

Wideband Class-B Power Amplifiers

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Abstract

Wideband Class-B power amplifier is required in Modern communication systems. The bandwidth limitation of Class-B Power amplifier is generally caused by the narrow band 2nd harmonic short. In this thesis the methods of 2nd harmonic manipulation in Class-B power amplifier are discussed.

In the beginning, the current and voltage waveforms at output of the amplifier are analyzed, and a series of load configurations which can give good performance in Class-B power amplifier is given.

In single-ended topology the traditional 2nd harmonic short networks are band limited and interaction between fundamental impedance and 2nd harmonic impedance limited the performance of short networks. Introducing varactors into the short networks the bandwidth of amplifier is extended. Performance of commercial varactor is restricted by the breakdown voltage and package parasitic. A 32% relative bandwidth Class-B power amplifier is realized with the 90 V break down voltage varactors from the Aeroflex central frequency of the amplifier is 1 GHz, the drain efficiency is above 65% over the frequency band.

In differential topology the fundamental signal and 2nd harmonic are isolated, which provides convenience for wideband design. In practical design the bandwidth limitation is generally caused by the non-idea transformer in fundamental matching, compensation capacitors are required at primary of transformer. In low power condition, the 2nd harmonic short bandwidth can be extended by using the coupling between primary inductors. Two loops structure is applied in this case. In high power design, the 2nd harmonic is shorted though the large compensation capacitors. One loop structure is applied in this condition. In simulation result these structures can provide 50% to 70% relative bandwidth, which indicates their potential in wideband Class-B design.

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Contents

Abstract	III
Acknowledgements	IV
Chapter 1. Introduction	1
Chapter 2. Class-B Power Amplifier.....	3
2.1. Waveform Analysis	3
2.1.1. Current Waveform.....	3
2.1.2. Voltage Waveform	5
2.2. Inverse Class-B Power Amplifier	10
2.3. Topologies of Class-B power amplifier	11
2.3.1. The Single-Ended Topology	11
2.3.2. The Differential Amplifier Topology	12
Chapter 3. The Single-Ended Topology.....	15
3.1. Short Network.....	15
3.1.1. QWTL.....	15
3.1.2. Resonator.....	19
3.2. Tunable Short Network.....	24
3.2.1. Equivalent Circuit of Transmission Line	24
3.2.2. Tunable Transmission Line	25
3.2.3. Tunable Series Resonator	27
3.3. Using Varactor in an Ideal Amplifier	28
3.4. Practical Realization	29
3.4.1. Varactor and transistor	29
3.4.2. Output Design	31
3.4.3. Input Design	38
3.4.4. Layout and Measurement Results	40
Chapter 4. The Differential Class-B Amplifier	43
4.1. Performance of Balun	44
4.1.1. Fundamental Matching.....	44

4.1.2. 2 nd Harmonic Short.....	49
4.2. Performance of Ideal Inductors Made Balun	50
4.3. Practical Realization	54
4.3.1. Two Loops Structure	54
4.3.2. One Loop Structure	58
4.4. Summary.....	63
Chapter 5. Conclusion and Recommendation	65
5.1. Conclusion	65
5.2. Recommendation	65
5.2.1. Matching Network Design	65
5.2.2. Tunable QWTL	66
5.2.3. Differential Structure with Bondwire	66
Appendix A. Class-B PA Voltage Waveform Analyze	67
Appendix B. Abrupt Junction Varactor Diode	71
Appendix C. Bond Wire Characteristic	75
Bibliography.....	77

