TU1B-1

Broadband Class-E Power Amplifier Designed by Lumped-Element Network Transforms and GaN FETs

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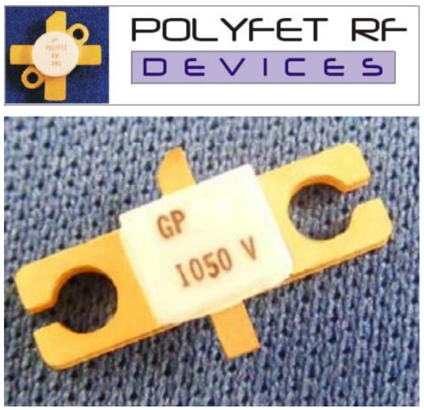
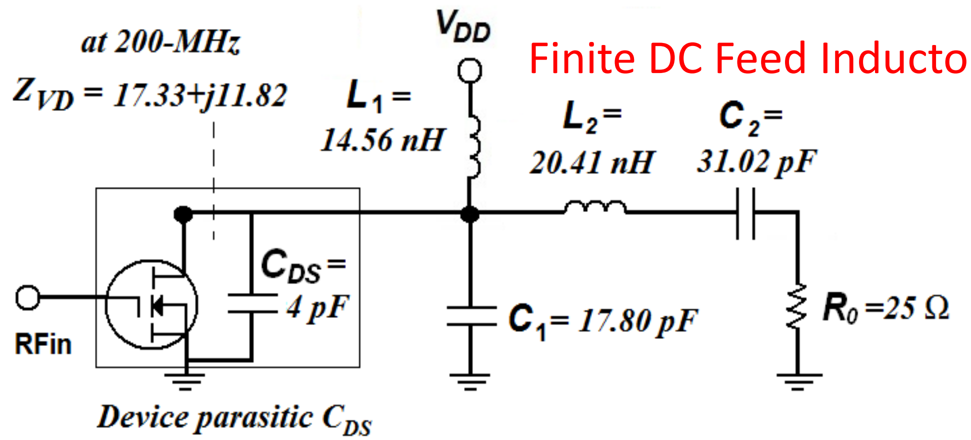
Outline

- Broadband Class-E Amplifier
- Network Transforms
- Transformation Sequence
- Output Network Topology Characteristics
- Prototype Performance
- Conclusions

Broadband Class-E Amplifier

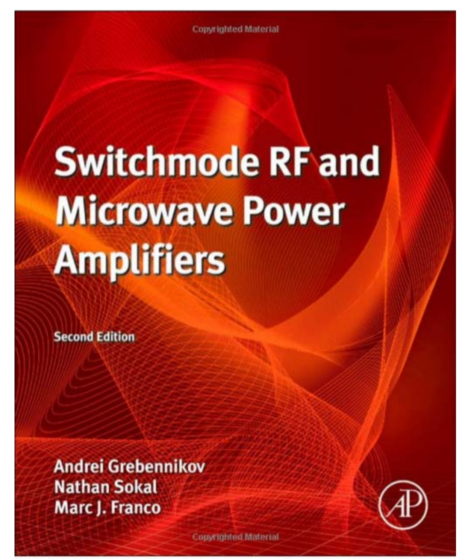


Polyfet GP2001
Coss=4pF

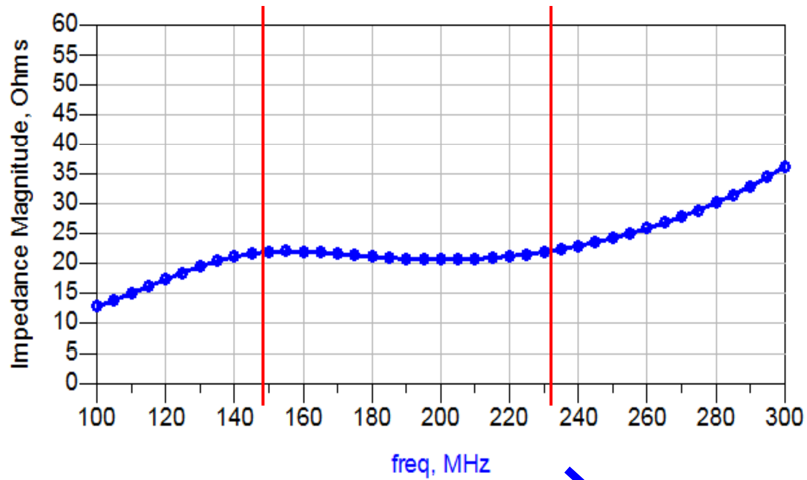


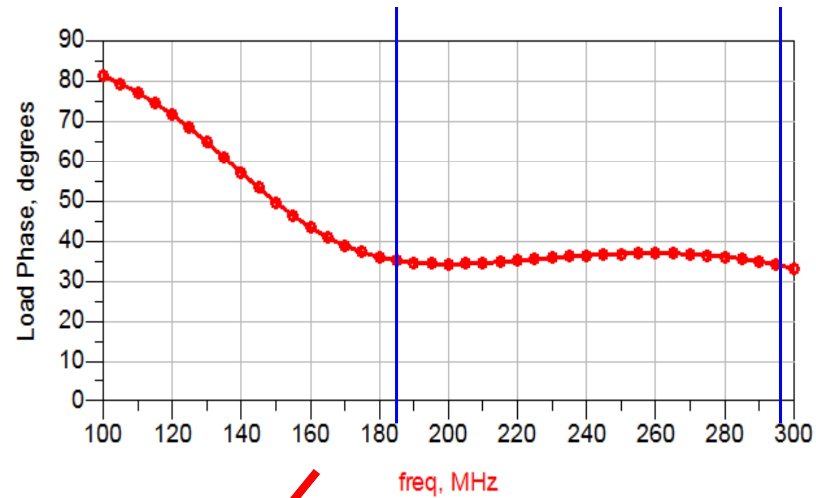
Design Frequency: 200-MHz
Output Power: 18-W (42.5 dBm)
Supply Voltage: 18.2 V
Load Resistance: 25-Ω

