A WAVEGUIDE-BASED COUPLED OSCILLATOR ARRAY INTEGRATED WITH A VOLTAGE-TUNABLE FREQUENCY SELECTIVE SURFACE FOR SPATIAL POWER COMBINING

YU LOU

DOCTOR OF PHILOSOPHY
CITY UNIVERSITY OF HONG KONG
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In recent years, research on quasi optical or spatial power combining techniques becomes more and more attractive due to the burgeon of wireless communications, such as telecommunication, satellite communication and radar systems, which trends to operate at higher frequency bands due to the exponentially increasing demands on bandwidth and high data rate. Due to the physical limitations of semiconductor devices, power from many devices should be combined together to meet the system requirements. However, as a matter of fact, the loss of any transmission structures at such frequency bands is really a serious issue which limits the use of conventional incorporating power combining approaches such as Wilkinson power combiner and compels the advent of new power combining methods. One of them is the quasi optical or spatial power combining technique in either free space or a closed cavity filled with air or dielectric materials, for which the combining is conducted in a low-loss medium, employing active circuit element such as amplifier, oscillator or mixer.

In this work, a spatially combined oscillator array is discussed. For this waveguide-based design, oscillators are coupled together within a common cavity resonator for synchronization and efficiently combined at the output waveguide. Both input and output sides of the oscillators are coupled using wideband waveguide-to-microstrip transition array, to conduct the power combining in a spatial way in a standard WR90 rectangular
waveguide.

The oscillation cores are designed with the negative resistance method. The MESFETs are properly biased and terminated so that the negative resistance of the active devices is large enough to cancel the loss of the resonator to meet the oscillation condition in both small signal and large signal cases.

In this research, the spatially combined oscillator array is synchronized using a common cavity resonator. To build a voltage controlled oscillator, a voltage-tunable frequency selective surface (VTFSS) is integrated within the cavity as a reflection phase tuner so that the electromagnetic characteristics of the common cavity resonator are electrically controllable. This spatially tunable design is advantageous in terms of simplicity especially for the waveguide design where available space is rather limited, because all the oscillators are tuned by a single voltage bias instead of the application of bias tuning upon each one of them.

To further enhance the output power level of the oscillators, a buffer stage is added at the outputs of the oscillator MESFETs. Not only does the buffer act as a gain block to the circuits, it also provides isolation, e.g. $S_{12}$ of a BFP740F transistor is around -15 to 20 dB, between oscillators so that the only significant coupling between oscillators is the one conducted through the common resonator with voltage-tunable FSS integrated.

The thesis is arranged as follows. Firstly, a brief introduction will be given in Chapter 1, followed by a research background with previous work by other researchers in Chapter 2.

After the background information on spatial power combining, all the components of the system will be discussed in detail through Chapter 3-6. The tolerance and fabrication problems are covered
in Chapter 7 for completion and conclusion will be drawn in Chapter 8.
CONTENTS

Abstract .......................................................................................................................... i
Acknowledgements ....................................................................................................... iv
Table of Figures ........................................................................................................... viii

Chapter 1 Introduction ................................................................................................. 1
  I. Motivations of Spatial Power Combining .............................................................. 1
  II. Spatial Power Combiners: Tile-Type vs. Tray-Type ........................................ 4
  III. Mutually-Coupled Oscillator Design and Injection-Locking Techniques .. 6

Chapter 2 Research Background ................................................................................. 8
  I. Classification of Power Combining Techniques ................................................... 8
  II. Background History of Quasi Optical Power Combining .............................. 9
     i. General Concepts and some clarifications ................................................. 9
     ii. Early Works on Spatial Power Combining ........................................... 10
     iii. Recent Work on Quasi Optical Power Combining ............................ 11
  III. This work ......................................................................................................... 15

Chapter 3 Waveguide-to-Microstrip Transitions and Their Applications .18
  I. Introduction .......................................................................................................... 18
  II. Rectangular Waveguide-to-Microstrip Transition ........................................... 20
     i. Structure of the Transition ......................................................................... 21
     ii. Design of the Finline Taper .................................................................... 21
     iii. The Sotline-Microstrip Transition ............................................................ 26
  III. Simulation and Measurement for the Proposed Transitions ....................... 28
  IV. Evaluation on the Effect of Mounting Grooves ............................................. 32
  V. Application of Phase Reversal Concept in Push-Push Oscillator Design .. 34
VI. Conclusion ........................................................................................................... 41

