RF Broadband Matching for 5G Probe Card without Using VNA

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- RF Matching Difficulty Comparison between FT and CP
- How to Find Out the Matching Solution by Using Smith Chart
- Bandwidth Comparison between T3 and T5 Matching Circuit
- Verification Case on T5 and T3
- Conclusion

● RF Matching Difficulty Comparison between FT and CP

Band	Duplex mode[A 1]	ƒ (MHz)	Common name	Subset of band	Uplink[A 2] (MHz)	Downlink[A 3] (MHz)	Duplex spacing (MHz)	Channel bandwidths[5] (MHz)
n79	TDD	4700	C-Band		4400 – 5000		N/A	40, 50, 60, 80, 100
n78	TDD	3500	S-Band	n77	3300 – 3800		N/A	10, 20, 40, 50, 60, 80, 100
n77	TDD	3700	S-Band		3300 – 4200		N/A	10, 20, 40, 50, 60, 80, 100

For 5G sub-6GHz application, its bandwidth should be over 900MHz, so the wideband matching is imperative for L/B.

Wider bandwidth for 5G is needed.

Band	Duplex mode[A 1]	ƒ (MHz)	Common name	Subset of band	Uplink[A 2] (MHz)	Downlink[A 3] (MHz)	Duplex spacing (MHz)	Channel bandwidths (MHz)
47	TDD	5900	U-NII-4[A 16]		5855 – 5925		N/A	10, 20
46	TDD	5200	U-NII[A 15]		5150 – 5925		N/A	10, 20
43	TDD	3700	C-Band		3600 – 3800		N/A	5, 10, 15, 20
48	TDD	3500	CBRS (US)		3550 – 3700		N/A	5, 10, 15, 20
49	TDD	3500	C-Band	48	3550 – 3700		N/A	10, 20
22	FDD	3500	C-Band		3410 – 3490	3510 – 3590	100	5, 10, 15, 20
42	TDD	3500	CBRS (EU, Japan)		3400 – 3600		N/A	5, 10, 15, 20
52	TDD	3300	C-Band		3300 – 3400		N/A	5, 10, 15, 20
38	TDD	2600	IMT-E[A 14]	41	2570 – 2620		N/A	5, 10, 15, 20
7	FDD	2600	IMT-E		2500 – 2570	2620 – 2690	120	5, 10, 15, 20
41	TDD	2500	BRS		2496 – 2690		N/A	5, 10, 15, 20
53	TDD	2400	S-Band		2483.5 – 2495		N/A	1.4, 3, 5, 10

4G LTE bandwidth is less than 5G.

RF Matching on CP:

• No room inside the probers to let engineers hook instrument cable up to Probe Card closely.

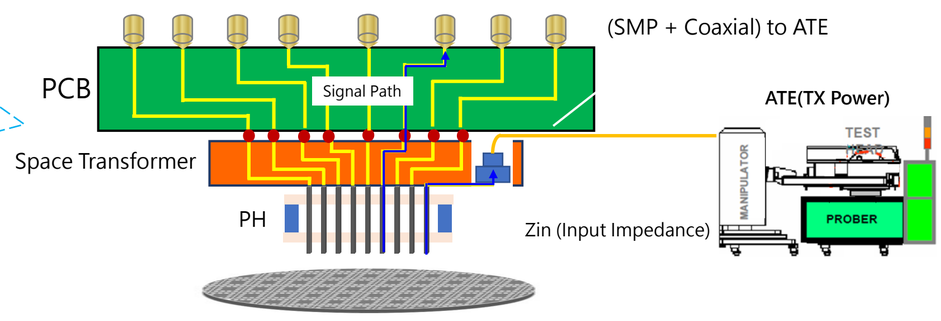
RF Matching on FT:

• Engineers can rely on VNA and move it closer to ATE for RF Matching.

For CP RF Matching:

• Engineers can only measure the power(dBm) from ATE program, and couldn’ t further to use instrument.

