A NOVEL APPROCH TO DESIGN X-BAND FREQUENCY GENERATOR

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ABSTRACT

Microwave oscillator is the main circuitry for the generation of the radio frequency (RF) communication system. Here in this paper we are presenting a simple and compact approach to generate the x-band signals by using T- type resonator on the micro strip line. The resonator circuit, which has the ability to stop or pass a particular frequency band. The t- Type resonator which is used in this circuit consists of transmission line which has the inductive and capacitive characteristics. The frequency generator which we have design shows the excellent phase noise characteristics as -113.77 dBc/Hz at an offset of 10 MHz from the carrier frequency of 9.943 GHz with an output power of 21.54 dbm thus by using the t- type resonator the oscillator cost and size reduces up to a great extant and the circuit performances increases. We are using impedance matching circuit to reduce the back oscillation which increases the circuit efficiency.

Keywords: Matching Network, Phase Noise, Reactance, Resonator, T-type resonator, VCO.

I. INTRODUCTION

The oscillator for x-band consists of low phase noise microwave oscillator circuit. To achieve low phase noise, the resonator-Q factor or a loaded Q should be high. As we know that resonator is the main part of microwave oscillator. There are various types of resonators available in the microwave like dielectric resonator (DR), hairpin resonator, and LC resonators and so on.

The above stated resonators are not compact in size and the Q factor of these resonators is lower than the T- type resonator. If we use dielectric resonator for high frequency applications than the size of the device is larger and the cost is also higher. If we use LC resonator for high frequency applications than there will be lead inductance and capacitance effects take place due to transmission line and the Q factor is low. So we are using T-type resonator which has high Q value and compact in size.

A T-type resonator is a combination of transmission lines which are in T shape as shown in fig.4. It can be fabricated on a micro strip planner transmission line by using this line; the size of the circuit reduces. The parasitic effects on these transmission lines are less. So this circuit can be used for the high frequency applications. As stated earlier this circuit has very low phase noise so it can be used for military applications, in satellites for communication, weather monitoring, in radar for air traffic control, defence tracking and maritime vessel traffic control. Due to shorter wavelength of X-band it provides high resolution imaging for target identification and discrimination.

II. MICROWAVE OSCILLATOR

Generally a microwave oscillator consists of an active device with negative resistance, a frequency determining network with a resonator at the input side and output impedance matching network at the output side. Here we are using an excellent low noise Hetero-junction FET (NE4210S01) as an active device and a high-Q Varactor diode (SMV1232-079LF) in the frequency selective network. The above mentioned device has low cost.

When we apply a fixed voltage across the Varactor diode than the reactance at the output of resonator is constant which decides the frequency of oscillation. If the applied voltage across the diode varies then the frequency of oscillation also varies due to variation in the reactance and the capacitance of the circuit.

T- Type resonator as shown in fig.1. The impedance Z_0 is 50 ohm and length of the transmission line L_1, L_2 and L_3 are 3mm, 4.14mm and 6.03mm respectively. The T- type resonator can be used as singal series microstrip line resonator by removing L_3 from the resonator circuit but the length is sensitive which changes the tunable reactance as compared to the T-type resonator.

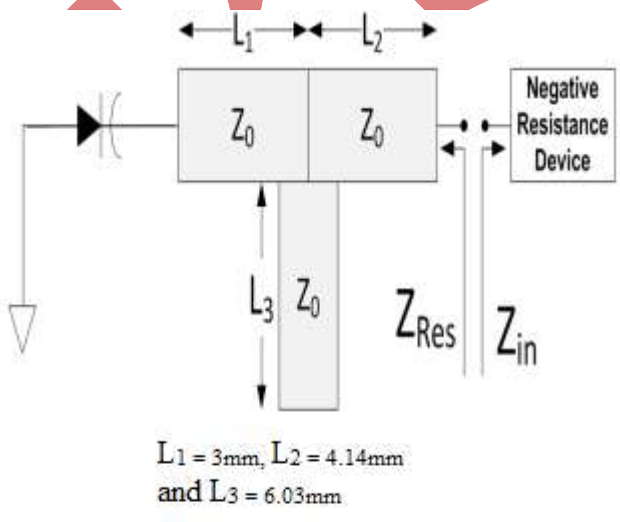


Fig.1 T-type resonator

As mentioned earlier the T-type resonator has high Q- value as:

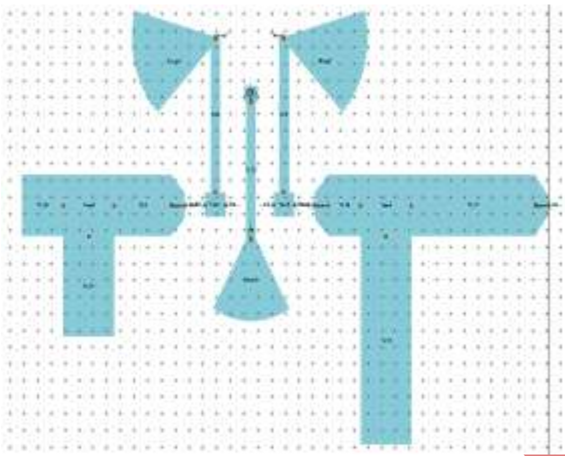
$$Q_L = W0 / \Delta W$$

Where ΔW is the difference in 3db bandwidth of insertion loss.

III. DESIGN AND SIMULATION

We have designed and simulated a Resonator which has high Q value and integrated with microwave oscillator. The negative of the circuit was designed in the PCB designing lab. The whole circuit was simulated and tested by the Agilent's ADS 2008 as shown in fig 2.

The T-type resonator has the DC blocking capacitor of 100nf and the microstrip line of 120 Ω. Which is shunted with a impedance (100 Ω) microstrip radial stub. Other blocking capacitors as shown in fig.4 are used with T network to block the DC sign also that only the RF signal power is coupled to the FET (NE4210S01).



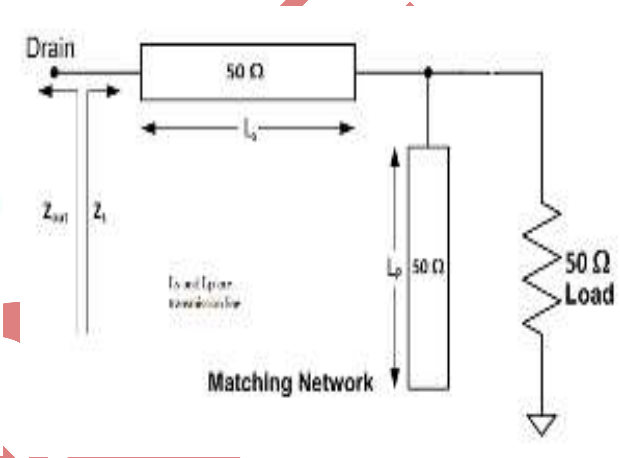


Fig.2 Schematic Layout Of The X- Band Oscillator Fig. 3 Output Impedance Matching Network

To unstable the transistor the positive feedback is applied with an external by pass capacitor of 1.5pf. The instability of the network is ensured by barkhusen's criteria as the stability factor for the unstable network should be less than 1.

Fig. 4 Fabricated Circuit of the X-Band Oscillator

The fabricated circuit as shown in above fig. 4 has all the parts of an oscillator. It has the frequency selective network that is resonator and the active device for oscillation as FET and at the output side the impedance matching network which reduces the back oscillations and provides the frequency signal for X-band.

IV DIMENSIONS OF THE CIRCUIT

The dimensions of the circuit are calculated by the Agilent's ADS. This has the facility to calculate the dimensions of all the transmission line and the angle of the radil stubs. By using we can find out the gaps between the terminals of the active and passive devices.