Switchmode RF and Microwave Power Amplifiers,
by Grebennikov, Sokal and Franco



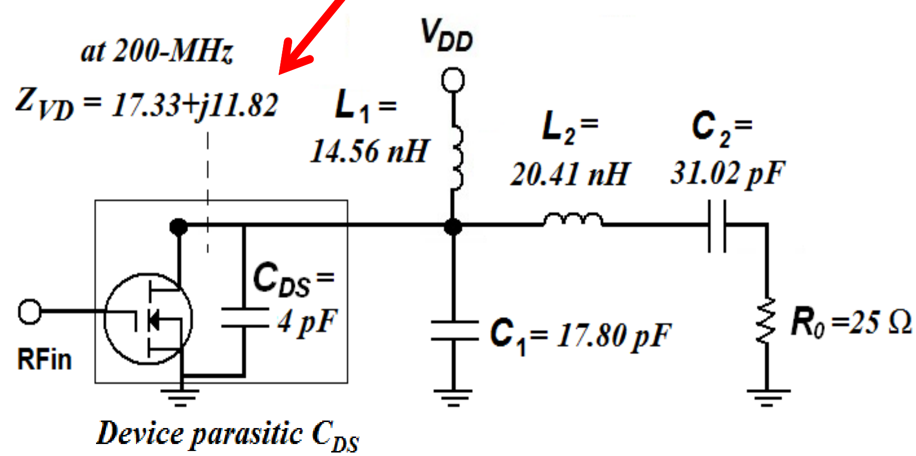
Broadband Class-E Amplifier



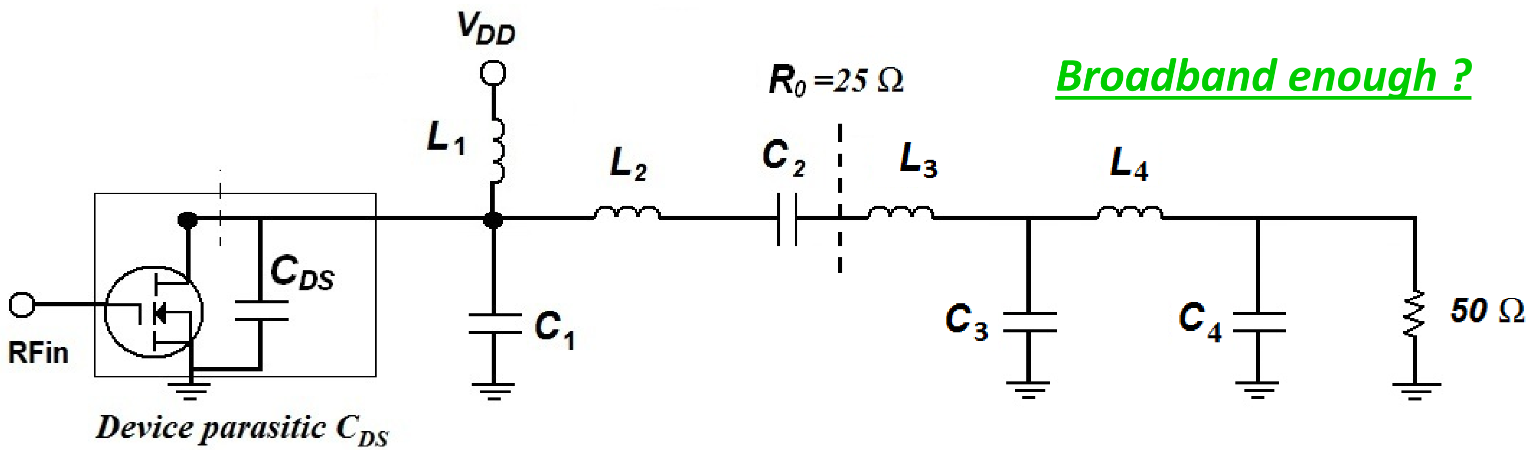


- Maintains load impedance and phase over a wide frequency range

- Requires broadband matching to 50-Ohms



Broadband Class-E Amplifier Topology for Broadband Performance



Broadband enough ?

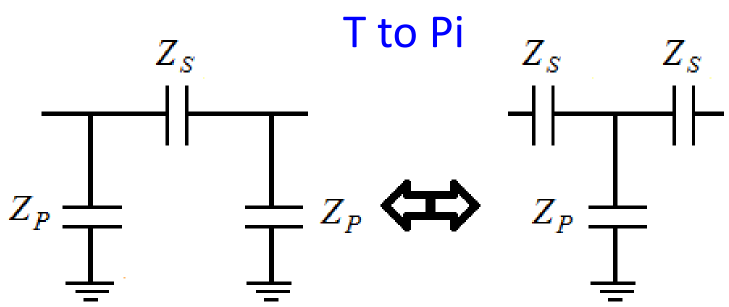
Matched to 50-Ohms

Non-optimum reactances at the harmonics

Minimum of 7 components
3 Inductors
4 capacitors

Network Transforms

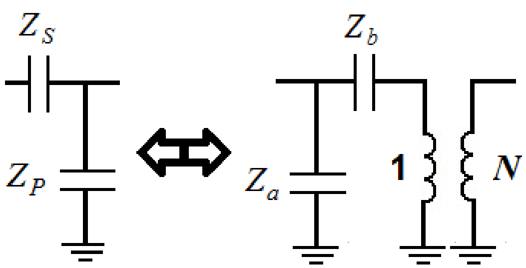
- Broadband impedance matching
- Equivalent at all frequencies
- Standard component values
- PWB parasitics management; i.e: stray capacitance to ground
- A shunt component to ground at all nodes
- Topology selection for a given application
- Minimum number of components
- Reduced insertion loss and more economic



