

## **INJECTION LOCKED 100 GHz LO NETWORK, FOR A 32 CHANNEL 220 GHz IMAGING ARRAY**

Israel Galin<sup>1</sup>, David S Zacharias<sup>2</sup>

<sup>1</sup>GenCorp Aerojet - P.O. Box 296, 1100 W. Hollyvale St., Azusa, CA 91702

<sup>2</sup>ZAX, Millimeter-Wave Corporation - 555 W. Allen Ave., San-Dimas, CA 91773

### **Abstract**

Multi-channel array receivers, for millimeter-wave (MMW) imagers, require local-oscillator distribution network with challenging electrical and packaging performance. This paper presents a local-oscillator (LO) distribution network driving 32 subharmonic (X2) mixers, of a 220 GHz imaging array. The LO distribution network features 32 outputs - each injection-locked and phase controlled relative to a master oscillator - yielding more than 20 mW power at each output. The waveguide network configuration facilitates LO distribution to a compactly packaged, 12" linear array of mixers. The paper provides a complete description and data for this MMW LO distribution network.

### **LO/Mixer Technological Mismatch, Creates Challenges/Opportunities**

Designers of MMW multi-channel receiver front-ends face a challenge/opportunity, originated with the mismatch between the available local-oscillators (LOs) output power, and the required LO drive for mixers. MMW LOs employing InP Gunn devices are designed for maximum possible output power - typically ~50 mW at 100-150 GHz - while individual mixers require LO drive typically of only ~10 mW.

Hence, single MMW LOs are capable of driving 2-4 separate mixers, simultaneously, through LO power divider networks. Larger MMW multi-channel receivers ( $\geq 5$  mixers) require LO power combining/coherent networks and LO power dividing networks. The added complexity of multi-channel MMW receivers promise in fact, economical and technical system enhancements. In the final analysis, LO distribution networks may facilitate system cost reduction, reduction in DC power consumption per receiver channel, and/or reliability augmentation through efficient LO redundancy.

This paper presents a local-oscillator distribution network embodied in a compact, efficient, and relatively simple structure, which is driving 32 subharmonic (X2) mixers of a 220 GHz imaging array. This LO distribution network is implemented as a simple network of separate oscillators, frequency injection locked and then phase matched, to yield coherent outputs - avoiding the complications commonly associated with power combining networks.

## **LO Distribution Network - Structure Description**

Figure 1 depicts the 32 output 100 GHz LO waveguide distribution network (produced by ZAX Millimeter Wave Corporation) which consists of sixteen free-running output oscillators, each employing a single InP Gunn device. Each output oscillator feeds separately a 1:2 power divider (matched terminated magic-T), yielding thirty-two outputs. A three port circulator yields a nominal 20 dB isolation - to minimize load pulling - between each free running oscillator and its respective pair of loads, at the 1:2 power divider outputs. Each circulator also facilitates frequency injection locking, of each of the sixteen free-running output oscillators, to a single master oscillator, through a 1:16 power divider (a network of 15 matched terminated magic-Ts). Finally, the LO distribution network's thirty-two outputs are separately provided with adjustable phase shifters yielding, in addition, to a single frequency locked outputs also outputs phase matching.

All oscillators are biased through separate voltage regulators - to minimize pushing effects.

This LO distribution network is compactly packaged to accommodate all 32 output ports in a linear 12" array, for interface with a similar size array of 200 GHz subharmonic (X2) pumped mixers [1].

## **LO Distribution Network - Electrical Characteristics**

Some of the most important electrical parameters of this LO distribution network feature:

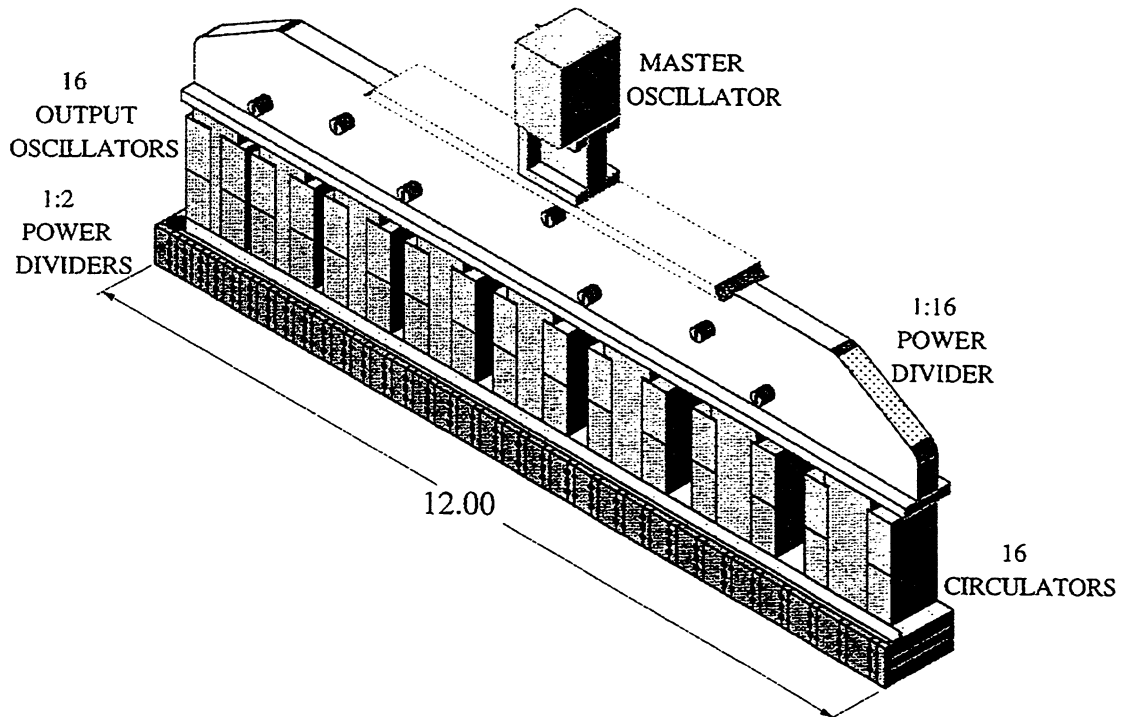
- ◆ A DC power consumption of all seventeen oscillators combined approximates 30 W, with a total current of 3.4 A (1.5-2.2 W per oscillator) - resulting in LO DC consumption of ~0.9 W, per receiver channel.
- ◆ Each of the 32 output ports provides a minimum of 20 mW of power at 100 GHz.
- ◆ Each of the 16 output oscillators delivers a minimum of 50 mW power.
- ◆ The master oscillator output power is some 75 mW providing an injection power of some 3 mW to each output oscillator.
- ◆ The frequency-versus-temperature coefficients of all oscillators (master or outputs) are matched, and each oscillator is set for 1-2 MHz/°C - designed to insure a frequency locking band over some 100-200 MHz (locked frequency over a 25±15 °C operating temperature).

## **Acknowledgment**

The work described in this paper was carried out and funded in part under a NASA contract NCC1-203.

**Reference**

- [1] I Galin, "A 220 GHz Subharmonic (x2) Mixer - For Ultra-Wideband Array Applications", The 20th International Conference on IR and MM-Waves, Orlando 1995.



**Figure 1**

**100 GHz LO waveguide distribution network - 32 output ports packaged in a linear 12" array.**