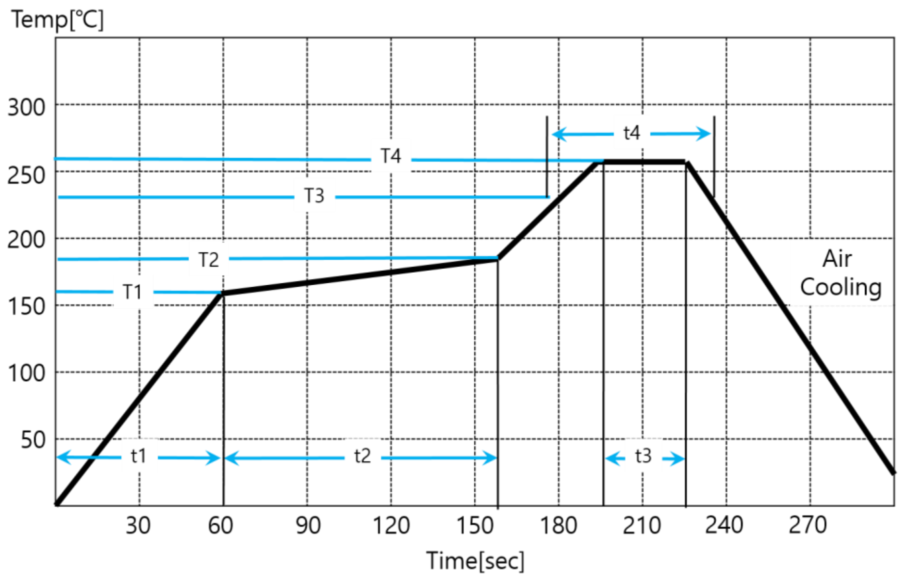
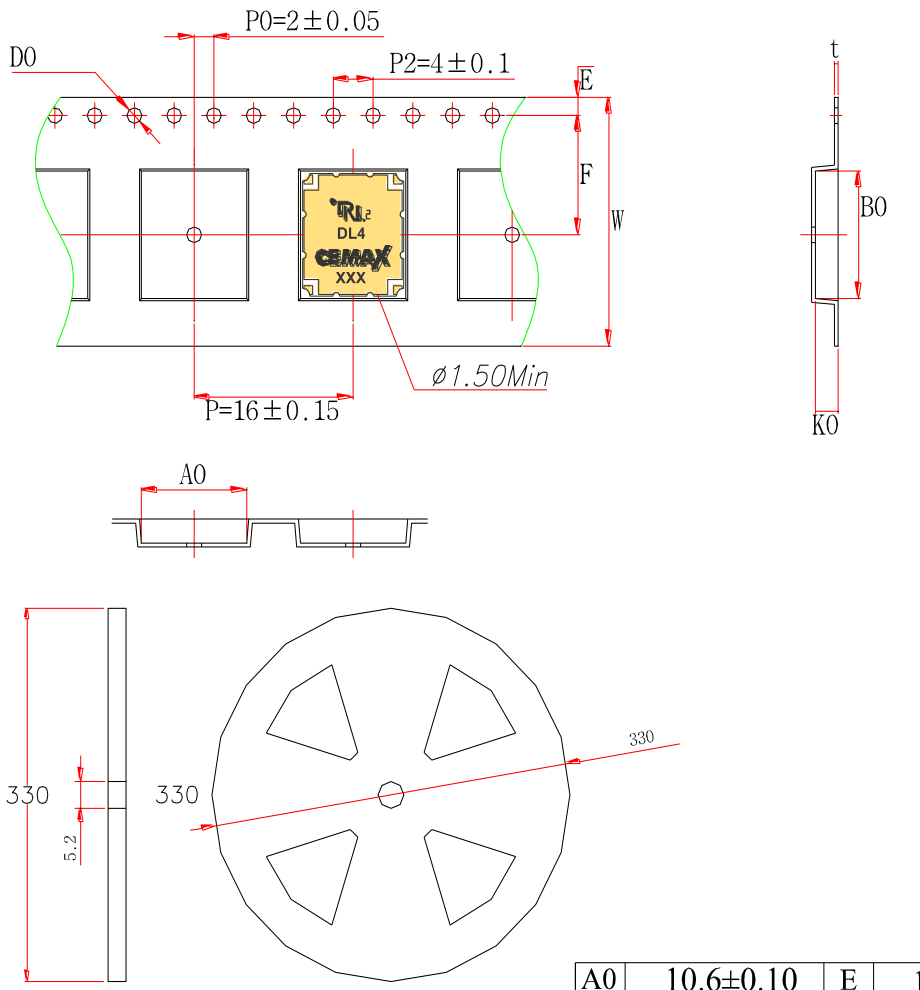


Figure 11. Thermal Reflow Profile

	Ramp Up	Pre-Heating	Peak	Soaking
Temperature(□)	T1:160±5℃	T2:180±5℃	T4:260±5℃	T3:230±5℃
Time(sec)	t1:60±5sec	t2:100±15sec	t3:30±5sec	t4:60±10sec

PACKAGING AND ORDERING INFORMATION



A0	10.6±0.10	E	1.75±0.10
B0	12.3±0.10	F	11.50±0.10
D0	1.55±0.05	t	0.40±0.05
K0	2.30±0.10	w	24.0±0.30

Starndard Packaging Quantity : 1,500 PCS / Reel

CAUTION

PLEASE READ THIS NOTICE BEFORE USING OUR DELAY LINES.

I. Be careful when transporting

- Ensure proper transportation as excessive stress or shock may damage Delay lines due to the nature of ceramics structure.
- Delay lines cracked or damaged on terminals may have their property changed.

II. Be careful during storage

- Store Delay lines in the temperature of -55℃ to +125℃.
- Keep the humidity at 45% to 75% around Delay lines.
- Prevent corrosive gas (Cl_2, NH_3, SO_X, NO_X, etc.) from contacting Delay lines.
- It is recommended to use Delay lines within 6 months of receipt. If the period exceeds 6 months, solderability may need to be verified.

III. Be careful when soldering

- Solder all the ground terminals, IN and OUT pad of Delay lines on the ground plane of the PCB.
- Delay lines may be cracked or broken by uneven forces from a claw or suction device.
- Mechanical stress by any other devices may damage Delay lines when positioning them on PCB.
- Do not use dropped Delay lines.
- Ensure that any soldering is carried out by the condition of specification sheet.
- Do not re-use Delay lines which are de-soldered from PCB.

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