Network Transforms

Example of Network Transforms

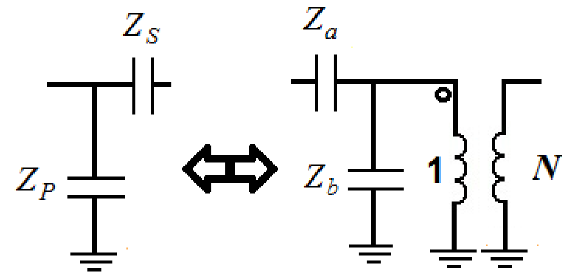
L-right to L-left



$$N = 1 + \frac{Z_S}{Z_P}$$

$$Z_a = \frac{Z_S}{N} \qquad Z_b = \frac{Z_P}{N}$$

L-left to L-right

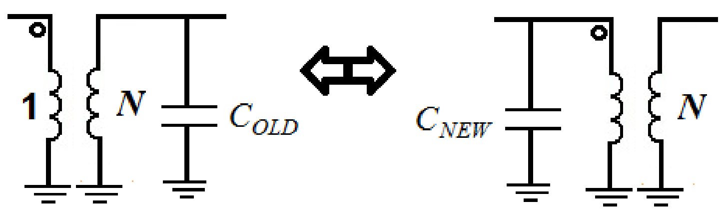


$$N = \frac{Z_P}{Z_S + Z_P}$$

$$Z_a = \frac{Z_P}{N} \qquad Z_b = \frac{Z_S}{N}$$

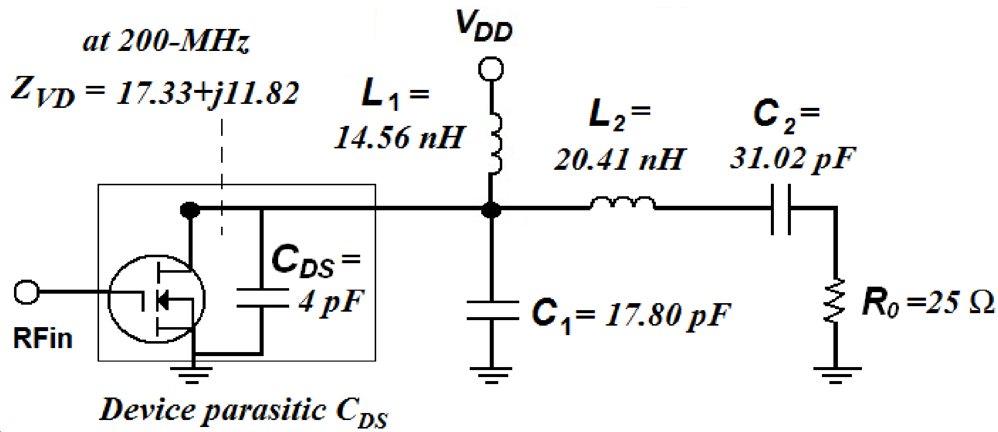
Equivalent Networks At All Frequencies

Move transformer right



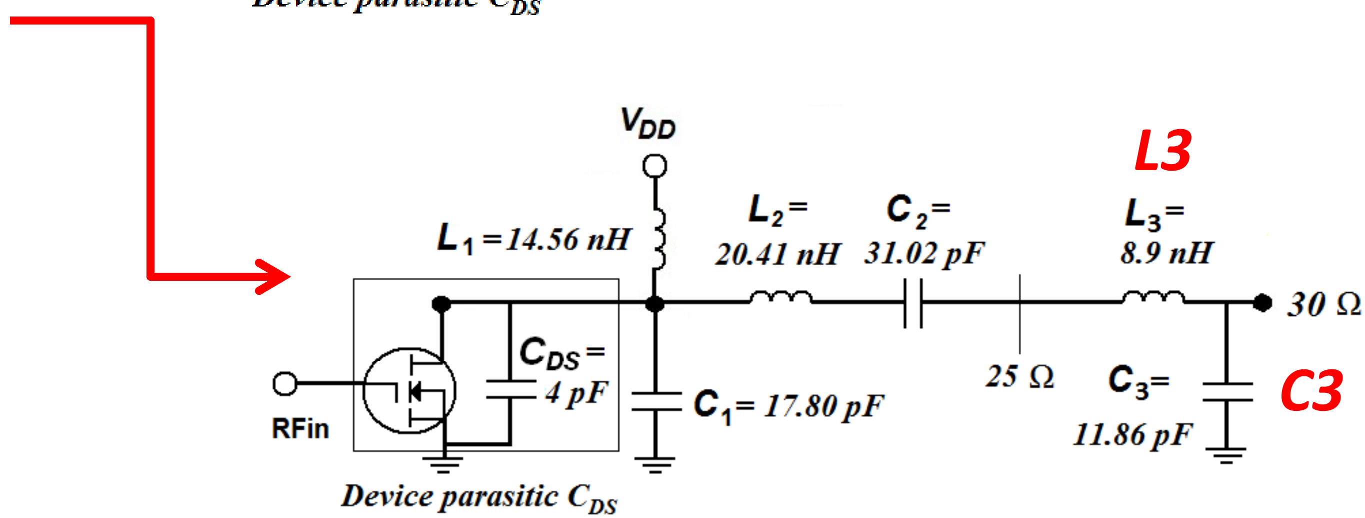
$$C_{NEW} = C_{OLD} \cdot N^2$$

Network Transforms Sequence



Original designed network

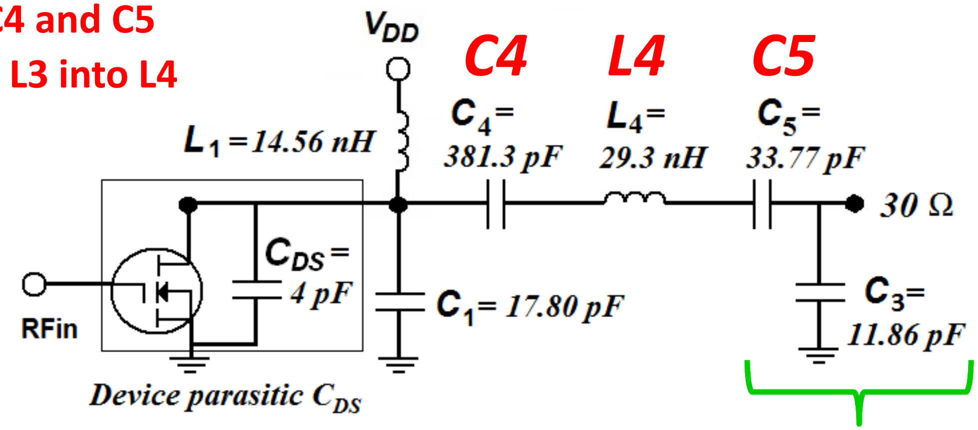
25-Ω load impedance



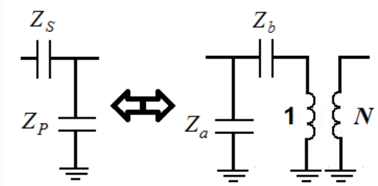
Matching from 25 to 30 Ohms

Network Transforms Sequence

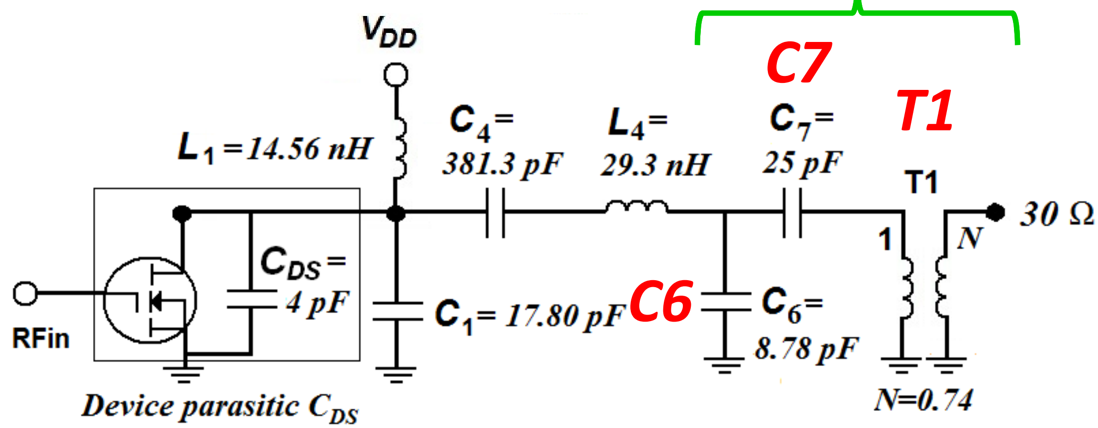
Split C2 into C4 and C5
Merge L2 and L3 into L4



