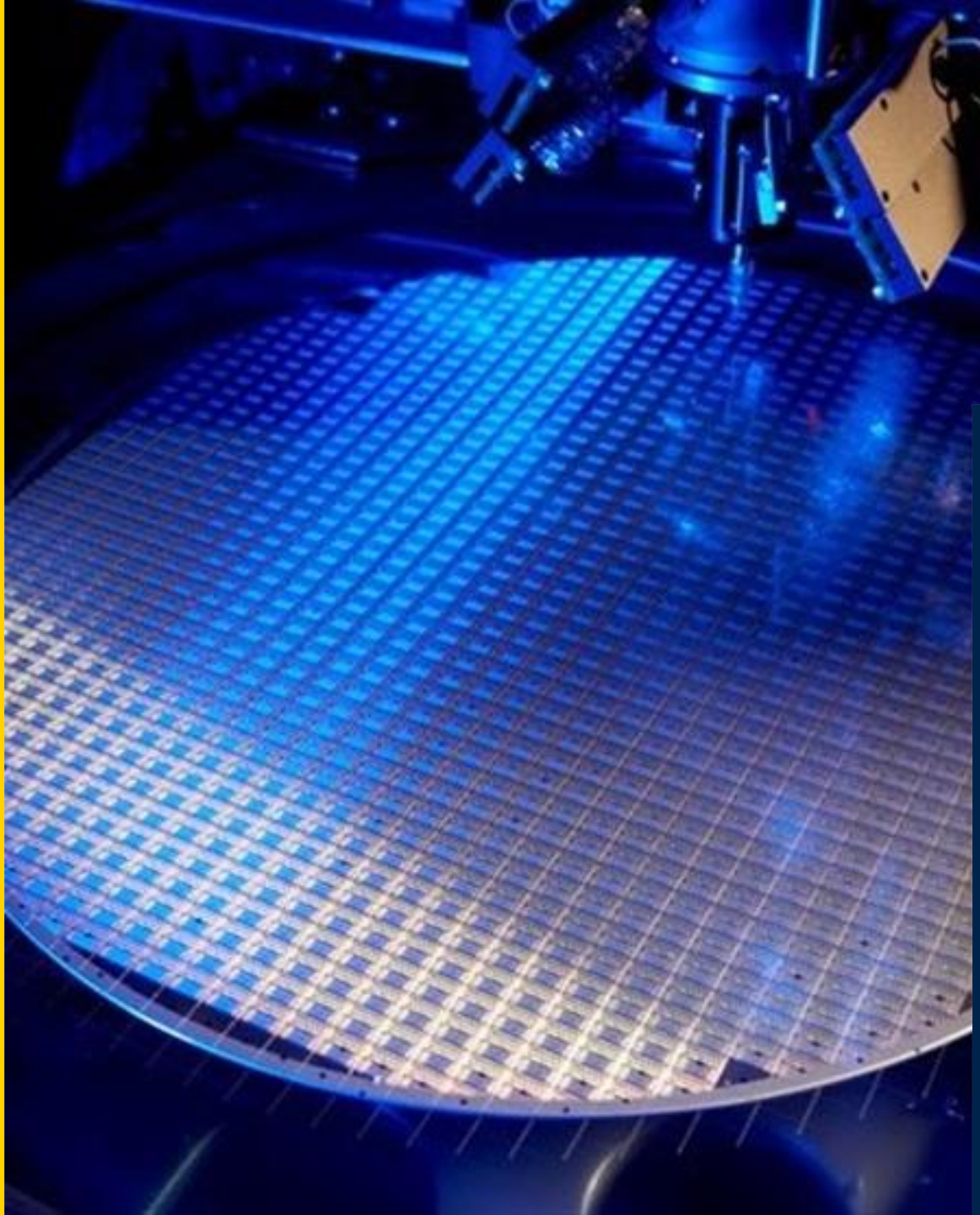

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RF Integrated Passive Devices