• It will let RF matching become difficult when signal path contains many impedance discontinuity interfaces, Normally, engineers can only do Try-and-Error tuning on the space transformer of the probe card.

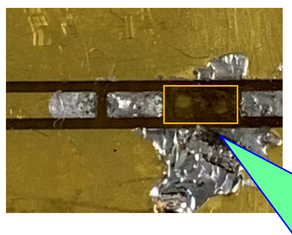


RF Matching Difficulty Comparison between FT and CP

For CP RF Matching:

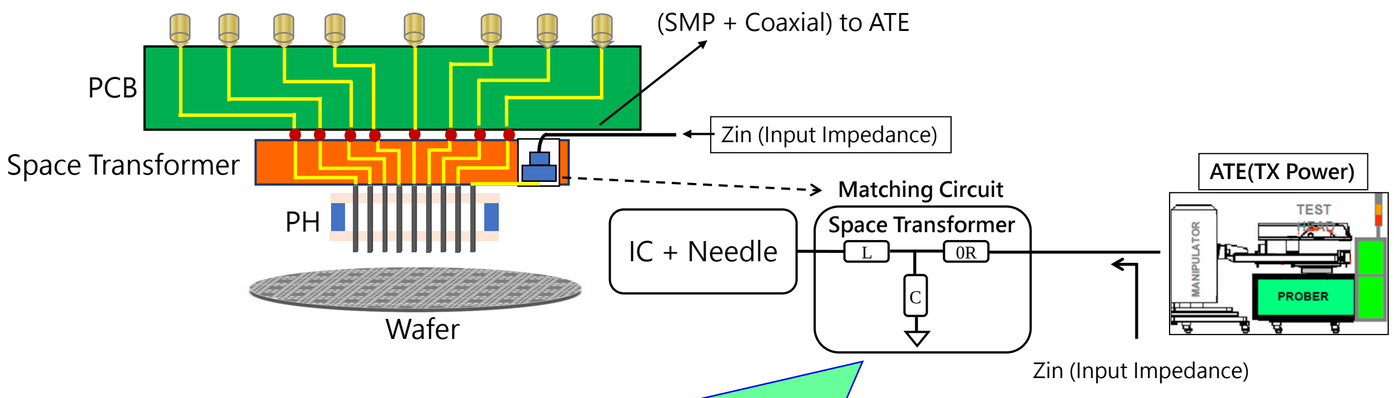
- It will take 1 hour or a little bit longer when soldering one component from the space transformer of the probe card and then re-docking probe card onto the prober roughly.

- Engineers probably force the component pads to peel off from the PCB after multiple soldering.



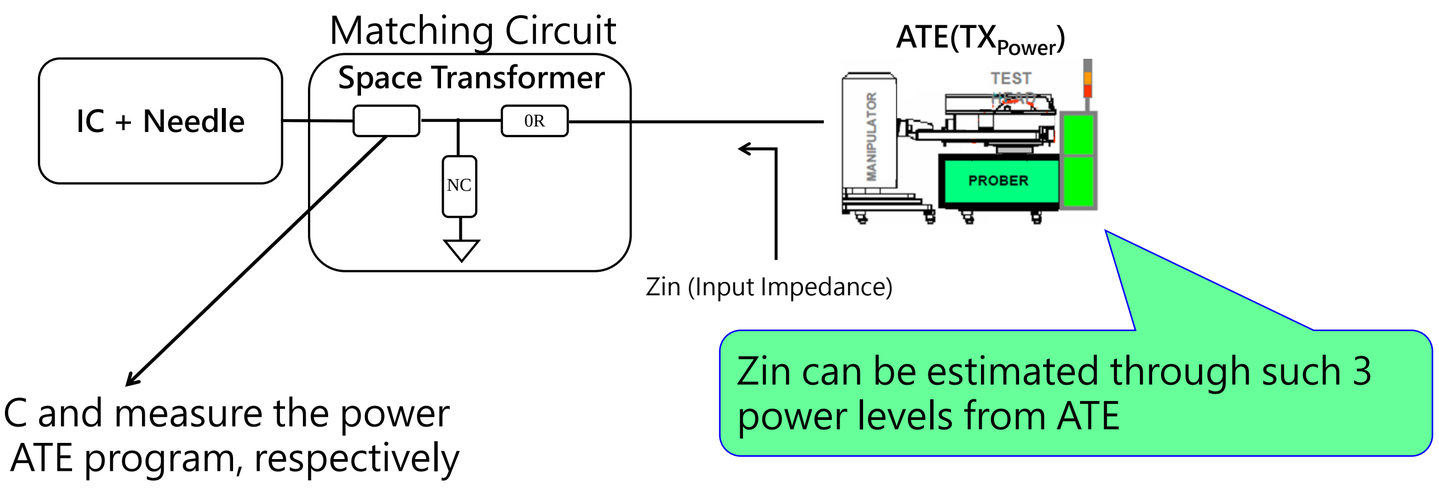
Component pads peel off and damage costly space transformer