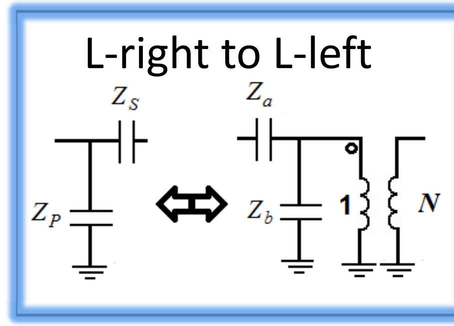
L-left to L-right



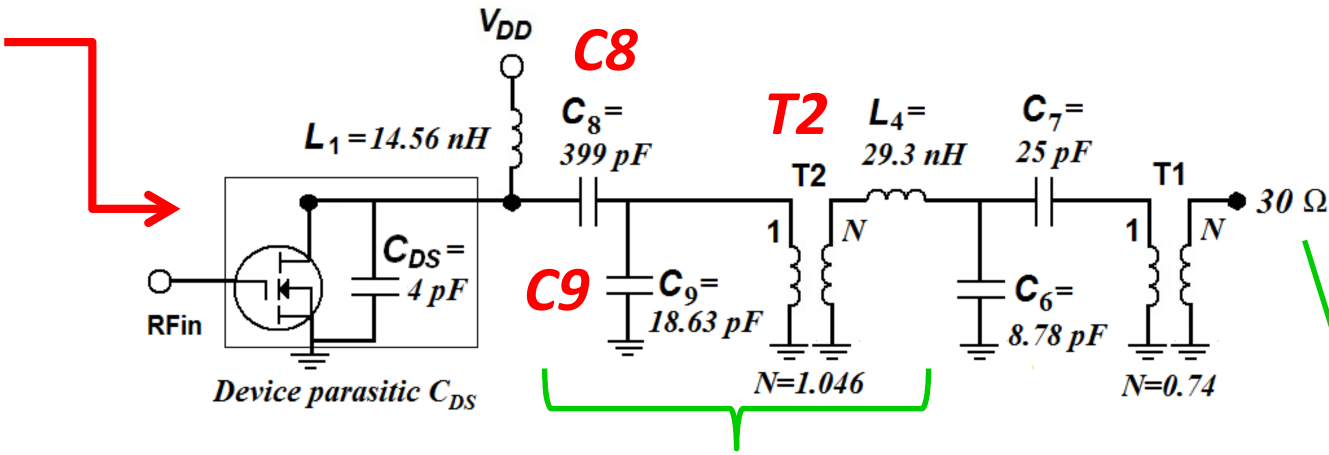
Apply L-left to L-right to C5 and C3

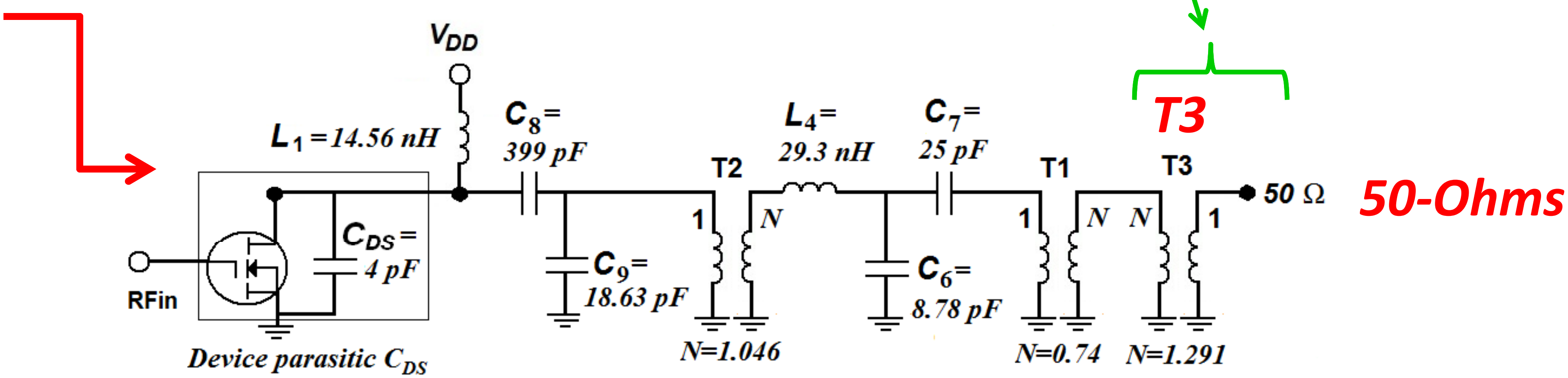


Network Transforms Sequence



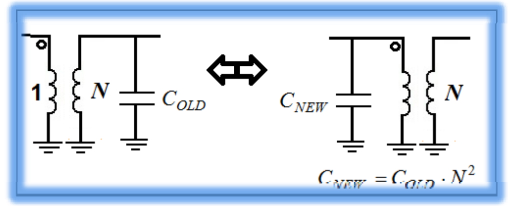
Apply L-right to L-left to C4 and C1