July 2020

Agenda

1 Introduction to IPD

2 5G Applications for IPD

3 IPD technology

4 Product Portfolio

5 Benefits

6 Conclusion

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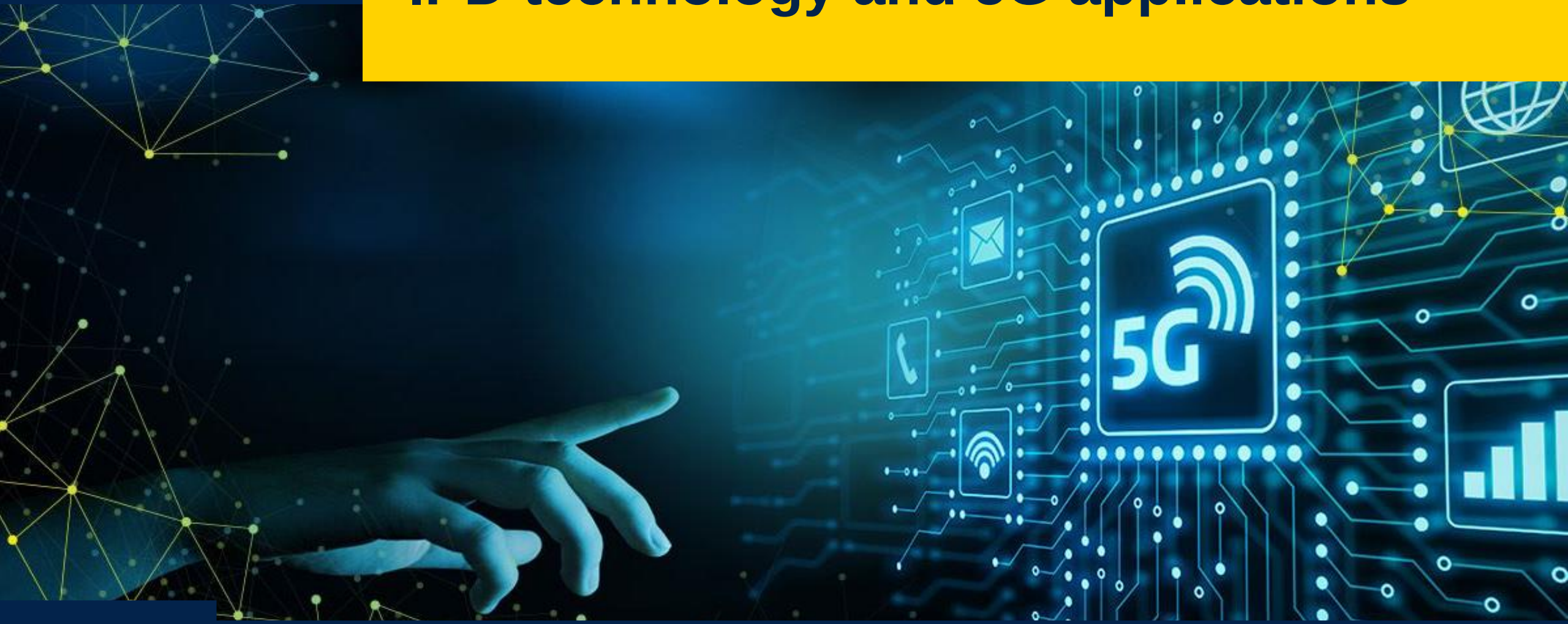
IPD technology and 5G applications



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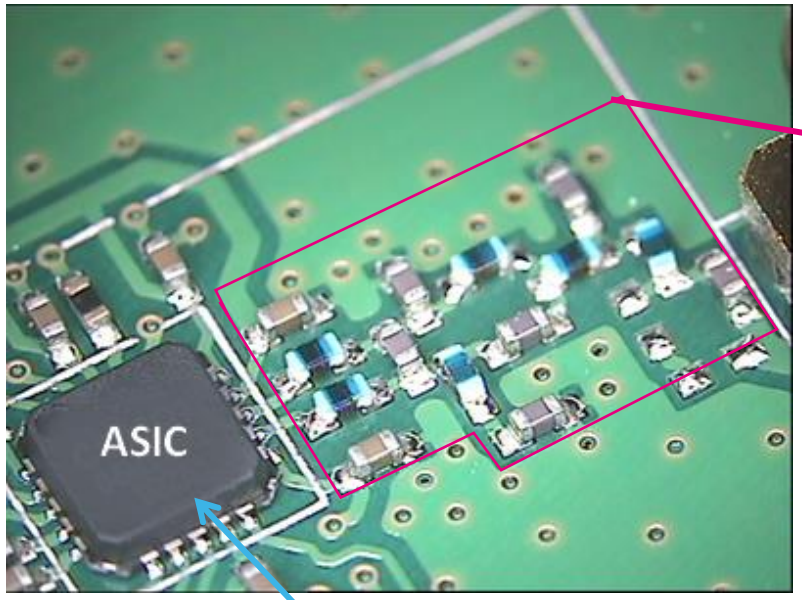
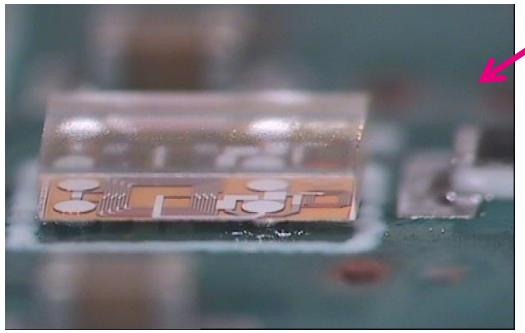
RF Integrated Passive Devices (IPD)
introduction

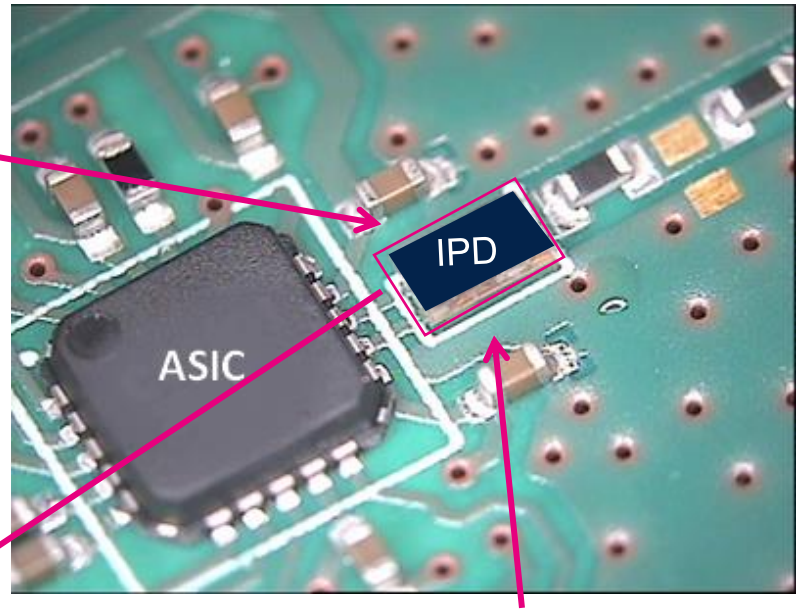
THIS IS **NOT** IPD



Application **S**pecific **I**ntegrated **C**ircuits



THIS **IS** IPD



RF **I**ntegrated **P**assives **D**evices

BENEFITS

- Design **simplification**
- **Performance** optimization
- System **integration**
- **Reliability** improvement
- BOM **reduction**
- Successful **development** story

