ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 11, November 2013

DESIGN AND CHARACTERIZATION OF MICROSTRIP IMPATT OSCILLATOR

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AIACTR

Abstract: In this work An IMPATT oscillator circuit at Ka band has been designed using inverted microstrip circuit.The Design of the oscillator consist of an active element(IMPATT) which converts dc power to RF power and a passive element with the electronic circuits for dc bias for the device to operate, providing the em enviroment at the device terminal to initiate oscillation and optimizes the oscillators output power and efficiency. The observed frequency of oscillation is 36.4 GHz with a maximum output 0f 1.472 mW.

DESIGN

Design of Microstrip Impatt Oscillator- Microstrip oscillator circuit generally consist of an impedance matching network and a resonant circuit for stabilizing the oscillations.The resonant circuit can be a metal resonant cap (1), Impatt diode resonant line section(2) or a dielectric resonator(3), resonant cap mounting of Impatt diodes for oscillations in one of the simple low cost techniques.The active devices used here was a GaAs IMPATT diode with its frequency of operation in the Ka band.

The diode specifications are listed below

Diode part number-IMPATT F14-DI-350-420, Maximum Current- 200mA, Output power 511 mW, Oparating frequency 35.2 GHz.

The details of the substrate used are given below.

Material : RT duriod 5880, Permittivity : 2.2, Tanδ : 0.0009,Thickness : 10 mil

The 10 mil substrate is chosen considering mounting of the diode. As seen from the case style of the diode, with a 10 mil (0.254 mm) substrate the diode chip can easily be mounted on the substrate and will be flushed with the substrate, giving a smooth surface finish.

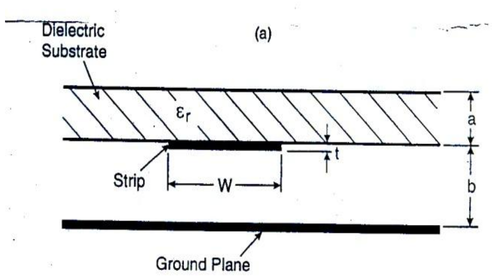

Figure 1Cross section of Inverted Microstrip Lines

Inverted microstrip line has been chosen due to following advantages, Inverted microstrip lines achieve a lower loss (or higher Q) than possible with microstrip line. Further this lines have a much lower effective dielectric constant (compared with that of a microstrip line), and performance being less sensitive to dimensional tolerances at high frequencies.Further the wide range of impedance values achievable using these lines makes them particularly suitable in realizing filters.The inverted microstrip retains the advantage of the suspended microstrip in terms of achieving larger strip dimensions and lower dissipative losses. Furthermore it reduces the radiation loss in contrast to that in an open suspended microstrip.

The resonator should be designed so that it matches the diode impedance and it should not radiate rather than guide the power to 50 Ω line. Using PCADD (software package) and Microfil (standard line length calculator) and considering the effective dielectric constant to be 1.01 for inverted configuration, the dimensions of the oscillator circuits are shown in Table I.

Table I Dimension of Oscillator Circuits

Resonator section		**Taper section**	
Radius of the resonator	4.09 mm	Initial Width	4.96 mm
Length 0f 20Ω line	4.41 mm	Final Width	1.56 mm
Width of 20Ω line	4.96 mm	Length	2.24 mm
Gap for surface mount capacitor	0.3 mm.	**Low pass filter**	
Length of 50 Ω line	3.0 mm	Width of Ist section	1.5 mm
Width of 50Ω line	1.56 mm	Width of 2nd section	2.4 mm

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SIMULATION

The microstrip circuits which are designed using inverted microstrip configuration is simulated using HP Advanced Design Software. The result ensures the correctness of the design logic.

The four section alternate low and high impedance line filter is simulated for S parameters over 1-45 GHz. frequency range. The simulated results [Figure 4] show the cutoff frequency of the resonator 11.0GH z. and an insertion loss of -35 dB over the required band. The return loss at the cutoff frequency is -20 dB. The resonator, impedance matching circuit and coupling line section is simulated and the result [Figure. 6] shows a return loss above -40 dB at the design frequency of 36 GHz. The entire design including the biasing circuit, rf coupling capacitor and 50 ohm termination is simulated. An isolation of -42 dB of the dc bias from millimeterwave power port and a good return loss at the design frequency (-25 dB) is observed.

The designed circuit is shown below.

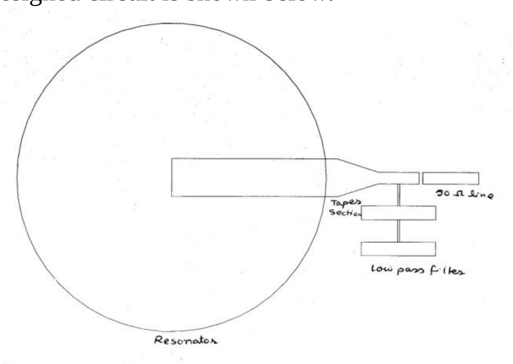

Figure 2 Schematic Layout of the PCB

FABRICATION AND TESTING

The Impatt Oscillator is driven by a constant current source [Figure. 5].Since the Impatt diode has low efficiency, it needs to be driven by a large source and highly regulated power supplies.