How to Find Out the Matching Solution by Using Smith Chart



Matching Circuit in Space Transformer

We can closely estimate the input impedance of the DUT after soldering series components R, L, and C sequentially on the matching network and getting three separate power levels from the TX power or RX strength of ATE datalog.



Bandwidth Comparison Between T5 and T3 Matching Circuit

T5 RF matching network is much preferred because its wider bandwidth matching can conquer some uncertain factors than T3.

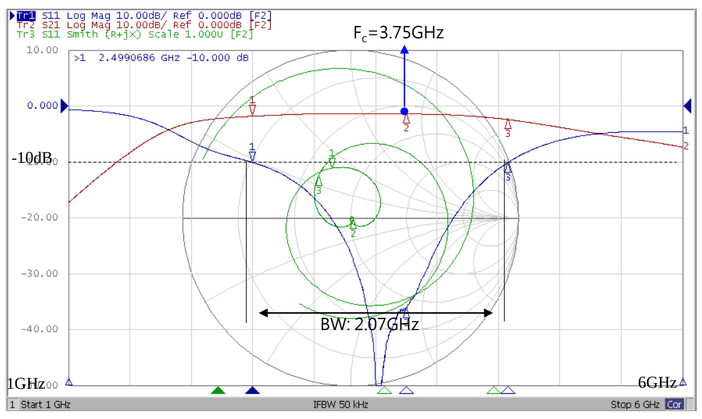
Such as:

1. wider bandwidth
2. better linearity
3. wider testing temperature range
4. more tolerance is allowable of overused solder on the component pad
5. more L, C variation is allowable for multi-site projects

1. wider bandwidth

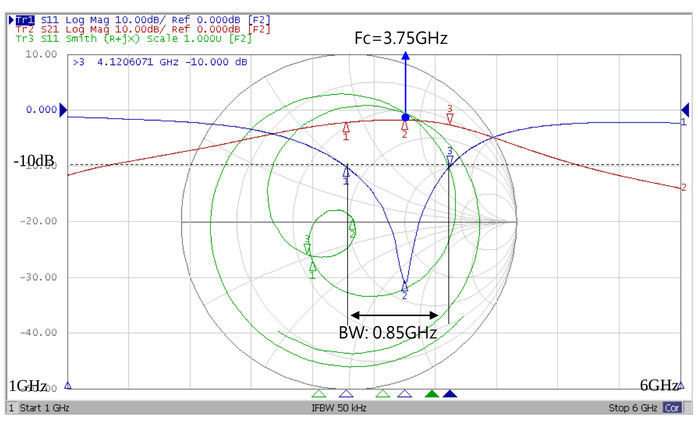
S11	BW, S11<-10dB
T5	2.07GHz
T3	0.85GHz

T5



S21 S11 S11(smith chart)