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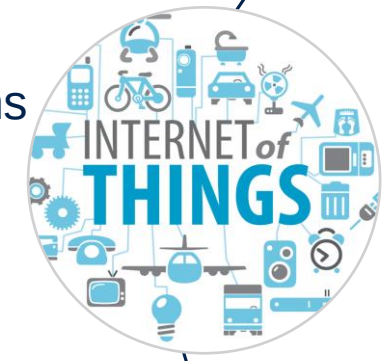
5G Use Cases and Applications

- Enhanced Mobile Broadband
- Sub 6GHz spectrum

- Massive Machine type communications
- Narrow-band IoT
- Low power consumption



5G

- uRLLC
- Low latency communication for V2X 5.9GHz

- Densification through mmWave and uWave bands
- 14-26GHz Ka-Ku bands
- 28 – 36GHz mmWave

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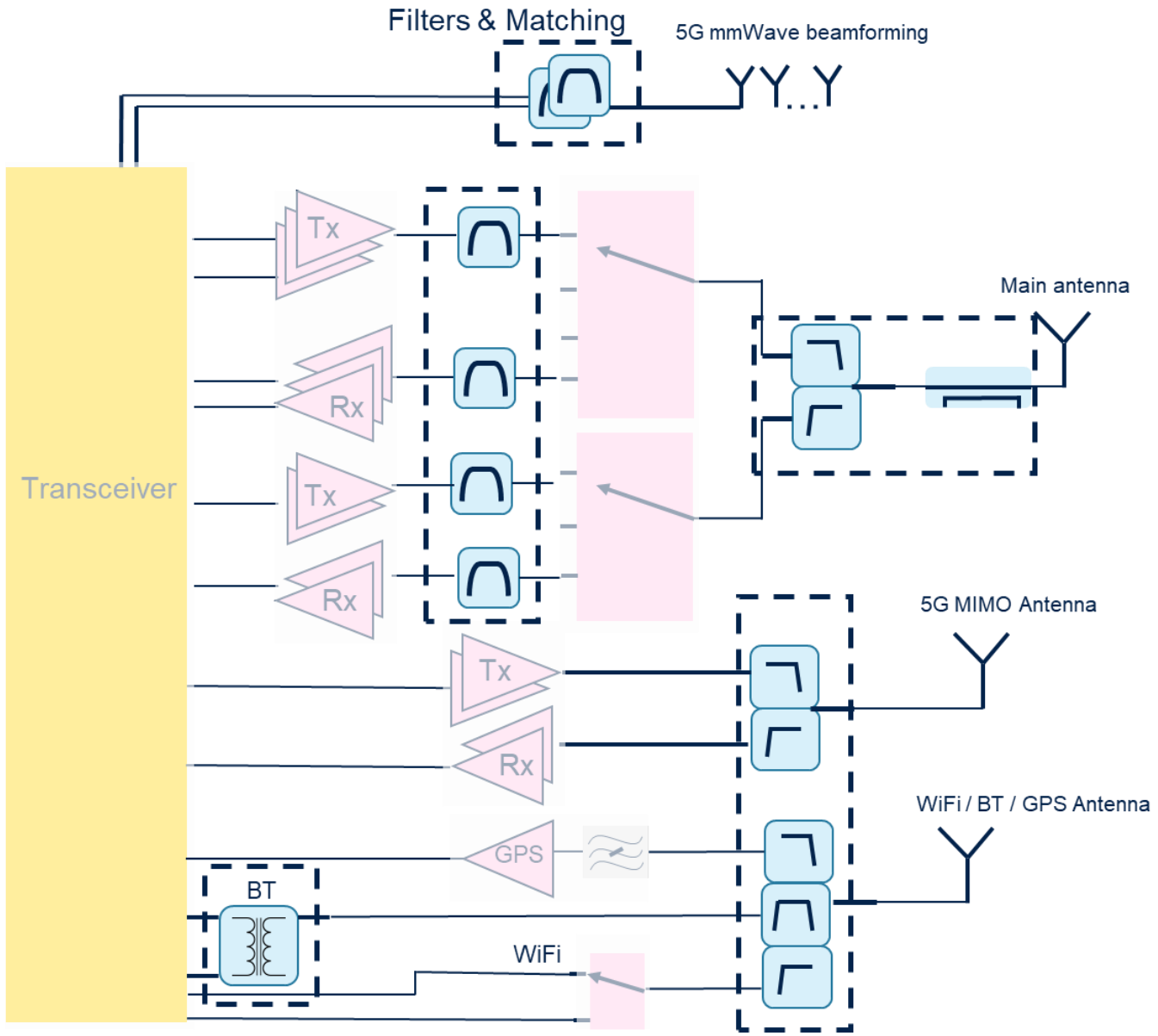
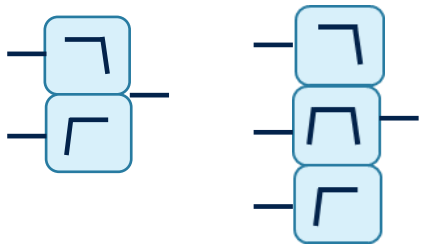
IPD in 5G RF Front-end



