LAYOUT GUIDELINES FOR MMIC COMPONENTS

Introduction

Hittite's surface mount ceramic and plastic packages are being used in high frequency applications for both military and commercial markets. Hittite's SMT packaged products range in frequency from DC to 43 GHz for use in microwave radio systems, VSAT, WLAN and cellular communication applications. In order to achieve the benefits offered by these devices, particular attention must be paid to the layout of the circuit board that the device is placed on.

Overview

As new applications require higher frequency, design layout and materials of the circuit board must be thoroughly examined. Design issues such as transitions from connector and devices, grounding, leakage, and coupling between structures will be more sensitive in higher frequencies. With the proper design techniques presented here, excellent performance can be achieved at these higher frequencies.

Material & Transmission Line Selection

As with all our evaluation boards, it is recommended that a grounded coplanar waveguide (CPWG) system on a Roger's 4350 material or equivalent be selected as a transmission line method. Table I (a) shows the material parameters for 4350 used by Hittite. Table I (b) presents the line width for 50-ohm transmission lines and a comparison of microstrip versus CPWG parameters on a similar substrate material. For these frequencies a .031'' (.79mm) line width and .011'' (.28 mm) gap were found to be optimal for this material. The RF ground plane spacing is placed at .020'' (.51 mm) which is a typical value for this material and prevents moding at these frequencies.

Table 1 (a):
Material Parameters

Frequency	DC - 10 GHz
RF Ground Plane Spacing	0.020" (0.51 m)
Relative Dielectric Constant	3.38 (4350)
Loss Tangent (measured)	0.002

Table 1 (b):
Comparison of Microstrip & CPWG @ 10 GHz

	MICROSTRIP	CPWG (10 MIL GAP)
Line Width	0.044" (1.12 mm)	0.031" (0.79 mm)
Dielectric	2.73	2.16
1/4 Wave Length	0.178	0.201

Layout Guidelines

As shown in Table 1(b), CPWG allows a thirty-percent reduction in line width for 50 Ohm lines. This permits a larger ground plane between RF lines thereby enhancing the isolation and reducing leakage. As a result of using CPWG it is necessary to have as many via holes connecting the top and bottom ground planes along the RF transmission lines. l/20 or less should separate these holes in order to achieve the modeled transmission line performance. In addition, the edge of the via holes should be 1 diameter distance from the edge of the ground plane away from the transmission line.

To prevent RF leakage from escaping onto the DC bias lines, it is necessary to damp the lines. This may be achieved in two ways. The first approach uses RF bypass capacitors on the control lines. At low frequencies (below 3GHz), this is generally sufficient as long as the capacitors are placed reasonably close to the device package. However, in the 10GHz range, l/4 resonance may start to occur at a distance of a few tenths of an inch from the device. If the capacitors are not placed directly at the pin of the package, the distance from the package to the capacitor may be on the order of l/4, which will result in a RF open circuit being presented at the pin of the device. This can result in unpredictable, and generally less than optimal performance.

Another method to damp RF signal leakage is through the use of series resistor in the bias and control lines. These resistors should be similar in value to the bias line impedance, approximately 80-120 ohms. Placement of the resistor should be as close to the device leads as possible. Figure 1 is the top layer metal artwork for a typical evaluation board Hittite has developed for characterizing our plastic and ceramic packages.

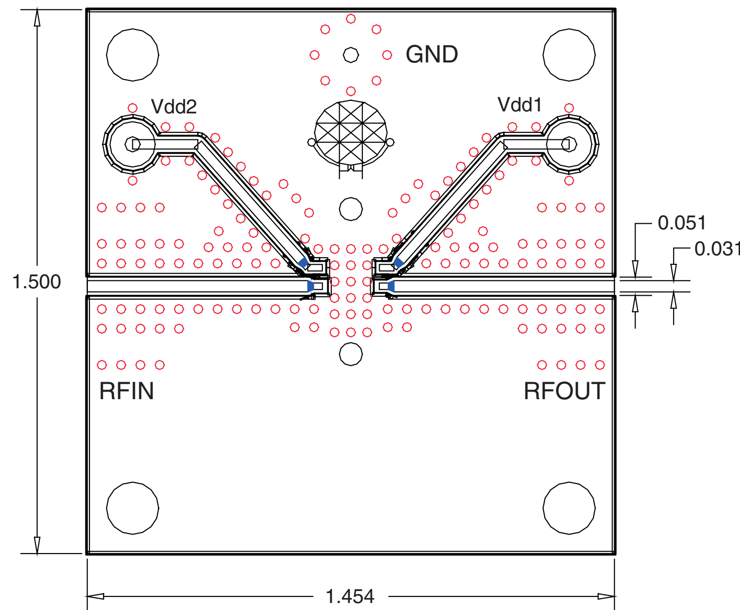
The evaluation board consists of two layers of 4350 bonded together with 4403 adhesive to an overall thickness of .062 - .067''. This thickness is required to accommodate the tab-launch PCB mount SMA connectors from Johnson Components (part number 142-0701-851). The stack-up of the material is shown in Figure 2. Each layer of the 4350 material has clad copper clad on each side resulting in four metal layers. Critical factors for this type of CPWG construction are the via hole placement (mentioned earlier) and plating requirements. Plating for the external metal layers (layers 1 and 4) for this construction should be 3 mils in thickness to maintain the correct impedance or the RF lines. Via hole diameters should be at least .014 mils in diameter to provide adequate

plating through this construction. Additional via holes around the ground plane, bias and control lines eliminates any hot spots due to leakage.

In the design and fabrication, ensure that the launch from the connector onto the substrate is well matched for signal and ground. This transition can be measured using Time-Domain Reflectometry (TDR), which is available on many network analyzers and some digital oscilloscopes.

Evaluation boards are supplied with samples upon request. Layout files are also available for customers to include in their design.

Figure 1: *Typical Top Layer Metal Artwork*



Achieving Accurate Measurements: Calibration Techniques

The design and layout guidelines presented are sufficient to achieve high performance from all of Hittite Microwave's ceramic and plastic MMIC components. In order to accurately characterize these components, an equally stringent calibration must be used to de-embed the performance of the MMIC from the other losses and mismatches. The method used at Hittite Microwave is a Line-Reflect-Match (LRM) calibration technique. This method uses a custom set of printed circuit calibration standards fabricated as a matching set with the actual evaluation PCB. This type of calibration can provide S-Parameter data de-embedded directly to the package leads. The accuracy of this method is dependent on how well the standards can be created, and how well the transitions from connector-to-PCB can be repeated. Hittite Microwave has developed standards to characterize many of our products.

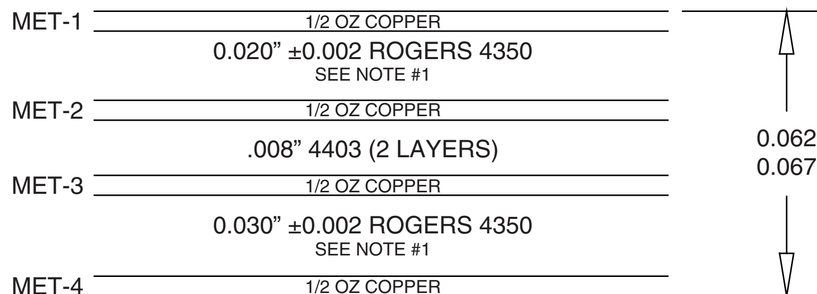


Figure 2: *Four Layer FR4 laminate Stack-Up*