行政院國家科學委員會專題研究計畫　期中進度報告

子計畫五：本地振盪電路之研製(2/3)

計畫類別：整合型計畫
計畫編號：NSC91-2219-E-002-018-
執行期間：91 年 08 月 01 日至 92 年 07 月 31 日
執行單位：國立臺灣大學電信工程學研究所

計畫主持人：瞿大雄

報告類型：精簡報告
報告附件：出席國際會議研究心得報告及發表論文
處理方式：本計畫可公開查詢

中　華　民　國 93 年 11 月 1 日

行政院國家委員會專題研究計畫期中進度報告

38GHz無線收發系統關鍵元組件技術 子計畫五：本地振盪電路之研製(2/3)

Research on local oscillators (2/3)

計畫編號：NSC91-2219-E-002-018
執行期限：91年8月1日至92年7月31日

計畫主持人：瞿大雄 教授 國立台灣大學電信工程學研究所

一、 中文摘要

本計畫為一三年計畫(90年至93年)，配合整合型計畫「38-GHz無線收發系統關鍵元組件技術」，進行其關鍵元組件-本地振盪器之研發。本計畫之重點有三：一為研製一適用於38-GHz無線收發系統之本地振盪器。二為建立振盪器陣列之理論推導、分析公式、電路研製及實驗量測。三為進行振盪器陣列之應用研究。

本報告係敘述第二年之研究成果，主要敘述本地振盪器之研製，以及N-推式耦合振盪器陣列之研製，及其理論分析與實驗量測結果。

關鍵詞：本地振盪器、振盪器陣列。

英文摘要

This is a three-year project (from 90/8 to 93/7) to conduct researches on the local oscillators under the main project “Key component technology of a 38 GHz wireless transmitting/ receiving system”. The major tasks of this project are the following three items. The first item is to implement the local oscillator circuit for 38GHz transmitting and receiving sytem. The second item is to develop the basic theory, formulation, circuits and measurement of the local oscillator array. The third item is to develop the active antenna array using oscillator array.

In this second-year report, the study results are mainly focused on the development of a 36GHz local oscillator, and a novel approach of Nth-harmonic oscillator using an N-push coupled oscillator array.

二、 計畫緣由與目的

Oscillator is an important component in a wireless system. It is required to provide a stable, low phase noise and medium power for the up-converter and down-converter operation. In the system design of 38GHz transmitter and receiver for this project, the local oscillator frequency is selected to be 36GHz, and is required to provide 10dBm for frequency converter. A frequency synthesizer is designed by another project to provide the 2.25GHz signal. This then leads the main feature of 36GHz local oscillator to be a multiplier chain structure. In this second-year report, we will describe the circuit implementatuin using direct multiplication structure.

For the oscillator array study, in this second year we developed a novel approach for N-th harmonic oscillator using N coupled oscillator array. Push-push oscillator is commonly used for implementing a second-harmonic oscillator [1]. By combining two out-of-phase oscillators, their fundamental frequency components are canceled and the second-harmonic components are enhanced. This structure can be extended to triple-push [2], quadruple-push and hence N-push harmonic oscillators.

From the oscillator injection-locking phenomenon, the relative phase between coupled oscillators can be controlled by the oscillator free-running frequency. As the output phase-shifted signals are properly shaped and combined, the desired harmonic components are constructively added and lower-order harmonic components are suppressed. This structure can be viewed as the general case of push-push oscillators. Since the output power is combined in a passive circuit, it does not suffer from the power limit of the output device in the cascade structure. The desired harmonic component can be selected by tuning the relative phase of the coupled oscillators and the conductive angle of the following voltage-clamping circuit. The second-harmonic, third-harmonic and fourth-harmonic oscillators are designed and verified experimentally.

三、 研究方法及成果

I. 36GHz local oscillator

Figure 1 is the block diagram of a 36GHz local oscilltor designed for 38GHz transmitter and receiver. The input signal is a –9dBm 2.25GHz CW signal from a synthesizer. This signal is then properly amplified, filtered and multiplied through a x2-x2-x4 multiplier chain to give a 36GHz 10dBm signal. Figure 1 shows the signal power/gain budget and the devices used.

Two sets of 36HGz local oscillators are implemented as shown in Fig.2. Each set containes two boxes with one x4 multiplier from 2.25GHz to 9GHz, and another x4 multipler from 9GHz to 36GHz. Figure 3(a) shows the measured results of the x4 multiplier from 2.25GHz to 9GHz, and Fig.3(b) is the measured result of the x4 multiplier from 9GHz to 36GHz. These two oscillators have been integrated with the 38GHz transceiver for vedio signal transmission demonstration.

