

Advances in Plastic Surface Mount Silicon and GaAs Schottky Diodes for High Frequency Detectors and Mixers

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As detectors and mixers have gone to higher frequencies (> 10 GHz), the use of Beam Lead diodes has been required in order to reduce the parasitics around the device. The parasitic inductance has been reduced by the wide beams and the parasitic capacitance has been reduced by the small body, both of which have caused the device cost and the assembly cost to become expensive. The Flip Chip technology has improved the device cost, but the assembly cost still remains expensive due to the small size and fragility of the bare device.

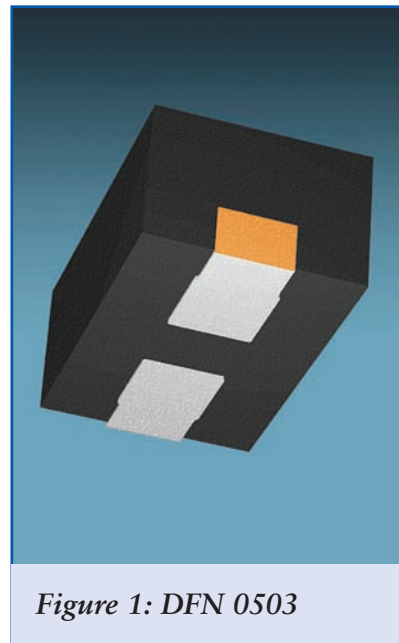


Figure 1: DFN 0503

Cost

In order to reduce the cost and maintain the high frequency performance of the detectors, a different approach had to be taken. The Plastic Dual Flat No-Lead (DFN) package has these advantages: low cost device assembly, low cost circuit assembly and low parasitics. Plastic package assembly lines with fully automated equipment are available to assemble both Flip Chip devices as well as chip and wire devices. The devices can be assembled, tested and put into tape and reel configuration. With devices mounted into tape and reel, the circuit assembly house can now very economically build the detector assembly.

Package Performance

The DFN 0503 package (shown in Figure 1) has low parasitic inductance and capacitance. For the Flip Chip assembly, the DFN package does not add any parasitic inductance. All of the inductance comes from the chip itself, which is less than 0.1 nH. The parasitic capacitance of this package is approximately 0.04 pF. When using chip and wire technology in this package, the bond wire adds an inductance of approximately 0.4 nH. The bond wire also adds to the para-

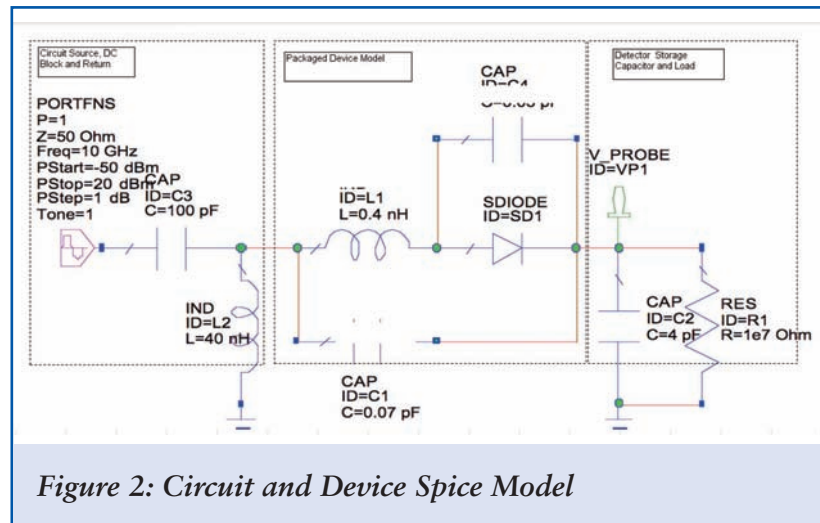


Figure 2: Circuit and Device Spice Model

GaAs and Silicon Schottky Mixer/Detector Diodes								
Part Number	Type	Freq	Vbr Min V	Ct Typ pF	Vf		Rs Max Ω	Package
					Min mV	Max mV		
SMGS11	Detector	>26.5	5	0.10	620	760	7	0503
SMGS21	Mixer	>26.5	-	0.15	620	760	7	0503
SMS201	Detector	>26.5	1	0.08	60	120	80	0503
SMS202	Detector	<18	1	0.13	60	120	80	0503

• GaAs Schottky diode SMGS11 is ideal for temperature compensated detector.
 • GaAs Schottky diode SMGS21 is an anti-parallel pair, ideal for a doubler and harmonic mixer.
 • Silicon zero bias Schottky diode SMS201 and SMS202 are simplest for a broadband detector design, with good sensitivity, -54 dBm typical and no DC bias required.