Table 1. Dimensions of the Oscillator Design

Structure		Width (mm)	Length (mm)
Resonator	for passive components	3.69	$L_1 = 3$ $L_2 = 4.14$ $L_3 = 6.03$
Output Matching Network	(a) Open Shunt Stub	3.69	12.53
	(b) Series transmission Line	3.69	2.36
Bias-Tee Network	(a) for varactor diode	0.7	9.3
	(b) for transistor's gate	0.7	9.3
	(c) for transistor's drain	0.7	8.456
	(d) Microstrip 60^0 radial stub(100nf)	0.31 $\theta = 60^0$	6.0
Negative resistance cell	Bypass capacitor(60 0 radial stub)	0.7 $\theta = 60^0$	4.85052
Gaps between microstrip lines	(a)for diode	0.7	8.456
	(b) for gate and source	2	
	(c) for source and drain	1.9	
	(e) for blocking Capacitor pad	2	

V RESULTS AND DISCUSSION

The fabricated microwave oscillator is shown in fig.4. The T-type resonator was measured using an Agilent (HP) 8510C vector network analyzer (VNA). The parameters of the designed hardware are shown in fig.5 and fig.6. When we apply reverse bias voltage across the transistor as V_{GS} = - 0.7 V and V_{DS} = +2 V than the oscillating frequency or output frequency is 9.9435 GHz which is an X-band frequency with an output power level of 21.5 dbm as shown in fig.6.

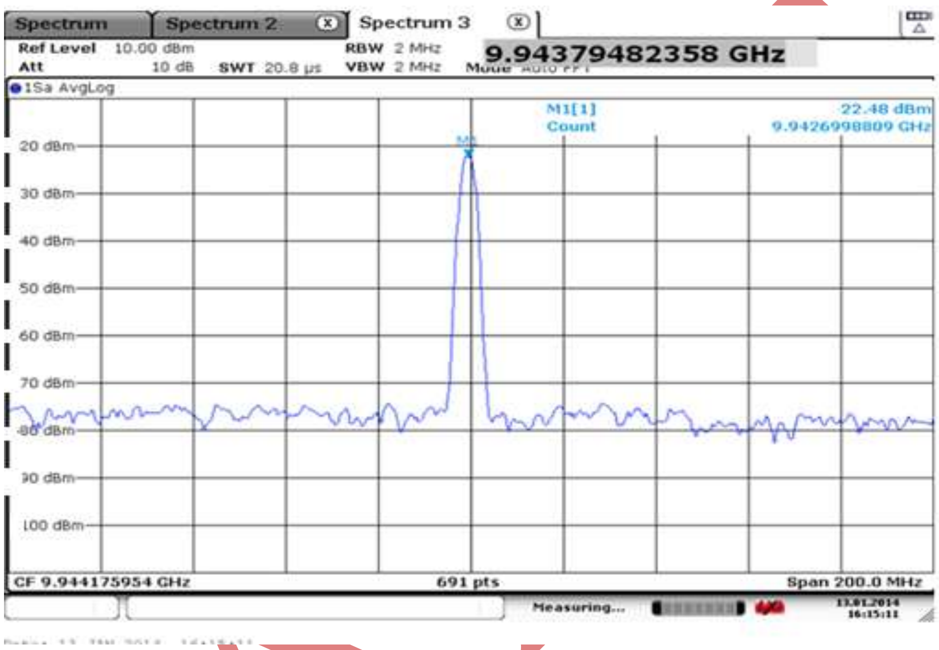


Fig.5 Output Characteristics

The phase noise is calculated using standard formula of phase noise shown in equation (1)

Phase Noise = PSideband–PCarrier–10*log10 (RBW) dB ………………………..(1)

Now we know that

$P_{carrier}$(at 9.943 GHZ) = 6.39

$(P_{sideband})_{upper}$ = 21.54

$(P_{sideband})_{lower}$ = 22.48

Now by the formula given in equation (1) we have calculated the phase noise that is -113.77 dbc/Hz. Which is better than the other oscillators as given in the table 2?