II. N-th harmonic oscillator using N coupled oscillator array

The operation of the developed Nth-harmonic oscillator is illustrated in Fig.4. For an Nth-harmonic oscillator, an array of N coupled oscillators is used to produce N duplicates of oscillation signals with 360°/N phase difference between adjacent elements.

Following the oscillator in each path, a voltage-clamping circuit is used to control the conductive angle of the output signal. Comparing to the conventional push-push oscillator, which only utilizes the harmonic component in the oscillation signal, this voltage-clamping circuit can enhance the nonlinear effect. The optimal clamping voltage depends on which harmonic is desired [3]. Usually, the voltage-clamping circuit is operated as a class C amplifier (or class B for the second-harmonic oscillator). Another advantage of the voltage-clamping circuit is that the transistor operated as a class C amplifier is closed to a unilateral two-port network. Therefore, the output power combining circuit and inter-stage matching circuits can be designed independently. The pulling effect is also reduced due to the isolation between the load and the oscillators.

While combining the output signals from N signal paths, the desired harmonic components are added constructively and the lower-order harmonic components are canceled out due to the symmetry of the signal phases. For push-push oscillators, anti-symmetric phase between the two oscillators is easy to achieve. Some of them are achieved by using dielectric resonators (DR) [4]. As N>2, the phase control should be treated as a nonlinearly coupled oscillators problem [5].

The schematic circuit diagram of the developed Nth-harmonic oscillator is shown in Fig. 4. In this year, second-harmonic, third-harmonic and fourth-harmonic oscillators are designed. NE32684A HEMT devices are used for the oscillators and voltage-clamping circuits in a FR4 substrate.

Series feedback at transistor source terminal is used to produce negative resistance for oscillation. A short stub provides a DC return path, and an open stub makes the source terminal in series with desired impedance. BB131 varactor diode is used for tuning the oscillator free-running frequency. The coupling network is implemented by transmission lines terminated with resistors. Common-source class C (or class B) amplifiers are utilized in the voltage-clamping circuit.

Since the harmonic oscillator structure proposed is general for any order of the harmonic signals, second-harmonic, third-harmonic and fourth-harmonic oscillators are verified experimentally in this study. Figure 5(b) shows the output spectrum of a second-harmonic oscillator. The clamping voltage is –0.7 V, which is closed to class B operation. The second-harmonic signal level is 5.67 dBm, and the fundamental signal level is –36.88 dBm with about 42 dB lower. Fig. 5(c) shows the output spectrum of a third-harmonic oscillator. The clamping voltage is –0.95 V. The third-harmonic signal level is –10.83 dBm, and the fundamental signal level is –25.67 dBm, which is about 15 dB lower than the third-harmonic signal level. Fig. 5(d) shows the output spectrum of a fourth-harmonic oscillator. The clamping voltage is –1.1 V. The fourth-harmonic signal level is –10.83 dBm, and all the fundamental signal level, the second-harmonic signal level and the third-harmonic signal level are below –25 dBm.

四、結論與討論

In this report, a 36GHz local oscillator using direct-multiply approach is designed for 38GHz transmitter and receiver. In addition, by extending the operation principle of push-push oscillators to N-push oscillators, an Nth-harmonic oscillator is developed using a coupled oscillator array and voltage-clamping circuits. From the injection-locking phenomenon of oscillators, relative phase between coupled oscillator array elements can be controlled by the coupling network and the oscillator free-running frequencies. As the phase-shifted signals are properly shaped and added, the desired harmonic components can be combined constructively with lower-order harmonic components suppressed. This structure can be viewed as the general case of push-push oscillators.

五、參考論文

[1] F. X. Sinnesbichler, H. Geltinger, and G. R.

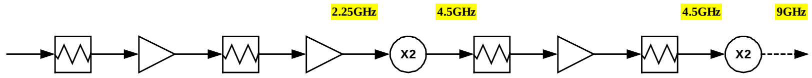
Olbrich, "A 38-GHz push-push oscillator based on 25-GHz f_t BJTs," *IEEE Microwave Guided Wave Lett.*, vol. 9, pp. 151-153, April 1999.

[2] Y. L. Tang, and H. Wang, “Triple-push oscillator approach: theory and experiments,” *IEEE J. Solid-State Circuits*, vol. 26, no. 10, October 2001.