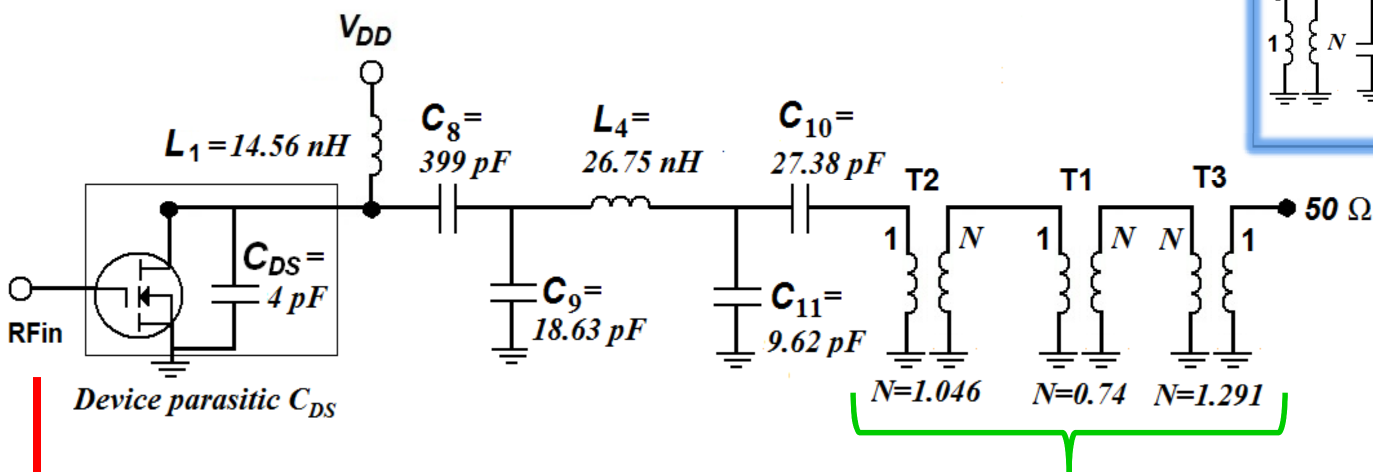




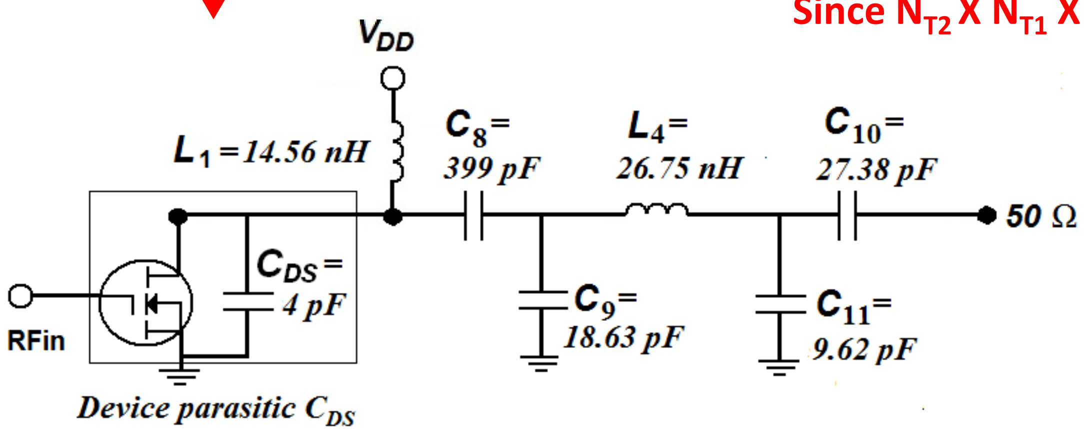
Add transformer T3 to match to 50 Ohms

Network Transforms Sequence





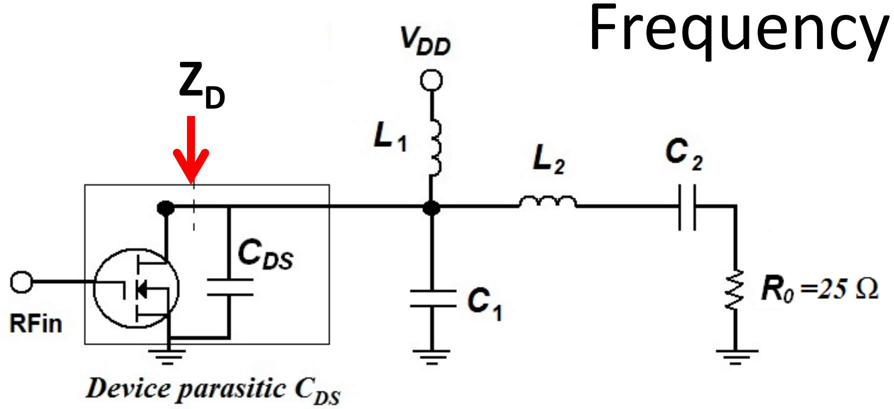
Push all transformers to the Right;
Since N_{T2} X N_{T1} X N_{T3}=1 all transformers vanish