T3



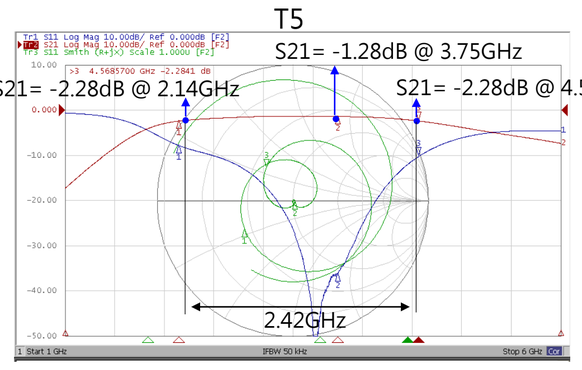
S21 S11 S11(smith chart)

● Bandwidth Comparison between T3 and T5 Matching Circuit

2. better linearity

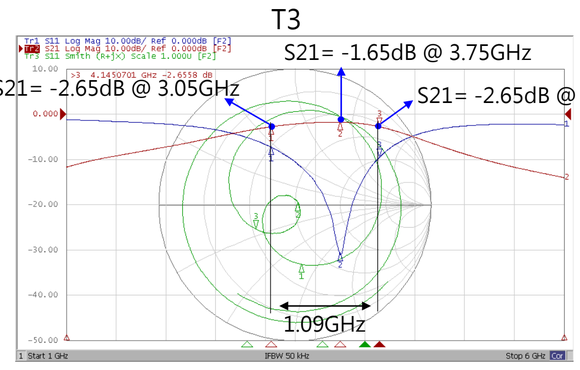
S21	BW, ΔS21<-1dB, Fc=3.75GHz
T5	2.42GHz
T3	1.09GHz

T5



S21 S11 S11(smith chart)

T3

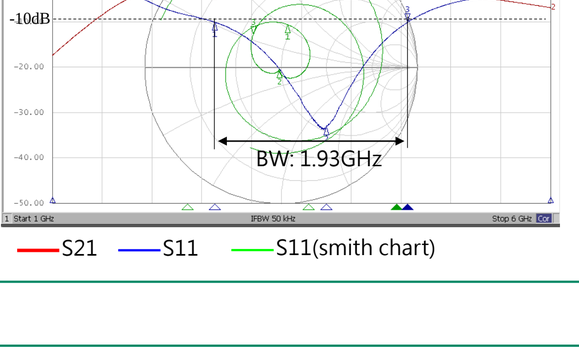


S21 S11 S11(smith chart)

3. wider testing temperature range

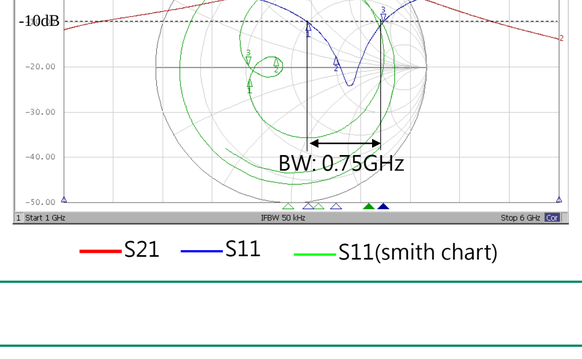
S11	25°C	100°C	Difference
T5	2.07GHz	1.93GHz	6.76%
T3	0.85GHz	0.772GHz	9.17%

T5(100oC)



S21 S11 S11(smith chart)

T3(100oC)

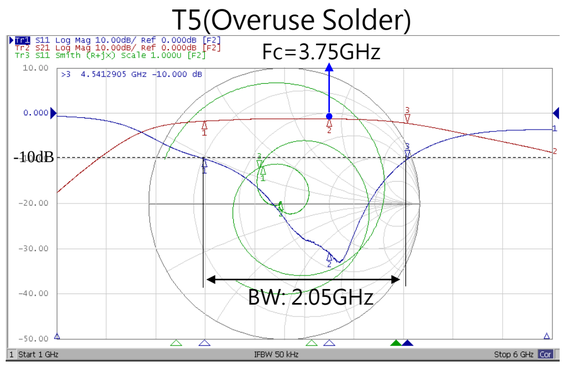


S21 S11 S11(smith chart)

