AN_02

User Guide for GaN HEMT Transistor

1. Introduction

In order to facilitate customers to quickly design with GaN devices, the design reference is given in the aspects of offset setting and machining.

2. Bias voltage setting

As the third generation of semiconductor, GaN has been widely used because of its excellent device performance. It has become the best choice of high power RF power amplifier. In the working mode of the device, it is different from the LDMOS enhanced device. GaN RF devices are usually in depletion mode, and the device is set to negative pressure as of the required voltage, such as -5 V. As the negative pressure voltage changes to 0 V, the device opens gradually. In view of this mode for applications, the gate voltage and drain voltage are required to be staggered on the turn on and turn off sequence. When turn on, it is necessary to ensure that the gate voltage is turned on first, and the drain voltage is turned on afterwards. When turn off, it is necessary to ensure that the drain voltage is turned off first, and the gate voltage is turned off afterwards. Avoid a short circuit from the drain to the ground due to the error of the bias timing, which may cause a large current to burn the device. The bias references for GaN applications are given below:

Table 1. Biasing sequences

GaN	
Bias ON	**Bias OFF**
1. Ensure the RF power is turned off	1. Turn off RF power
2. Apply pinch-off voltage of - 5 V to the gate	2. Apply pinch-off voltage to the gate
3. Apply nominal drain voltage	3. Turn off drain voltage
4. Bias gate to desired quiescent drain current	4. Turn off gate voltage
5. Apply RF power	

3. Machining

Because of its high power density, GaN has a smaller chip area than LDMOS at the same power level. Therefore, in the selection of package, we can use small-size package instead of large-size LDMOS package, so as to save the PCB area of the client. As far as packaging requirements are concerned, it has no special features with traditional LDMOS devices. It is mainly due to its high power density, small size, slightly higher thermal resistance than LDMOS, so the requirements for heat dissipation will be higher. Therefore, ceramic packaging and welding are the mainstream of high-power packaging to meet the performance and heat dissipation requirements. And the small power end, usually adopt plastic packaging, meet the performance at the same time, save cost. In the following, the ceramic packaged devices and plastic packaged devices are given design references for PCB and heat sink processing respectively.

3.1 Machining of ceramic packaged devices

3.1.1 PCB aperture design

PCB wiring requirements can be controlled by itself according to each frequency band, here is mainly a design reference for PCB aperture. In defining the size of the package outline on the PCB, only a few package sizes are relevant. These are summarized in figure 1 below. A1 represents the maximum length, B1 represents the maximum width, and C3 represents the depth of the device's pin bottom to the device bottom. The package body is placed through an aperture in the PCB, and onto the heat sink. The dimensions of the aperture in the PCB should be such that the package can be comfortably inserted through it. In general, apertures in a PCB are made with certain accuracy. Therefore it is advisable to design the PCB aperture larger than the maximum package body dimensions in that way there will always be at least 0.2 mm left for package insertion.

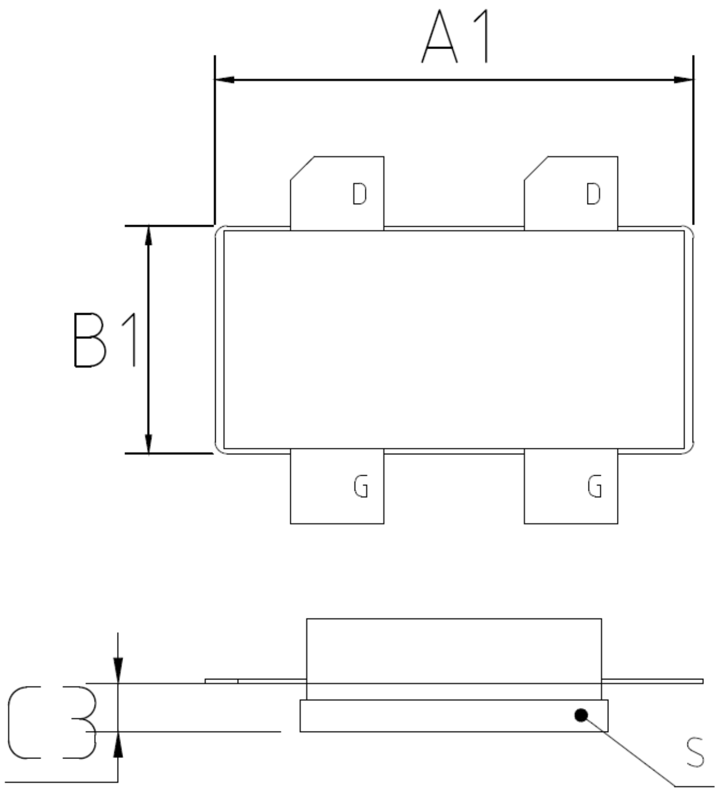

Fig 1

3.1.2 Groove size design of heat sink

The design of heat sink mainly depends on the requirements of heat dissipation. Generally, materials with thermal conductivity greater than 390 W/m • K are selected. As device manufacturers, pure copper (red copper) materials are usually selected. For the design of drilling or structural parts, the design can be carried out according to the customer's own needs. Here, the rules for the size of groove in heat sink are mainly described. The purpose of groove is to set a suitable slotting length, width, and depth, so that the package can be placed appropriately in the heat sink slot. If the groove is too shallow, it will cause the lead and PCB gap to be too large;

if the groove is too deep, it will cause the lead and PCB to bend.