ST IPD

5G sub-6GHz, LTE and WiFi 2.5G filters

WiFi & Cellular Diplexers & Triplexers



Baluns & Matching Networks

High directivity couplers

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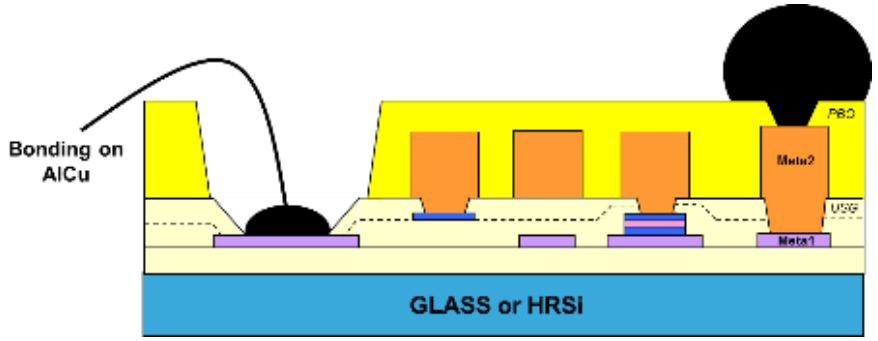
IPD technology

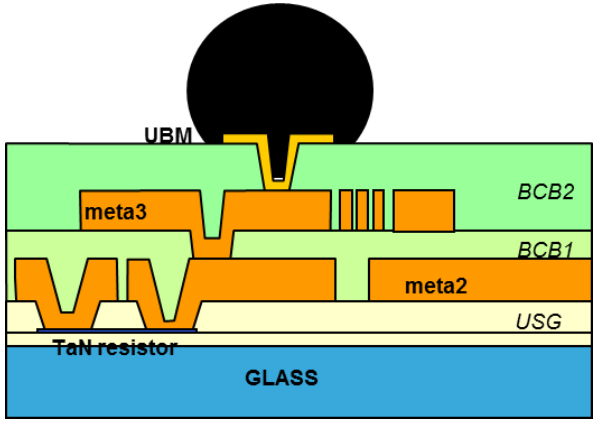
1 COPPER LAYER TECHNOLOGY : RLC07



- ✓ One thick Cu layer
- ✓ MIM capacitors (70pF – 1nF / mm²)
- ✓ Resistor layer
- ✓ Wirebonding / flipchip bumping

2 COPPER LAYERS TECHNOLOGIES : L01 + RLC06X

- ✓ Two thick Cu layers
- ✓ MIM capacitors (29pF – 2nF / mm²)
- ✓ High Q capacitor option
- ✓ Resistor layer
- ✓ Wirebonding / flipchip bumping



Integration and performance improvments with Copper thickness increase & New High Q material

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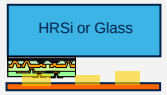
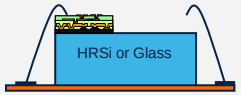
Packaging capability

Side view

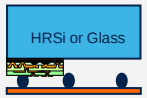
CSPG



CSPG w/o bumps



Wirebonding



CSP µbumping

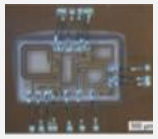
Package for Standalone Assembly

Package for Integration into Module

Pad view

350 µm Thickness

125 µm Thickness



125 µm Thickness

230 µm Thickness

Automotive Grade Qualification Available

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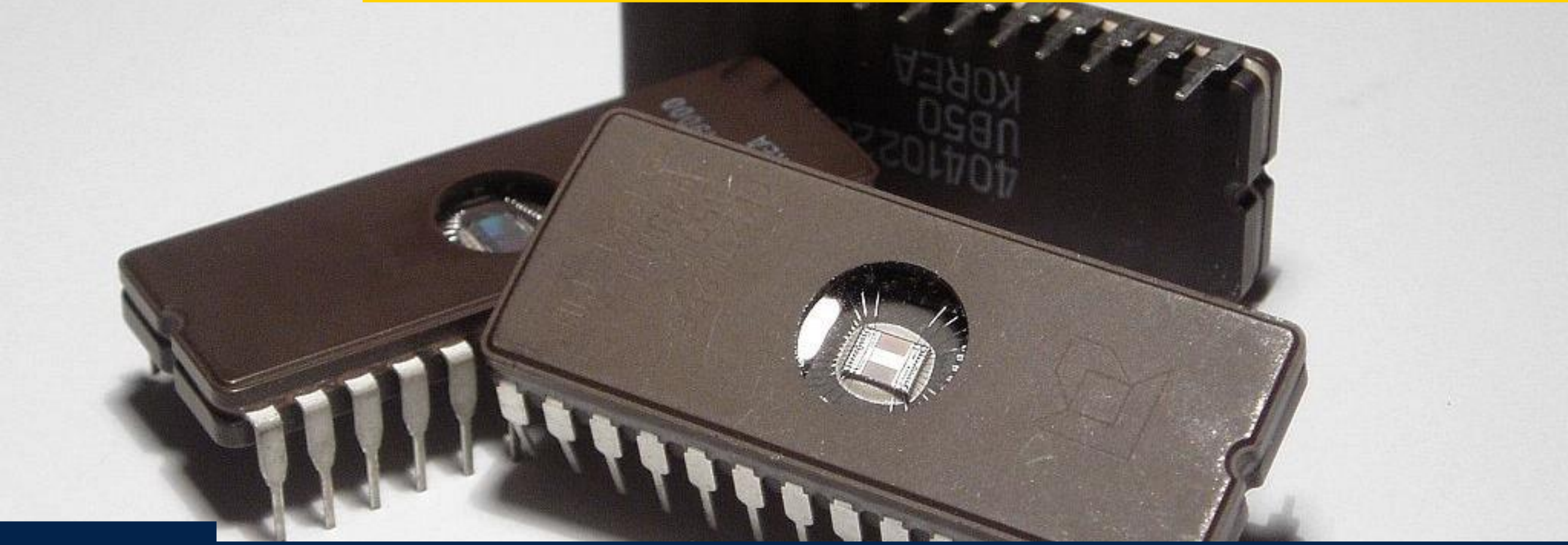
Product Portfolio