4. more tolerance is allowable of overused solder on the component pad

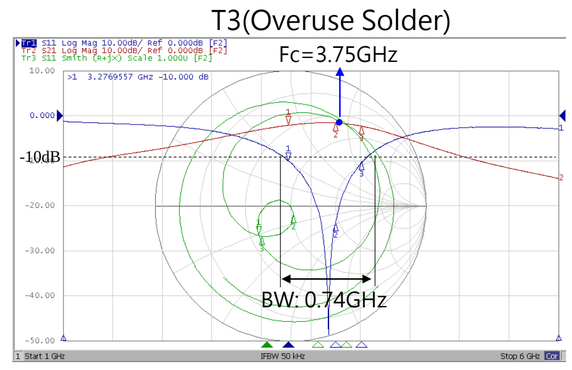
S11	Origin	Overuse Solder	Difference
T5	2.07GHz	2.05GHz	2.38%
T3	0.85GHz	0.74GHz	12.9%

T5(Overuse Solder)



S21 S11 S11(smith chart)

T3(Overuse Solder)



S21 S11 S11(smith chart)

5. more L, C variation allowable on multi-site projects

S11	Origin	Component Variation (Value - 10%)	Difference
T5	2.07GHz	1.93GHz	6.76%
T3	0.85GHz	0.75GHz	11.76%

T5(Component Variation)

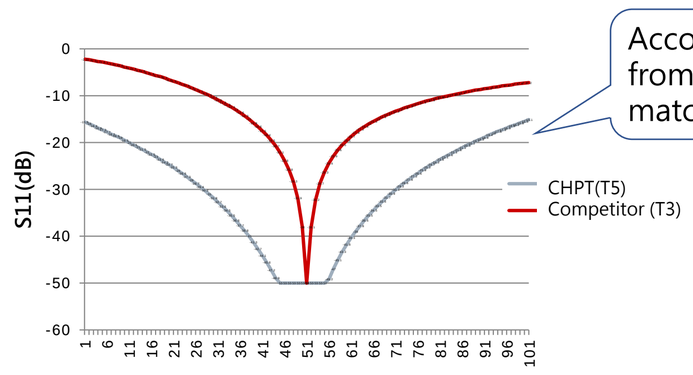
S21 S11 S11(smith chart)

T3(Component Variation)

S21 S11 S11(smith chart)

● Verification Case on T5 and T3

3 Advantages:
1. Easy to match to 50ohm (Shorter time for matching)
2. Cover the variation of component value variation (Stable for Multi-site)
3. Better S11 with flatter S21 for the whole channel. (Channel flatness)



● Conclusion

◆ For CP testing, engineers usually do Try-and-Error tuning on the space transformer of the probe card and peel off the component pad from the PCB through multiple soldering.

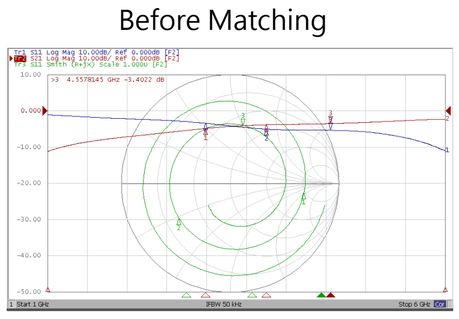
◆ CHPT RF Matching Tool can come up with the best T5 or T3 RF matching component after series R, L, C respectively and measure the power(dBm) from ATE program.

◆ 5 advantages of T5 Circuit than T3:

1. Wider Bandwidth(shorter time for matching).
2. Better insertion loss linearity.(better channel flatness)
3. Wider testing temperature range.
4. More tolerance is allowable of overused solder on the component pad.
5. More L, C variation is allowable on multi-site projects.(multi-site is stable).

◆According to the verification results from customers, the bandwidth of T5 matching circuit is wider than T3.

Before Matching



After Matching