List of Figures

Figure 1-1. Conventional architecture of a transmitter	1
Figure 2-1. Input voltage and output current waveforms of amplifier.....	3
Figure 2-2. Relation between conduction angle and efficiency.....	5
Figure 2-3. Voltage waveforms with different b	7
Figure 2-4. Verify Class-B theory	9
Figure 2-5. Current and voltage waveform of inverse Class-B power amplifier.....	10
Figure 2-6. Topology of power amplifier with 2 nd harmonic short network	11
Figure 2-7. Desired impedance variation trend	11
Figure 2-8. Differential structure.....	12
Figure 3-1. Reactance of QWTL with different characteristic impedance	15
Figure 3-2. Ideal power amplifier with QWTL 2 nd harmonic short network.....	16
Figure 3-3. Frequency performance of ideal amplifier with QWTL	17
Figure 3-4. QWTL with different shunt capacitor	18
Figure 3-5. Performance of QWTL in ideal amplifier.....	19
Figure 3-6. Reactance of series resonator with different inductance	19
Figure 3-7. Performance of amplifier with series resonator	20
Figure 3-8. Series resonator parallel capacitor	21
Figure 3-9. Performance of amplifier with series resonator and output capacitor.....	21
Figure 3-10. Series resonator parallel inductor.....	22
Figure 3-11. Parallel resonator with different inductance	23
Figure 3-12. Performance of amplifier with parallel resonator and output capacitor	23
Figure 3-13. Equivalent circuit of transmission line.....	24
Figure 3-14. Tuning effect of shunt capacitance	27
Figure 3-15. Series resonator with varactor.....	27
Figure 3-16. Performance of QWTL with different quarter wave frequency	28
Figure 3-17. Performance of tunable QWTL in ideal amplifier	28
Figure 3-18. CGH40060F Package Model	29
Figure 3-19. Varactor used in design.....	30
Figure 3-20. Back to back connection of varactor.....	30

Figure 3-21. Quarter wave frequency for different transmission line lengths	31
Figure 3-22. Performance of CGH60060D with optimized load and perfect harmonic short	32
Figure 3-23. Frequency performance of amplifier with different characteristic impedance QWTL	32
Figure 3-24. Impedance variation of shorted QWTL and three sections matching network	33
Figure 3-25. Schematic of amplifier with ideal component	33
Figure 3-26. Simulation result with ideal component.....	34
Figure 3-27. Biasing of back to back connected varactors	35
Figure 3-28. Output schematic of tunable Class-B power amplifier	36
Figure 3-29. Impedance variation of practical transmission line.....	36
Figure 3-30. Selection of matching network	37
Figure 3-31. Performance without stabilization network	38
Figure 3-32. The schematic of stabilization network	39
Figure 3-33. Input schematic of tunable Class-B power amplifier	39
Figure 3-34. Layout of tunable Class-B power amplifier	40
Figure 3-35. Simulation result of tunable Class-B power amplifier with momentum data	40
Figure 3-36. Measurement result of tunable Class-B power amplifier.....	41
Figure 3-37. Picture of tunable Class-B power amplifier	42
Figure 3-38. Compare measurement result and simulation result	42
Figure 4-1. Schematic of Ideal differential power amplifier	43
Figure 4-2. Performance of ideal differential Class-B power amplifier	43
Figure 4-3. Structure of balun.....	44
Figure 4-4. Coupling among three inductors	44
Figure 4-5. Equivalent circuit for fundamental signal	45
Figure 4-6. Equivalent circuit for fundamental matching.....	45
Figure 4-7. Connection of the compensation capacitor	46
Figure 4-8. Effect of shunt and series compensation capacitor	47
Figure 4-9. Bandwidth of compensation structure.....	48
Figure 4-10. 2 nd harmonic path in differential structure	49
Figure 4-11. Schematic of testing differential amplifier.....	50
Figure 4-12. Frequency performance of balun with different k1	51
Figure 4-13. Impedance convert rout.....	51