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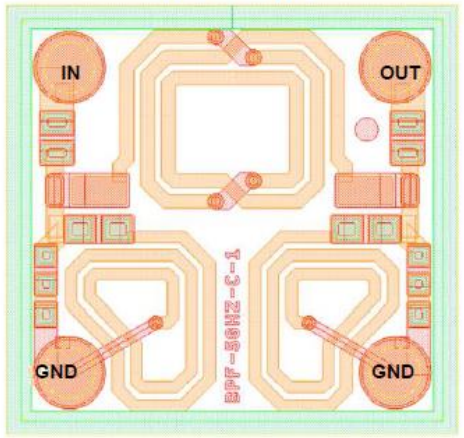
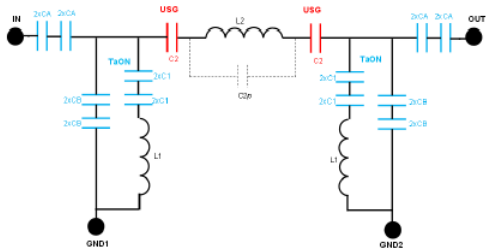
Band Pass Filter for 5GHz

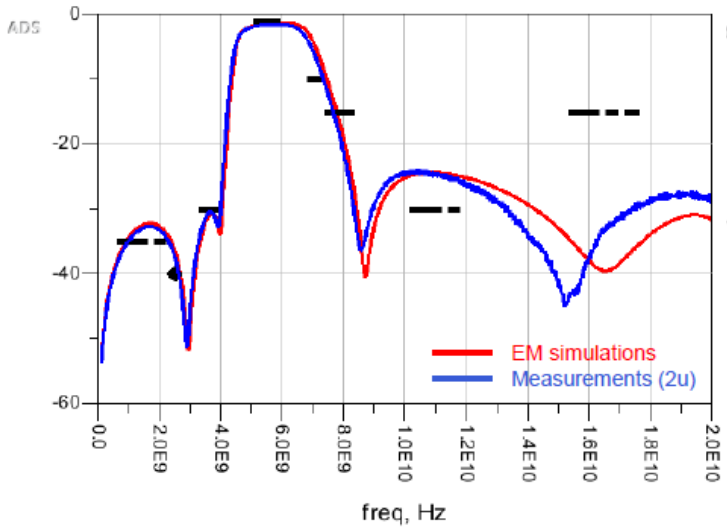
Die Layout

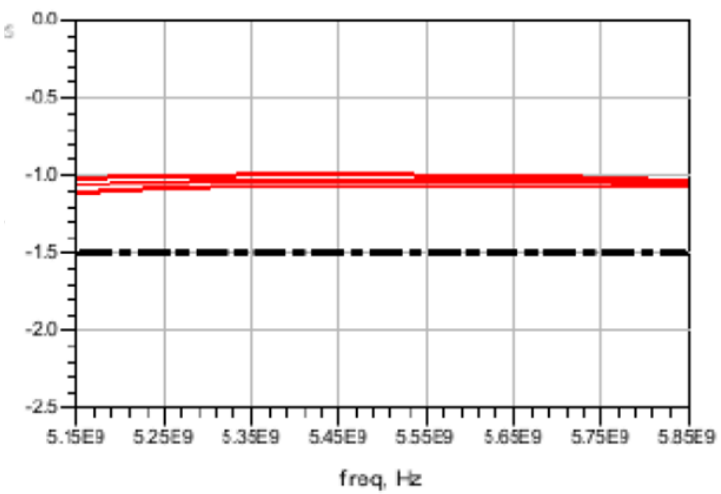


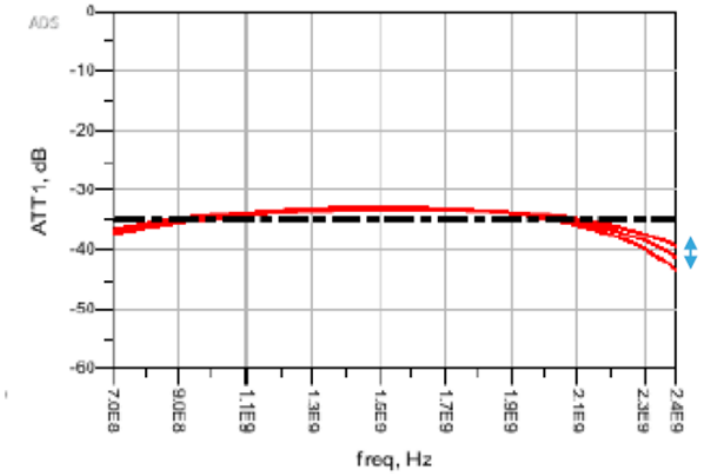
Die size 0,95x0,90mm²

Electrical Schematic









Low dispersion over process and temperature