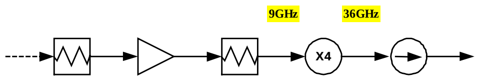
[3] S. A. Maas, *Nonlinear Microwave Circuits*, Norwood: Artech House, 1988.

[4] F. X. Sinnesbichler, H. Geltinger, and G. R. Olbrich, "A Si/SiGe HBT dielectric resonator push-push oscillator at 58 GHz," *IEEE Microwave Guided Wave Lett.*, vol. 10, pp. 145-147, April 2000.

[5] R. A. York and T. Itoh, “Injection- and phase-locking techniques for beam control”, *IEEE Trans. Microwave Theory and Tech.*, vol. MTT-46, no. 11, pp. 1920-1929, November 1998.



	Attenuator	VNA-25	Attenuator	VNA-25	KBA-20	Attenuator	HMC326MS8G	Attenuator	HMC204C8	
Stage Gain (dB)	-6	15	-6	15	-16	-4	21	-4	-15	
Power Level (dBm)	-9	-15	0	-6	9	-7	-11	10	6	-9

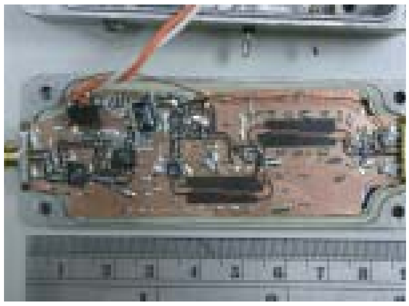


	Attenuator	Amplifier	Attenuator	CHX2092	2W9NT	
Stage Gain (dB)	-3	27	-3	0	-1	
Power Level (dBm)	-9	-12	15	12	12	11

Local Oscillator Link Budget Caculation

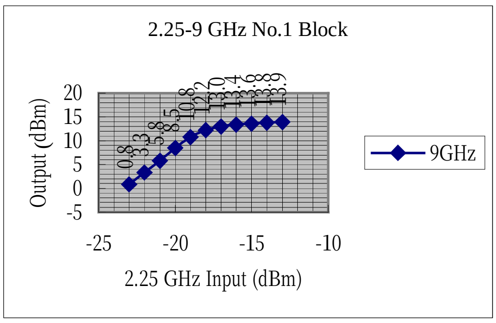
Fig.1 Power/gain budget of the designed 36GHz local oscillator.

(a)

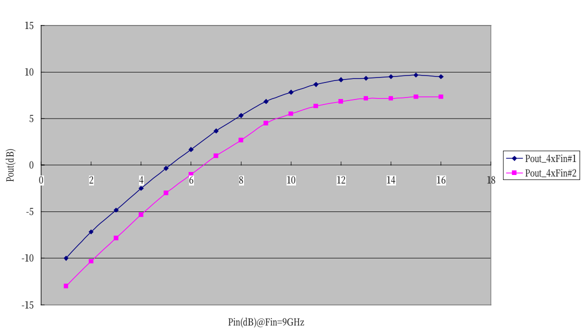


(b)

Fig. 2 (a) 36GHz local oscillator and (b) x4 multipler from 2.25GHz to 9GHz.



(a)



(b)

Fig. 3 Measured results of (a) x4 multipler from 2.25GHz to 9GHz and (b) x4 multipler from 2.25GHz to 9GHz.