Figure 4-14. Effect of k2 in fundamental matching and second harmonic short the compensation capacitor is shunted.....	52
Figure 4-15. Effect of connection of compensation capacitor	53
Figure 4-16. Simplest structure for coupling line	54
Figure 4-17. Secondary winding place inside primary winding	55
Figure 4-18. Simulation result of two loops structure when secondary winding place inside primary winding.....	56
Figure 4-19. Secondary winding place outside primary winding	57
Figure 4-20. Simulation result of two loops structure when.....	58
Figure 4-21. One loop transformer	59
Figure 4-22. Asymmetry coupling.....	59
Figure 4-23. Effect of large compensation capacitors in differential structure.....	60
Figure 4-24. One loop structure.....	60
Figure 4-25. Performance of one loop structure	61
Figure 4-26. Frequency performance of one loop structure	62
Figure A-1. Voltage waveform with phase difference $\pi/4 < \Delta\phi < \pi/2$	68
Figure A-2. Voltage waveform with phase difference $-\pi/2 < \Delta\phi < -\pi/4$	69
Figure B-1. Doping profile and equivalent circuit of the Abrupt Junction Varactor Diode	71
Figure B-2. C-V and Q-V of varactor.....	72
Figure B-3. Voltage swing on varactor.....	73
Figure C-1. Non-ideal transformer	75

List of Tables

Table 2-1. Comparison of Class-B and inverse Class-B.....	10
Table 3-1. Important parameter of substrate.....	31

Chapter 5.

Conclusion and Recommendation

5.1. Conclusion

In this work several topologies for Class-B power amplifiers are discussed. It had been shown that with a suitable setting of the fundamental and 2nd harmonic impedance over the frequency band, wideband performance could be achieved. Two structures are considered in this work.

The single-ended topology is easy to apply, but its wideband performance is affected by the interaction between the fundamental load and 2nd harmonic impedance. The candidates for a 2nd harmonic short network QWTL and series resonator are bandwidth limited. Varactors have been introduced to extend the bandwidth. The tuning ratio of varactor is restricted by the supply voltage of the amplifier. The tuning range of the quarter wave frequency and characteristic impedance of tunable QWTL are constrained by the capacitance variation of the varactors. All these factors limited the achievable bandwidth in a power amplifier. Also package parasitic of transistor and varactor reduce the bandwidth performance of the 2nd harmonic short network. In the end a 32% bandwidth power amplifier has been designed and realized.

The differential topology can separate the fundamental and 2nd harmonic signals. This proves to be a big advantage for wideband design. In the differential topology the balun is critical to the performance. The fundamental matching and 2nd harmonic short in differential topology using a non-ideal balun is discussed. Based on these conclusions bondwire based baluns are investigated to realize the function. The bandwidth performances of several bondwire configurations are discussed.

In practical wideband designs, the 2nd harmonic impedance cannot be manipulated to zero over the frequency band. Therefore, reducing the real part of 2nd harmonic impedance and manipulating its imagery part is a wise thing to do in wideband Class-B power amplifier design.

5.2. Recommendation

5.2.1. Matching Network Design

In chapter 2 we achieved the conclusion, that in order to get good performance the fundamental reactance should track with the 2nd harmonic impedance. In this work the design of matching network is generally based on the requirement of fundamental resistance, the variation of the reactance is not considered specifically. By carefully adjusting the parameters of the components and change the structure of the matching network, better performance might be possible to achieve.

5.2.2. Tunable QWTL

In tunable single-ended power amplifier, the bandwidth and performance of amplifier is limited by the breakdown voltage and capacitance of the varactor. If higher breakdown and larger capacitance varactors are available, better tunable power amplifier can be made.

In this work the tunable QWTL is used to short circuit the 2nd harmonic. There are still other ways to use QWTL in power amplifier. For example in Doherty power amplifier, the QWTL is served as impedance converter. Using a varactor based QWTL wideband performance can be achieved for the Doherty amplifier in a comparable way as what we did in this work. However, note that in an ideal Doherty power amplifier the characteristic impedance of impedance converter is constant. [25]. In our approach the impedance of tunable transmission line is changed with quarter wave frequency, so extra work is still required to avoid problems in the Doherty operation.

5.2.3. Differential Structure with Bondwire

Bondwires which directly connect to the die of the transistor can be used as circuit element and can provide better performance than those components at outside of transistor package. In this work the bondwires are used to implement a balun structure. Some interesting results are achieved in the end, which indicate the potential of this solution. This differential design is still in an initial stage so there might be other topologies and modifications that can be used to enhance the performance. The realization of the proposed topologies needs a detailed design study and more in depth simulations.

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