Matched to 50-Ohms

Final Network

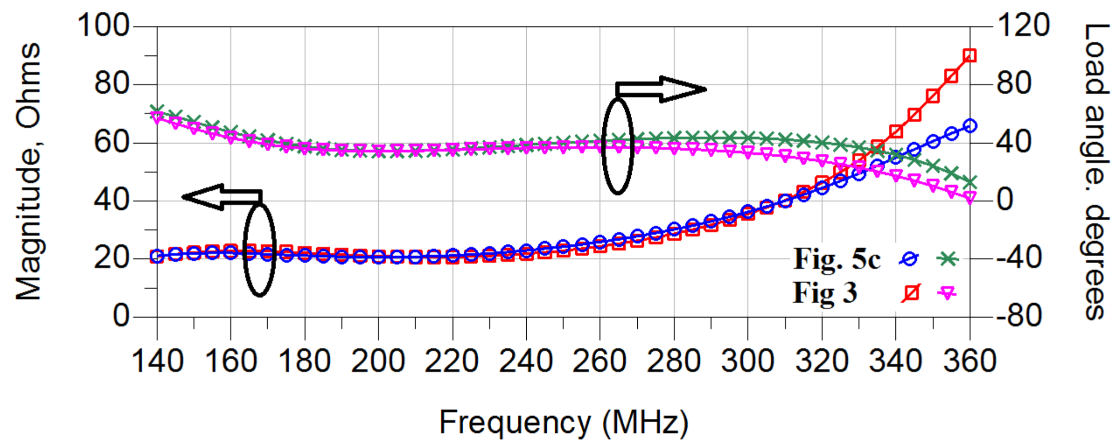
Frequency response

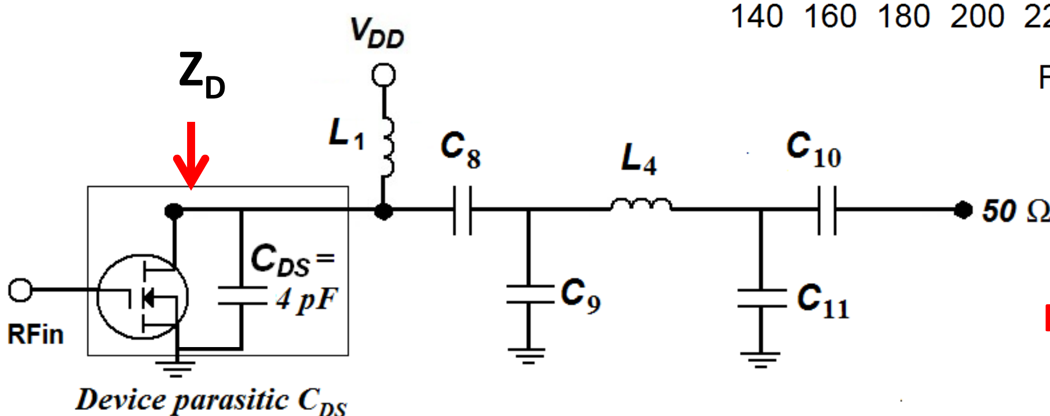


Initial Network

Fig. 3

Z_D

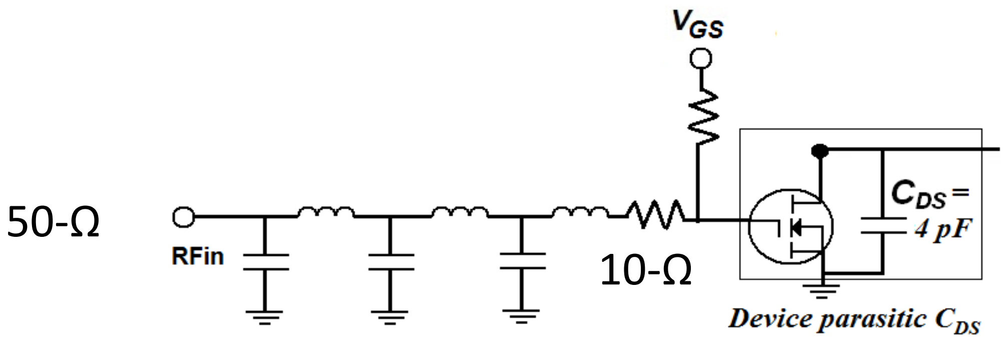




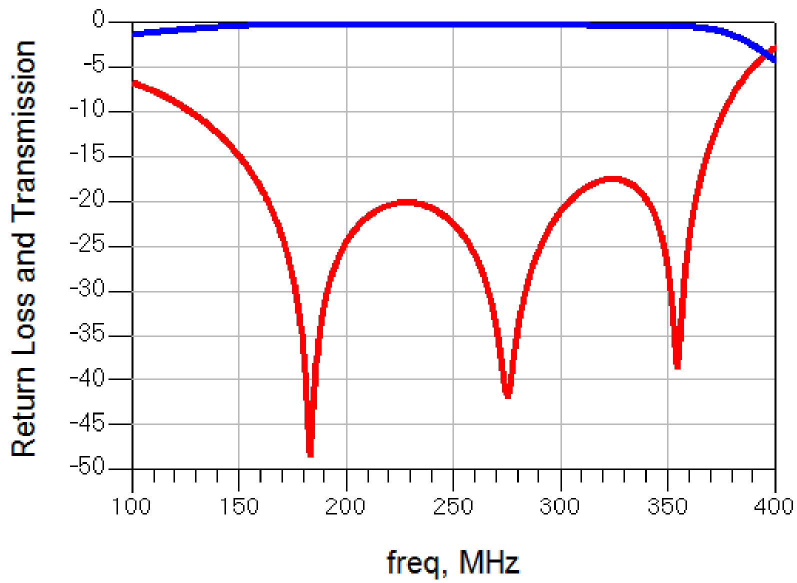
Final Network

Fig. 5c

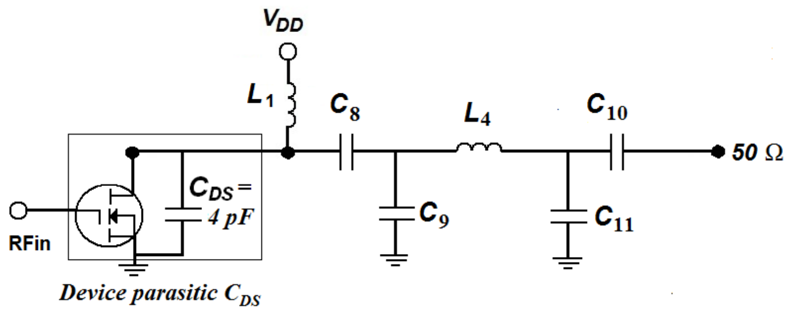
Input Matching



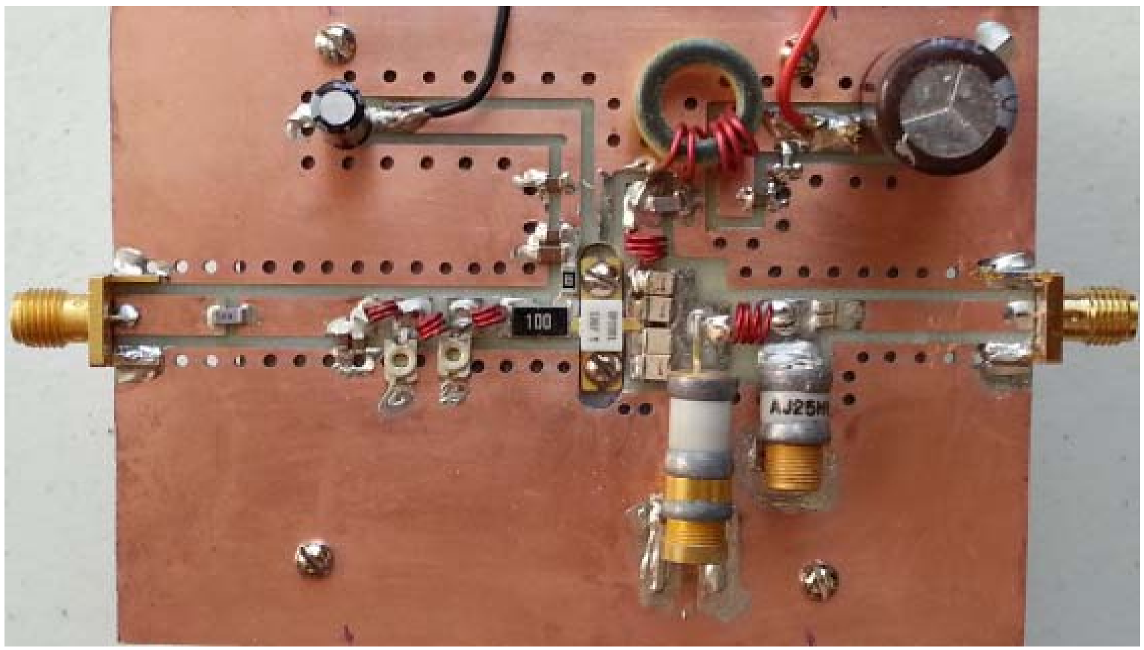
Three-section input match



Prototype

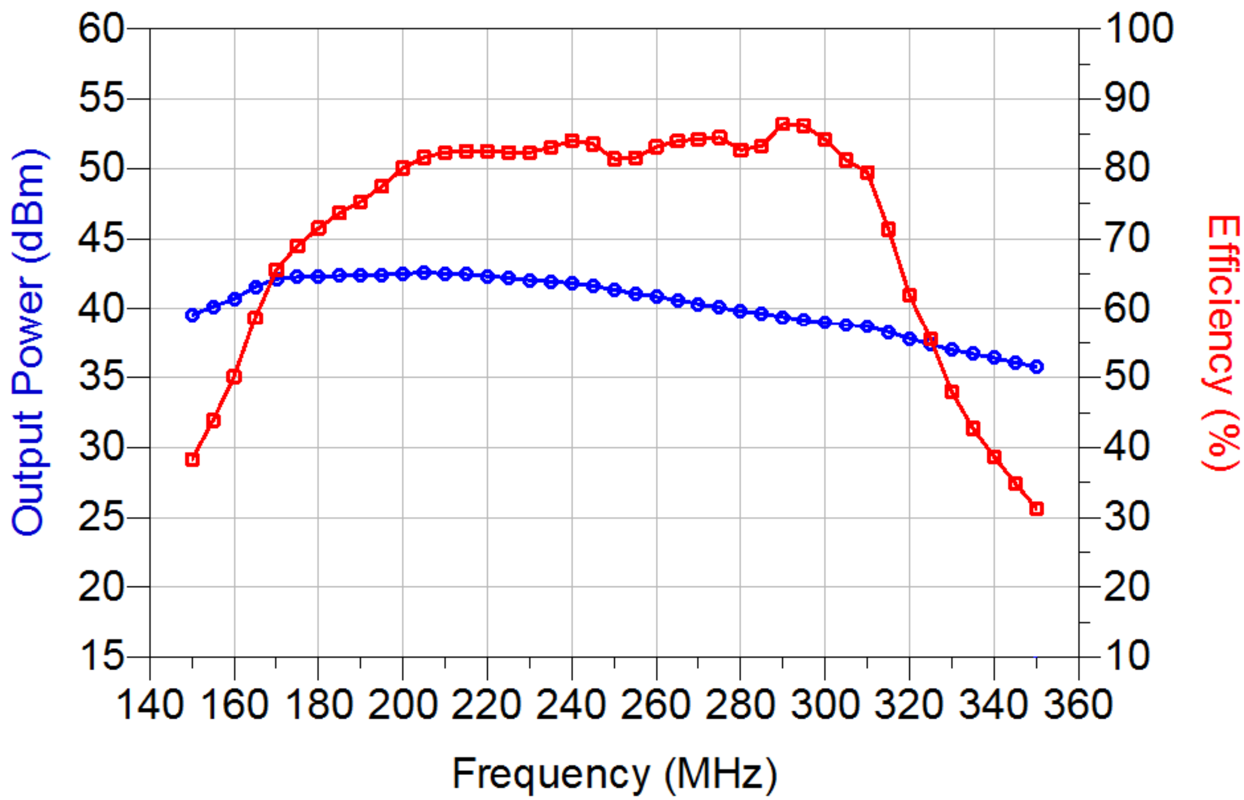


RF in



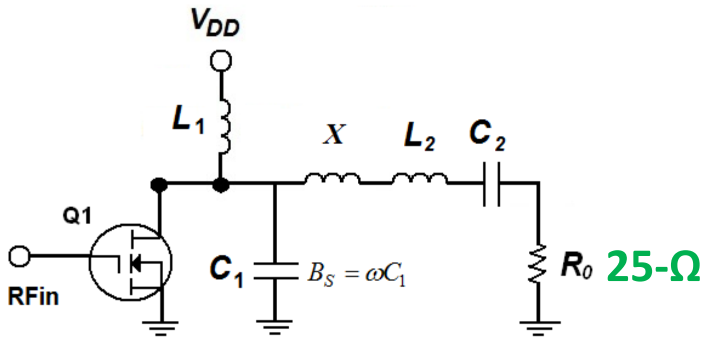
RF Out

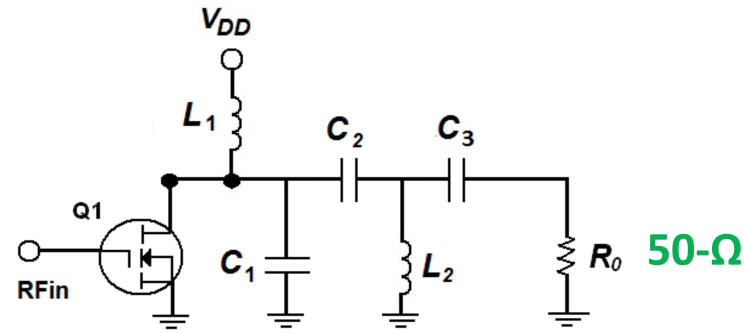
Broadband Performance



Fixed Input power of 28-dBm over the frequency range