Table 1

sitic capacitance to extend the package capacitance to 0.07 pF. In addition, the bond pad on the chip device adds a parasitic capacitance of 0.03 pF.

Device Performance

The SMGS11 is a Flip Chip GaAs detector diode and has 1 mA forward voltage of ~ 680 mV. This requires the diode to be forward bias to be used as a detector diode. The bias used for

SD1			
Diode Parameter	SMGS11	SMS201	SMS202
Is, A	3.20E-14	3.00E-06	3.00E-06
Rs, Ohms	4.09	25	25
N	1.1	1.06	1.06
TT, S	3.00E-12	0	0
Cjo, pF	3.00E-12	0.06	0.1
Vj, V	0.7	0.35	0.35
M	0.25	0.5	0.5
Fc	0.5	0.5	0.5
Eg	0.87	0.69	0.69
BV, V	15	3.8	3.8
IBV, A	1.00E-05	3.00E-04	3.00E-04
XTI	2	2	2

Package Parameters	SMGS11	SMS201	SMS202
L1	0.1	0.1	0.4
C1	0.04	0.04	0.07
C4	0	0	0.03

Figure 3: Spice Parameters for Diode and Package

Circuit Layout

The circuit layout uses a series blocking capacitors to prevent the DC current from going back into the generator, an inductor for DC return to ground, the diode in series, storage capacitor to ground, and a load impedance to ground. The blocking capacitor should be large enough to look like a short circuit over the frequencies of interest. The inductor for DC return to ground should be large enough to look like an open circuit for the frequencies of interest. The storage capacitor impedance needs to be much lower (10 times lower) than the diode video impedance. The values chosen for a broad band detector are shown in Figure 2; Spice circuit model.

Using the above parasitic of the DFN 0503, a Spice model of the complete package device can be laid out. Figure 2 shows the circuit layout of this model and Figure 3 shows the Spice parameters for each of the three devices (SMGS11, SMS201 and SMS202) along with the package parasitic parameters.

The SMGS11 and SMS201 are Flip Chip devices and work at a frequency above 26.5 GHz. The SMS202 is a Chip and wire assembly and works at a frequency below 18 GHz. Shown in Figures 4, 6, and 8 are the transfer curves of the devices at three frequencies. Figures 5, 7 and 9 show the output voltage versus frequency for the three devices. All of these curves are with the devices mounted on a 50 ohm transmission line with no tuning. The biasing circuits use conical bias choke and beam lead capacitors to avoid circuit resonance.

Conclusion

As can be seen in the performance curves shown above, the DFN 0503 plastic pack-

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the circuit performance shown below is 40 uA. This brings the video impedance of the detector to around 650 ohms. In the case of the SMS201 (Flip Chip) and SMS202 (chip and wire), which are silicon detector diodes, the 1 mA forward voltage is ~ 200 mV. These devices are considered Zero Bias Detector die and require no DC bias. The video impedance of these devices is 2000 - 6000 ohms.