Chapter 4 Voltage Tunable Frequency Selective Surface Design .... 42
I. Introduction ........................................................................................................... 42
II. Structure and Data of the Tunable FSS ............................................................ 44
III. Cancellation OF Bonding Wire Inductance ................................................... 52
IV. Design and Implementation of the on-Board Inter-Digital Capacitor ... 56
   i. Conventional Inter-Digital Capacitor ............................................................ 56
   ii. Inter-Digital Capacitor with DC Path (one pair of finger connected) .... 59
   iii. Inter-Digital Capacitor with DC Path Used in the VTFSS ...................... 61
V. Final design of the VTFSS .............................................................................. 64

Chapter 5 Oscillation Core Design ................................................................. 67
I. Design Flow of the Whole System ................................................................. 67
II. Basic Oscillator Theory ............................................................................... 69
III. Oscillator Core Design ............................................................................... 72
IV. Conclusion ..................................................................................................... 79

Chapter 6 Test of The Whole System ............................................................ 80
I. Introduction on the Modules ........................................................................... 80
II. Mechanical Tunable Oscillator in Waveguide Environment ....................... 83
III. Single Oscillator Tuned with VTFSS with Coax Output ......................... 86
IV. 2 by 2 Coupled Oscillator Array with Coax Output .................................. 87
V. 2 by 2 Coupled Oscillator Array with Waveguide Output ......................... 89
   i. Introduction .................................................................................................. 89
   ii. Experimental Data on the Unbuffered Array .......................................... 90
   iii. 2 by 2 Waveguide-Based Coupled Array with Buffer LNA .............. 96
VI. Conclusion ................................................................................................... 102
Chapter 7       Fabrication and Tolerance Issue............................................. 103

I.  Design and Fabrication of the PCB ........................................................... 103
   i.  The Uniformity of the Array Elements ................................................. 103
   ii. The Loss from the Discontinuities ...................................................... 105

II. Fabrication of the Mechanical Parts......................................................... 105

III. Tolerance of the Design......................................................................... 106

Chapter 8       Conclusion ............................................................................. 107

Appendix ........................................................................................................ 110

References ..................................................................................................... 120
### TABLE OF FIGURE