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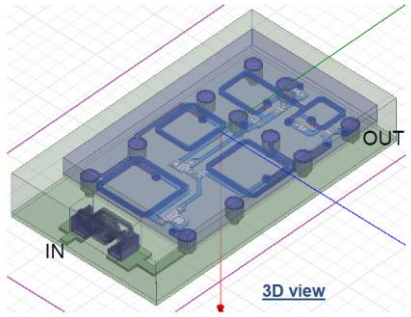
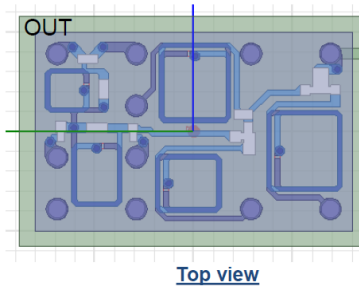
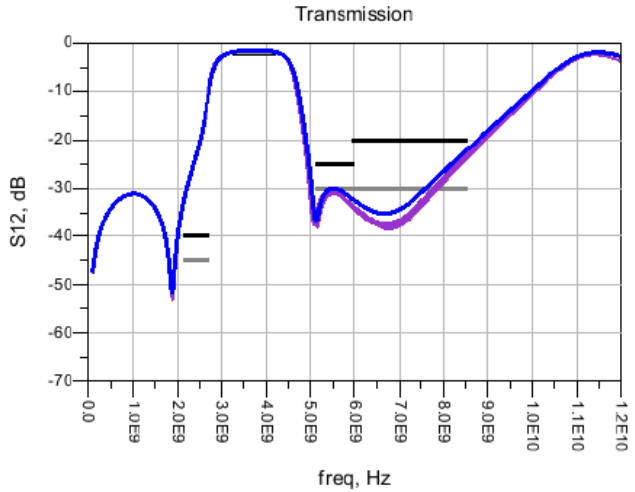
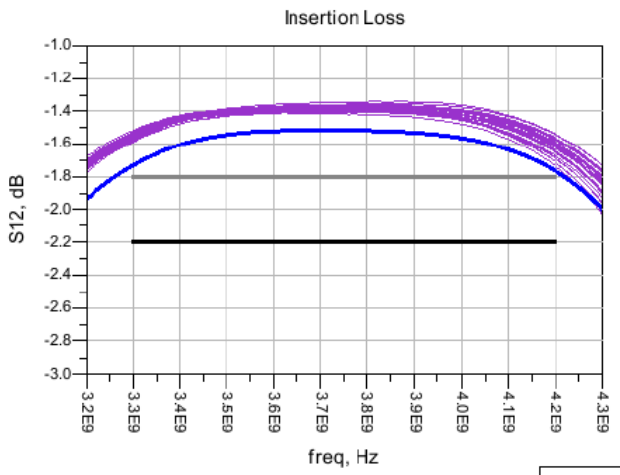
Filters for 5G NR Band N77



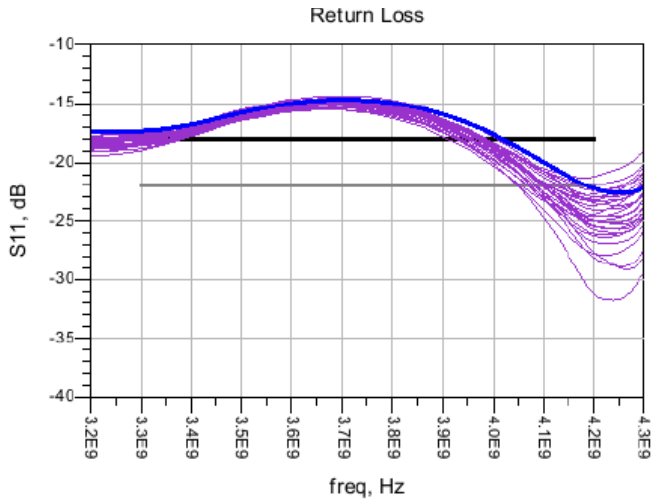


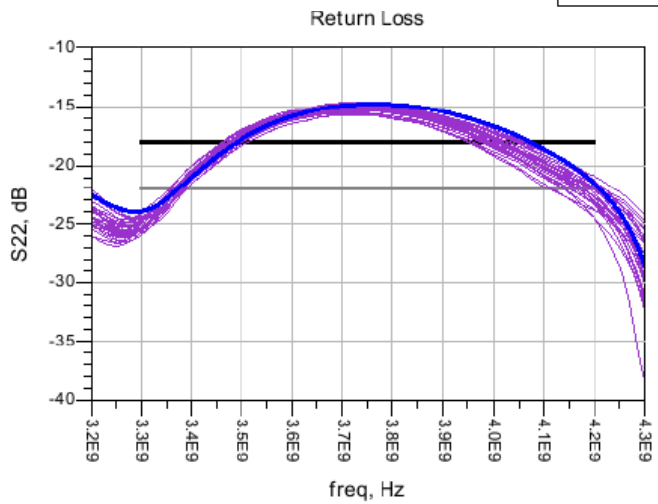
IPD die-size: 2.03 x 1.16mm
Z-height: 0.23mm