The oscillator circuit is fabricated and shown in Figure 7.The tested result of the device shows oscillations at the biasing voltage level of 25 Volt.The frequency of oscillation is 36.34 GHz [Figure 8.].The current vs. power plot is shown in Figure 9.It is observed that at the minimum voltage (32.4V) across the diode, the current drawn was 142.4 mA. with a power output of 472 mW.

CONCLUSION

In this work a challenging work of design, development and evaluation of microstrip based Impatt oscillator in inverted configuration has been performed. After a lot of research a simple design methodology is implemented with the above mentioned design parameters. The diode and the substrate were mounted properly in the mechanical package and placed in the test set up.

The frequency of oscillations obtained is 36.34 GHz. This is in close agreement with the designed value of 36 GHz.The maximum output power is 1.472 mW. The air gap between the ground plane and the microstrip line can be varied to obtain the optimized power output and more power output is possible by preventing soldering loss. The efficiency of the diode was 2% against the rated value of 15%. This may be due to absence of temperature compensation and tuning mechanism. Further miniaturization can be achieved using alumina substrate and modifying the taper section into step discontinuity.

However the performance and efficiency can be improved by adopting different design methodology. But considering the fabrication tolerance inverted microstrip configuration in Millimeterwave frequency is useful due to increased circuit area. Design techniques in microstrip configurations are much smaller than the waveguide counterparts and further miniaturization can be possible using

a) Alumina substrate, where circuit dimensions reduce considerably.

b) Modifying the filter circuit layout, by bending the inductive line the circuit layout can be reduced.

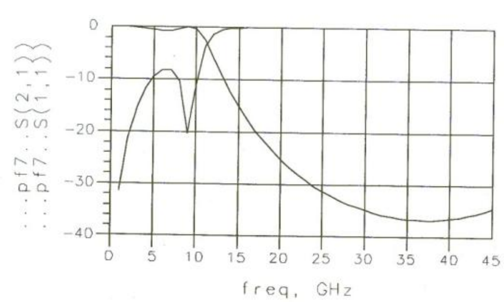

Figure 4 Simulation result of the LP Filter

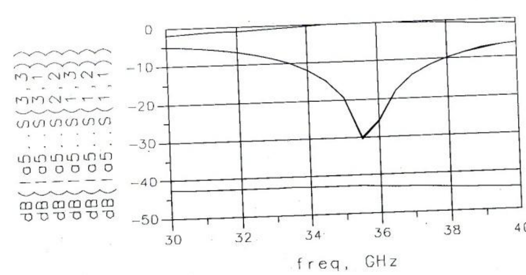

Figure 5. Resonator Simulation result

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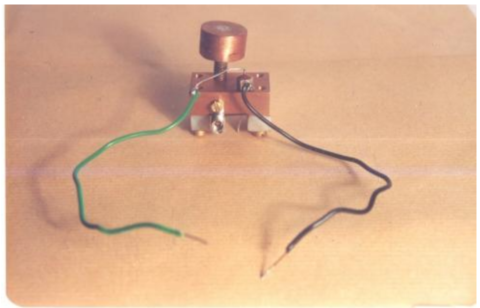

Figure 7 Hardware of Fabricated Impatt Oscillator

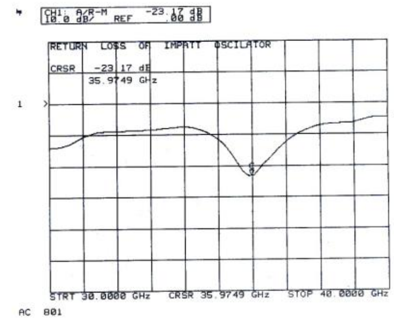

Figure 8 Return Loss of Impatt Oscillator

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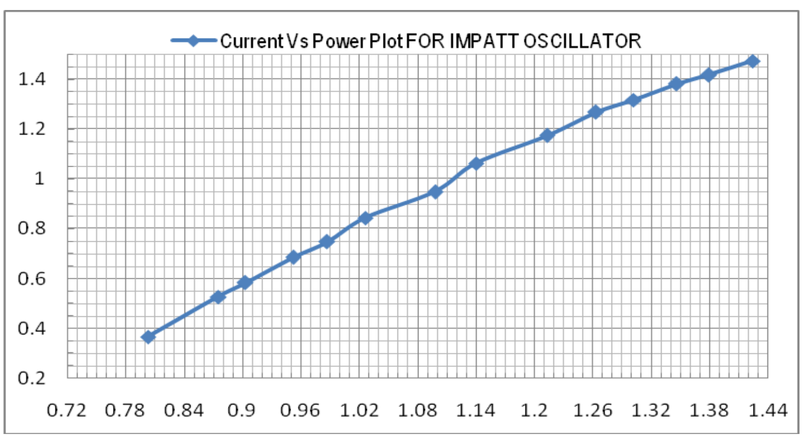

Figure 9 Current Vs Power Plot for Impatt Oscillator

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