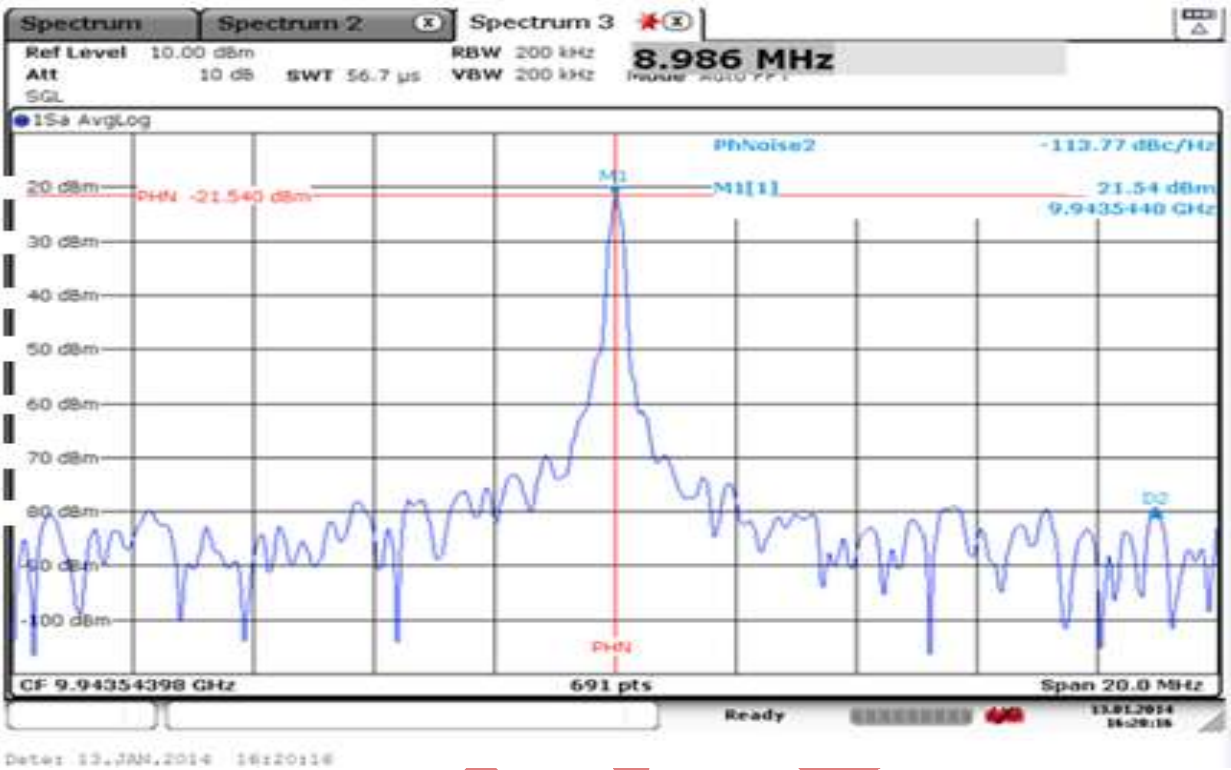


Fig.6 Output Characteristics

Comparison of the present result with reported results

Table 2. Comparison of Present Result with Previous Results

References	Oscillation Frequency (Ghz)	Output Power (dbm)	Phase noise (dbc/hz)
2002[1]	10	10.16	-95.6
2006[2]	10	6	-92
2007[4]	9.2	10.87	-101.4
2011[5]	9.09	15.23	-103.08
Present work	9.94	21.54	-113.77

IV CONCLUSION

The microwave oscillator with T- type resonator was designed, fabricated and characterized for X–band applications. The oscillator designed by using T- type resonator has very low phase noise as -113.77 dbc/Hz offsets with the output power of 21.54 dbm. The overall size, phase noise and output power level have been discussed. The proposed oscillator is possible to fabricate commercially at a lower cost and smaller size and it is ready to use in the X- band applications in microwave circuits.

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