EM Simulation
Measurements





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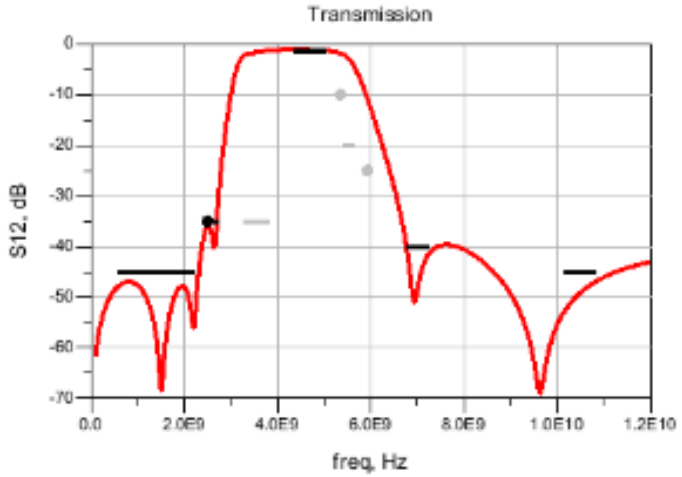
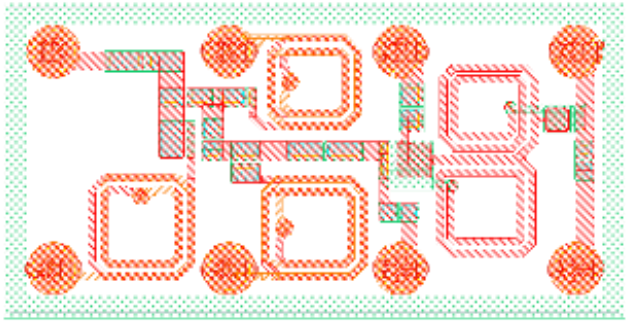
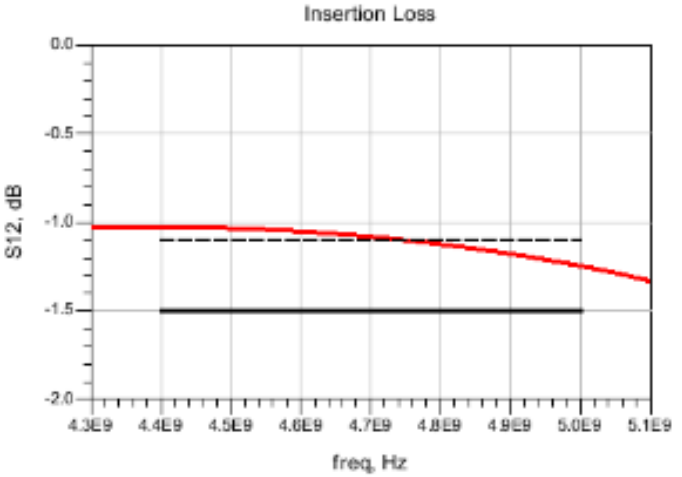
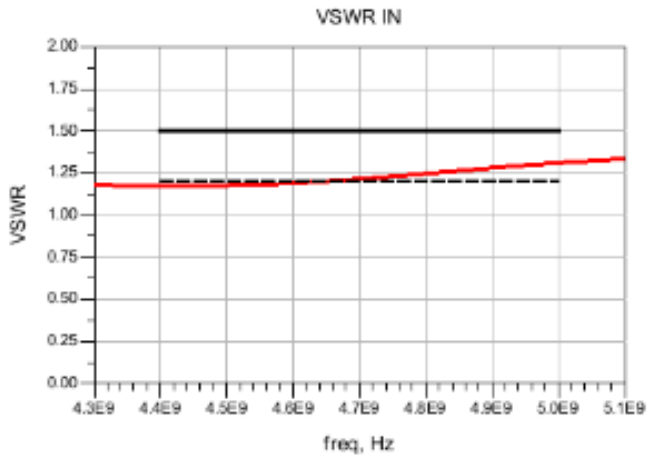
Filters for 5G NR Band N79