Figure 1-1: Conventional power combining scheme ........................................... 2  
Figure 1-2: Tile-type Spatial power combining scheme ..................................... 4  
Figure 1-3: Tray-Type spatial power combining .................................................. 5  
Figure 2-1: Classification of Power combining techniques .............................. 8  
Figure 2-2: Analogy of optical and quasi-optical systems .............................. 9  
Figure 2-3: Active Grid Array ................................................................. 12  
Figure 2-4: E field on the transverse plane of a rectangular waveguide .......... 13  
Figure 2-5: Tile combiner with hard horn ...................................................... 13  
Figure 2-6: Hologram approach ............................................................... 14  
Figure 2-7: The proposed Design ............................................................... 15  
Figure 3-1: A 2-element waveguide-to-microstrip transition/splitter with 180  
  degree out-of-phase outputs and a 4-element transition/power splitter ........... 20  
Figure 3-2: Approximation of simulation for the finline ............................... 21  
Figure 3-3: Design procedures of a taper transition ..................................... 22  
Figure 3-4: Beta vs. position .................................................................... 23  
Figure 3-5: Beta vs. gap size for different frequencies ................................. 24  
Figure 3-6: Phase reversal concept used in the design ................................. 27  
Figure 3-7: Simulated scattering parameters of the transitions in back-to-back  
  configuration (PEC used for all metal layers) ........................................... 30  
Figure 3-8: Measured scattering parameters of the proposed transitions ........ 30  
Figure 3-9: Measured phase difference between the two output ports for the  
  2-element transition ........................................................................... 31  
Figure 3-10: Magnitude imbalance of the transitions ..................................... 31  
Figure 3-11: Measured phase difference between the two output ports for the  
  2-element transition ......................................................................... 32  
Figure 3-12: Measured results for the 2-by-2 transition array ....................... 33  
Figure 3-12: Effect on the scattering parameters with different groove depths . 33
Figure 3-13: Push-Push oscillators. ................................................................. 34
Figure 3-14: Structure of the coupling circuit................................................. 35
Figure 3-15: Simulated amplitude response. ................................................. 35
Figure 3-16: Simulated phase response......................................................... 36
Figure 3-17: Circuit diagram in ADS.............................................................. 37
Figure 3-18: Simulated Spectrum of the push-push oscillator. ..................... 38
Figure 3-19: Measured spectrum. ................................................................. 38
Figure 3-20: Spectrum with phase noise measurement. .............................. 39
Figure 3-21: Phase Noise Vs. offset frequency. ............................................. 40
Figure 4-1: Complementary split-ring resonator........................................... 44
Figure 4-2: Unit cell and the 4 by 2 VTFSS. .................................................. 45
Figure 4-3: Simulated data for the FSS with different capacitor loaded (0.25pF to 1.25pF) ........................................................................................................... 46
Figure 4-4: Measured S parameters using lumped capacitors integrated with FSS cells. .............................................................................................................. 46
Figure 4-5: Characteristics of Infineon BB857 diode. .................................... 47
Figure 4-6: Measured S-parameters for BB857 diode loaded FSS................. 48
Figure 4-7: Phase response for the BB857 loaded FSS. ................................. 49
Figure 4-8: Photo of the module and the microscopic photo of the chip wirebonded on the substrate. ................................................................. 50
Figure 4-9: SMV2019 diode performance vs. frequency for different bias voltages ................................................................. 52
Figure 4-10: Chip with bonding wire: circuit diagram and simulation result. ... 53
Figure 4-11: simulation for different cancellation capacitors. ....................... 55
Figure 4-12: Inter-digital capacitor............................................................... 56
Figure 4-13: Simulated input impedance of the inter-digital capacitor .......... 57
Figure 4-14: Effective capacitance of the inter-digital capacitor ................. 58
Figure 4-15: Modified inter-digital capacitor with DC path......................... 59
Figure 4-16: simulated s parameter for the capacitor with one pair of figures connected for DC return. ................................................................. 60
Figure 4-17: Simulated impedance of the one-figure connected capacitor. ... 60
Figure 4-18: Effective capacitance of the one-figure connected capacitor. ...... 61
Figure 4-19: Inter-digital capacitor used in the VTFSS design ......................... 61
Figure 4-20: Simulated S-parameter for the interdigital capacitor in the vtfss design. ................................................................................................................ 62
Figure 4-21: Simulated impedance of the proposed capacitor. ......................... 63
Figure 4-22: Simulated effective capacitance of the proposed capacitor in the VTFSS. ............................................................................................................... 63
Figure 4-23: (a) 4 by2 VTFSS (b) unit cell with diode chip. .............................. 65
Figure 4-24: Measured reflected phase of the VTFSS using HP8051C .............. 66
Figure 5-1: Design flow of the whole system. .................................................... 67
Figure 5-2: Simulation setup in Agilent ADS. .................................................... 68
Figure 5-3: Basic oscillator structure................................................................. 69
Figure 5-4: Circuit diagram of the oscillator core. ............................................. 72
Figure 5-5: DC bias of the circuit...................................................................... 73
Figure 5-6: Reflection coefficient looking into the resonator. ............................ 74
Figure 5-7: Reflection coefficient looking into the transistor............................. 74
Figure 5-8: Loop gain at small signal. ............................................................... 75
Figure 5-9: Loop gain at large signal................................................................. 77
Figure 5-10: Loop phase at large signal............................................................. 77
Figure 5-11: Simulated sum of loop impedance at large signal ......................... 78
Figure 5-12: Simulated loop phase when the bias on VTFSS varies ................. 78
Figure 6-1: Full picture of the system ................................................................. 80
Figure 6-2: Waveguide module used in the experiments. ................................. 81
Figure 6-3: Mechanically tuned single oscillator with coax output. ................. 84
Figure 6-4: 2mm-thick mechanical-tuning slides used in the experiment .......... 84
Figure 6-5: Oscillation frequency of the mechanically tuned oscillator in waveguide. ............................................................................................................ 85
Figure 6-6: output spectrum for the single oscillator with different bias on the VTFSS (the loss of the connectors and cables are not calibrated). ...... 86
Figure 6-7: Test modules for the 2 by 2 coupled oscillator array with a coax output. ................................................................................................................ 87
Figure 6-8: Measured spectrum for the 2 by 2 coupled oscillators with a coax output.

Figure 6-9: Measured spectrum of the 2 by 2 coupled oscillator array without the buffer amplifier with waveguide output.

Figure 6-10: Measured spectrum when bias on the VTFSS varies from 0 volt to 20 Volts.

Figure 6-11: Measured spectrum at 50MHz span for single, two and four oscillator(s).

Figure 6-12: Measured spectrum at 20MHz span for single, two and four oscillator(s).

Figure 6-13: Buffered oscillator array.

Figure 6-14: Simulated s-parameters for the BFP740F buffer amplifier.

Figure 6-15: Measured spectrum of the buffered oscillator array.

Figure 6-16: Measured spectrum at 100MHz span.

Figure 6-17: Measured spectrum at 10 MHz span.

Figure 6-18: Tuning of the buffered oscillator array.

Figure 7-1: Design of the resonator.

Figure 7-2: Faricated finline.

Figure 7-3: Surface of the waveguide wall.