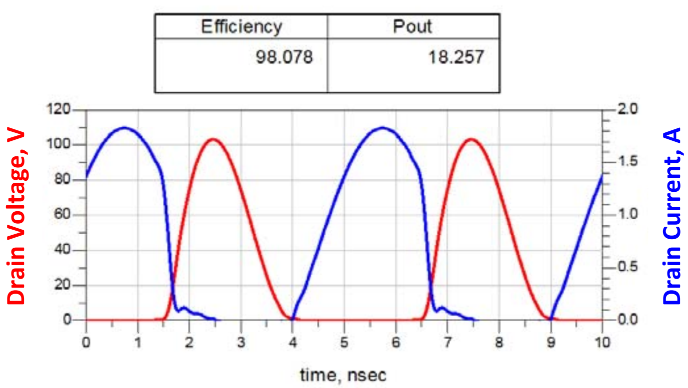
Other Network Transforms and True-transient Class-E Network Topologies



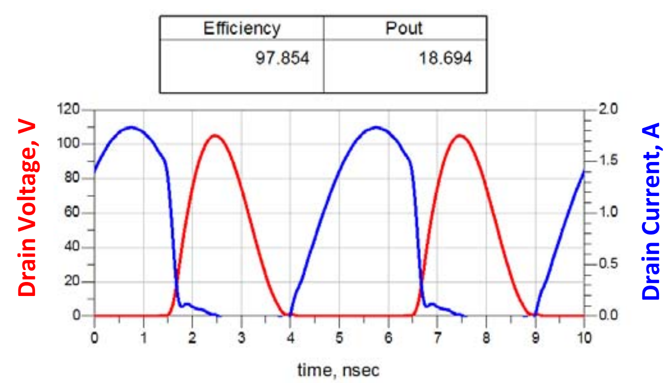


Equivalent networks at all frequencies

True broadband impedance matching



Exact equivalent waveforms



Conclusions

- Understanding where to apply a given network transform determines the final topology
- The number of topologies are infinite; Choose the most suitable for your application
- Attention has to be paid for realizable component values
- Impedance matching can be perform with ideal transformers and then eliminate the transformer using a network transform
- In this example, a class-E amplifier achieves excellent broadband performance by using exact equivalent transforms for broadband matching and topology transformation.

Thanks to

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20.0 Watts Single Ended
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HIGH EFFICIENCY, LINEAR
HIGH GAIN, LOW NOISE
ROHS COMPLIANT
Suitable for use across 1-3000Mhz

- Thanks to Mr. Jerome Citrolo and Marcos Cervantes Provided the GaN FET GP2001 used for the prototypes

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- Thanks to Dr. Nick Chen for his support on this presentation