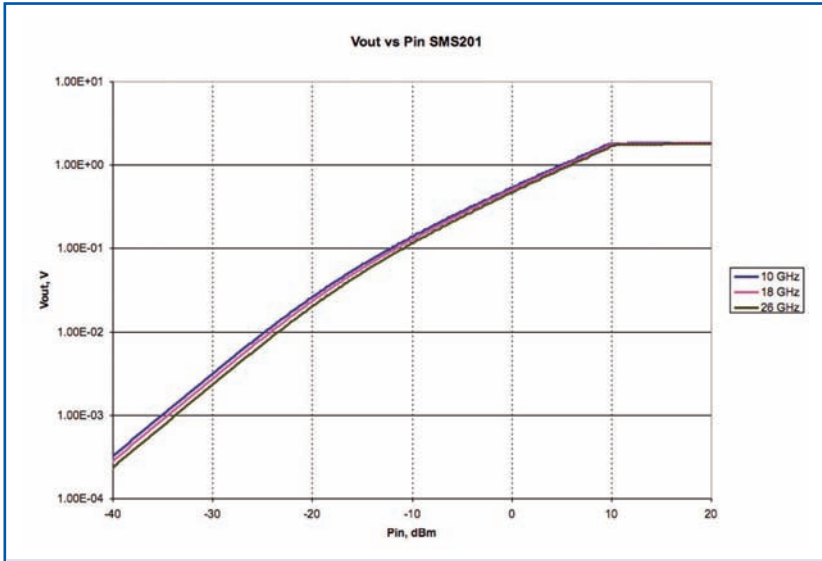


Figure 4: Transfer Characteristics of the SMGS11

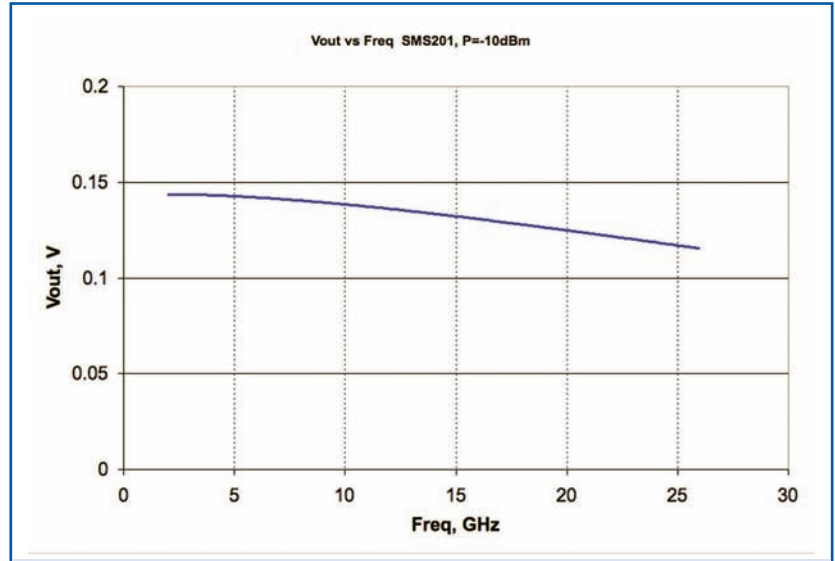


Figure 5: Output vs. Frequency of SMGS11

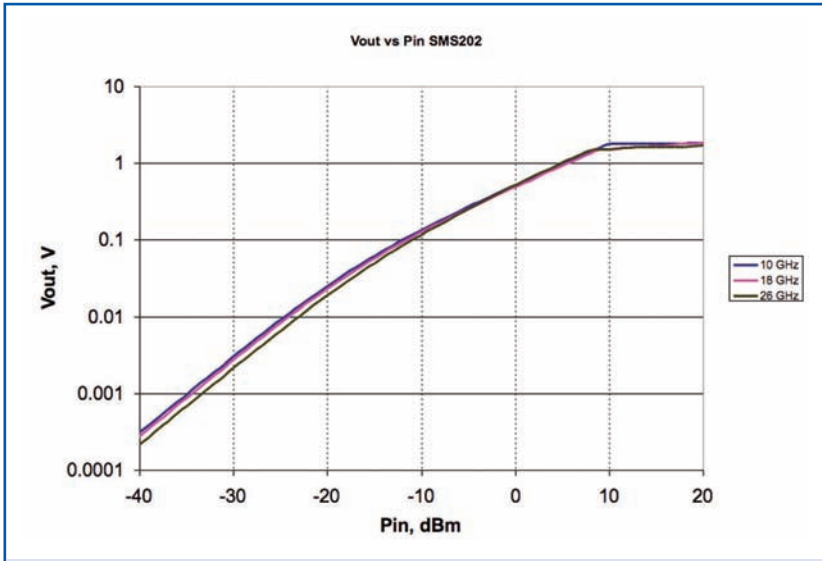


Figure 6: Transfer Characteristics of the SMS201

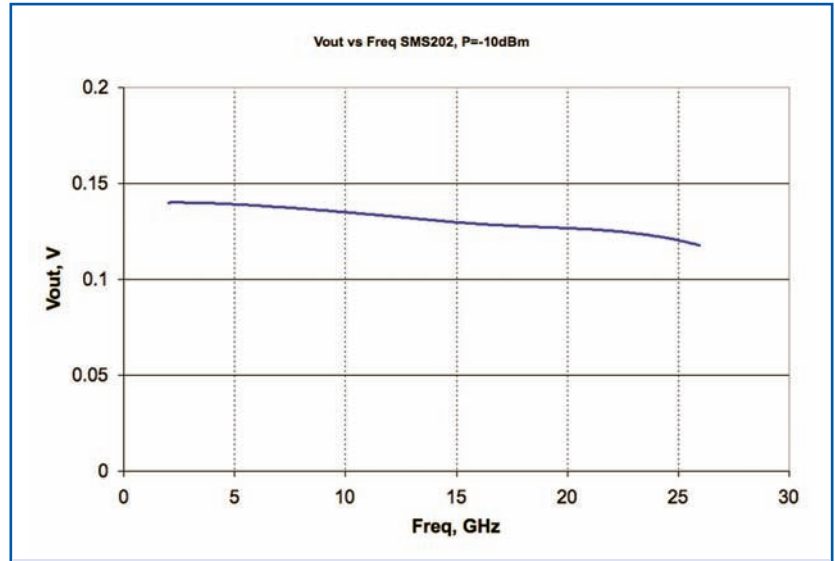


Figure 7: Output vs. Frequency of SMS201

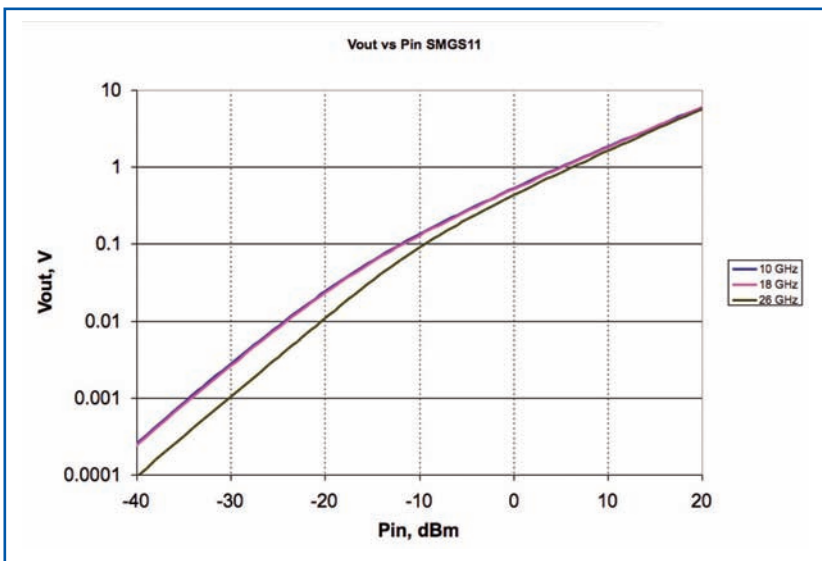


Figure 8: Transfer Characteristics of the SMS202

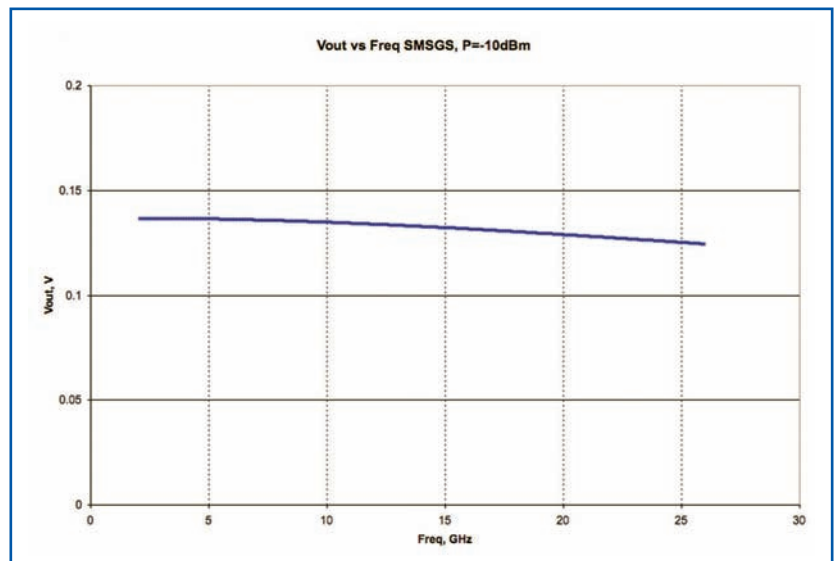


Figure 9: Output vs. Frequency of SMS202

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age Schottky diodes offer good performance with a cost advantage over the traditional Beam Lead and Flip Chip technologies. An additional device, SMGS21, which is an anti-parallel Schottky diode configura-

tion, is offered in the same DFN 0503 package for use in mixer and doubler applications that offer the same advantages as the single diodes do for detectors.

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