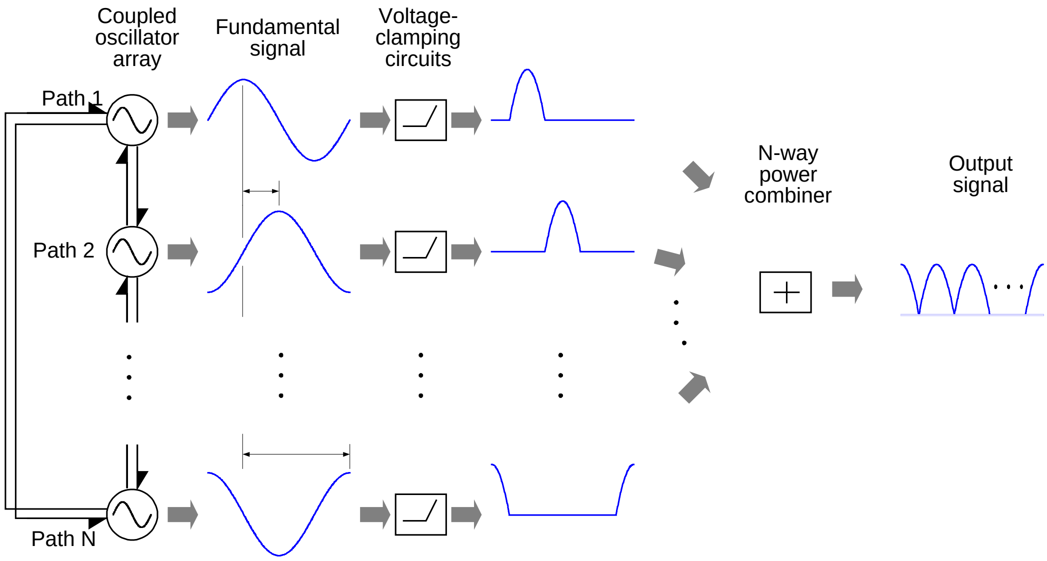
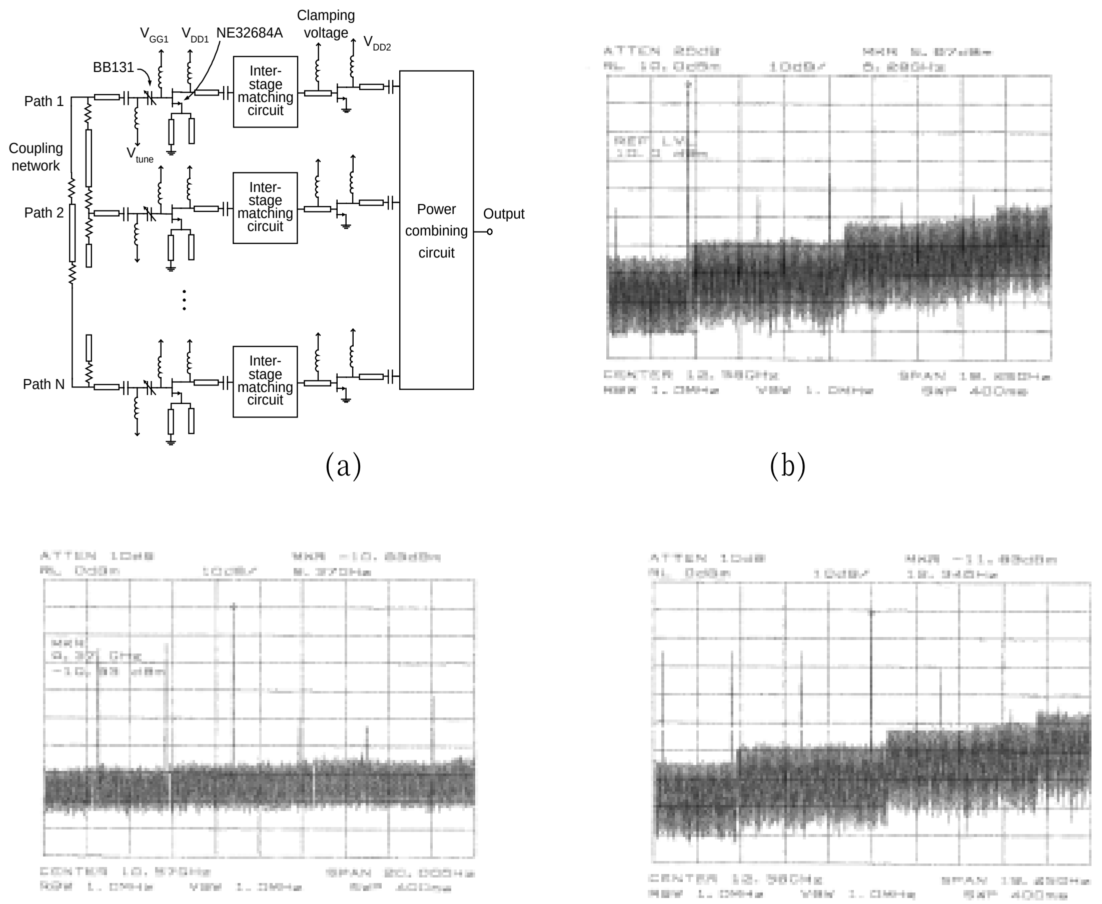


Fig.4 Block diagram of an Nth-harmonic oscillator.



(a) (b)

(c) (d)

Fig.5 (a) Schemetic circuit of Nth-harmonic oscillator, and measured results of (b) double-push (c) triple-push (d) quadrture-push oscillator array.