First, the width and length of the groove must be slightly larger than the width and length of the package. Dynax recommends that the width and length of the heat sink groove be 0.1 mm larger than the maximum package size. At the same time, the machining tolerance is taken as 0.05 mm. The calculation formula is similar to that used to determine the aperture in PCB:

Groove length = A1 (max) + 0.1 mm + tolerance (0.05 mm)

Groove width = B1 (max) + 0.1 mm + tolerance (0.05 mm)

For the groove depth, when the transistor is put in and the bottom is in good contact with the heat sink, the package pin is in good contact with the PCB pad, and the gap is ideal within 0.5 mm. Refer to the current experience: usually take the minimum size from the bottom of the lead to the bottom of the shell as a reference, and consider the processing tolerance of 0.05 mm.

Groove depth = C3 (min) - PCB thickness - tolerance (0.05 mm)

3.2 Machining of plastic packaged devices

Plastic packaged devices are mainly welded directly to the PCB through the metal surface of the bottom of the device, through holes are opened on the ground surface of the PCB, and heat conduction is conducted through the metal of the hole wall. Therefore, there is no need to design PCB aperture and heat sink groove for plastic packaged devices. As shown in the figure 2 below, the middle dotted box part is the back grounding metal surface, which is welded with PCB to ensure grounding and heat dissipation.

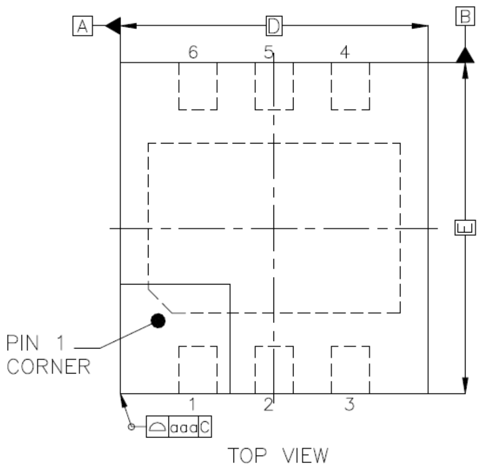

Fig 2

In order to ensure better grounding and heat dissipation, holes need to be drilled on the back of the plastic packaged device to the corresponding PCB pad. The recommended hole diameter is 0.254 mm (0.1 inch), and the distance between the hole and the center is 0.762 mm (0.03 inch). Refer to the figure 3 below for hole diameter and hole distance:

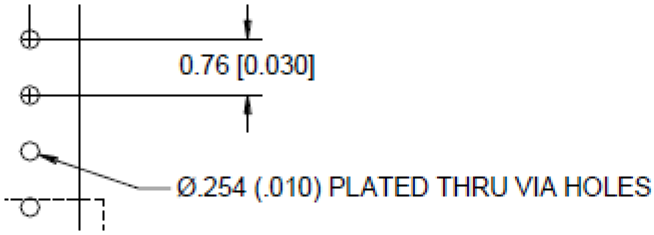

Fig 3

For low-power devices, through-hole heat dissipation can be used. For high-power devices, according to the actual application needs of customers, different heat treatment methods are adopted, such as PCB multilayer board, and copper embedding method is adopted to enhance heat conduction effect.

4. Storage Requirements

After receiving the Dynax's products, please check whether the packaging is in good condition first, if there is any damage, please contact us. When using and storing the device, please pay attention to anti-static. Details are as follows:

- MSL grade I (ceramic products): vacuum packaging, ambient temperature ≤ 30℃,
  Humidity ≤ 85%RH, Maximum storage time = 2 years.
- MSL grade III (plastic products): vacuum packaging, ambient temperature ≤ 30℃,
  Humidity ≤ 60%RH, Maximum storage time = 2 years.

At the same time, from unpacking the vacuum packaging of the product to welding on the customer's system, the entire process environment meets the following conditions: ambient temperature ≤ 30℃, humidity ≤ 60%RH, maximum interval time ≤ 168 hr.

5. Revision history

Table 2. Revision history

Revision	Date	Description
V01	01/2018	Initial version.
V02	01/2020	Add description of Moisture Sensitivity Level.
V03	04/2020	Added mechanical processing instructions for PCB and heat sink.
V04	11/2021	Update document format.

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