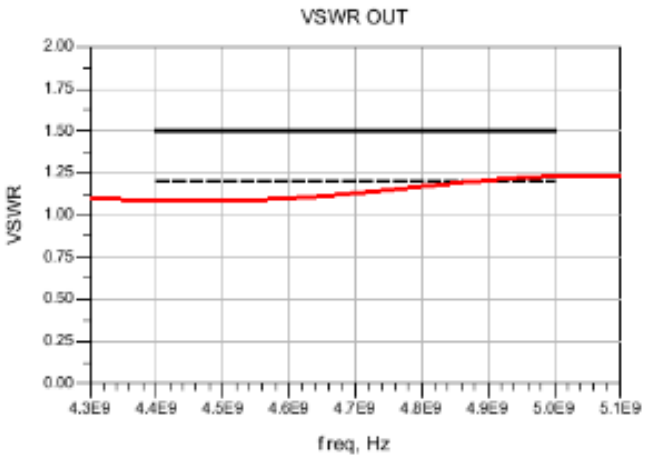




IPD die-size: 1.6x0.8mm
Z-height: 0.25mm







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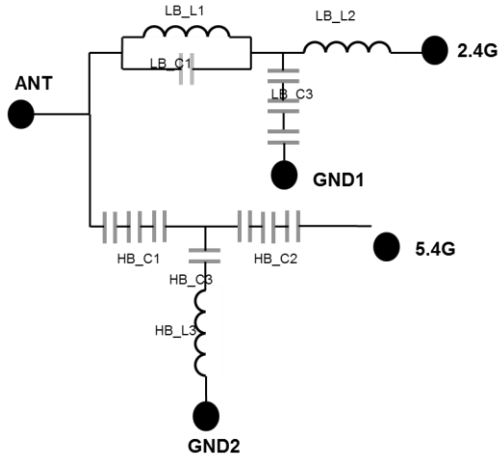
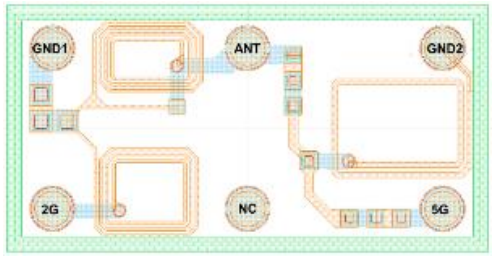
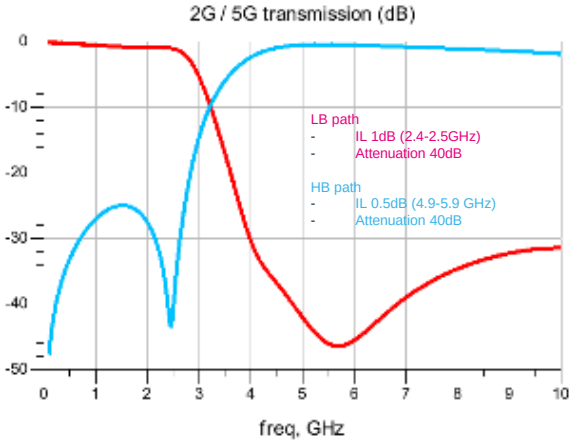
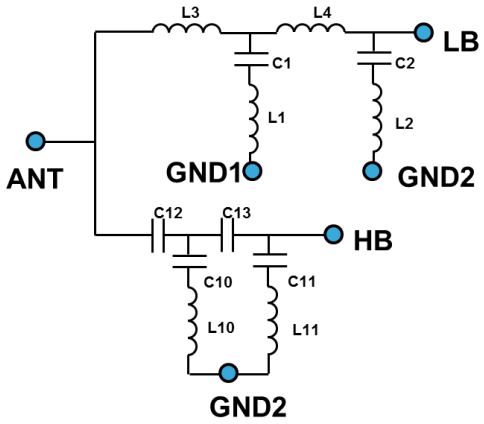
Diplexers for 2.5 / 5GHz

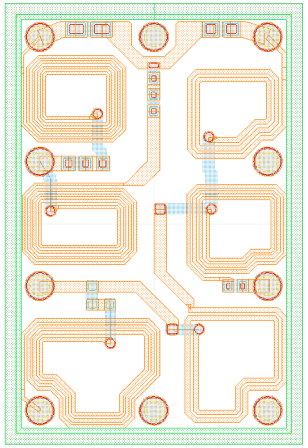




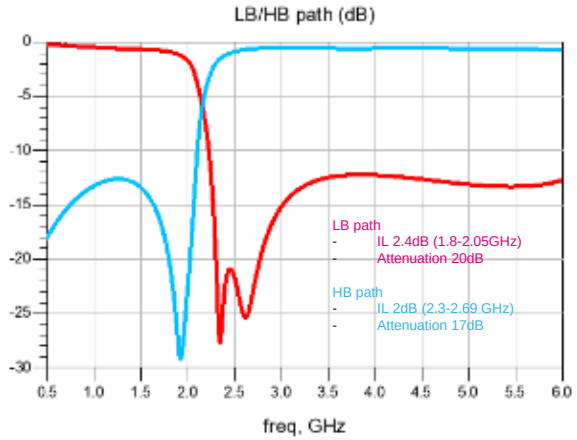
Die size 1.6 x 0.8 mm²
Z-height: 0.3mm







Die size: 1.2 x 1.8 mm²
Z-height: 0.3mm



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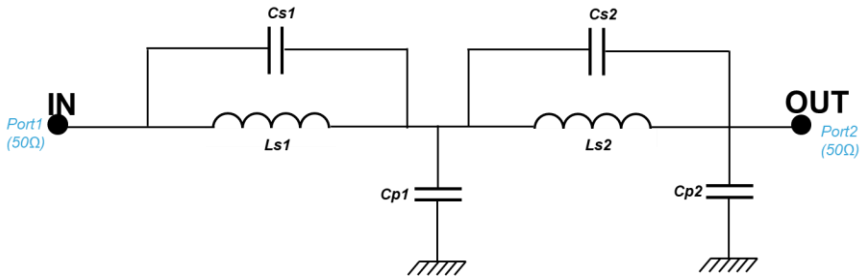
Filters for Low Band GSM 800-900

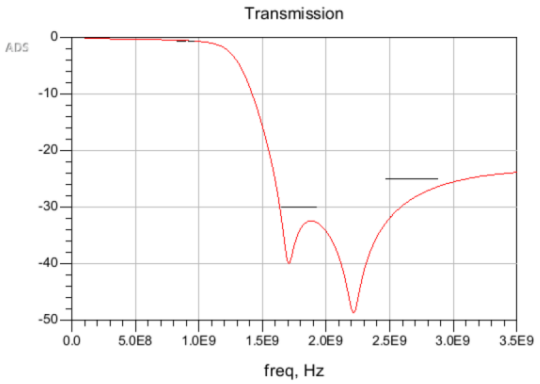
Specifications

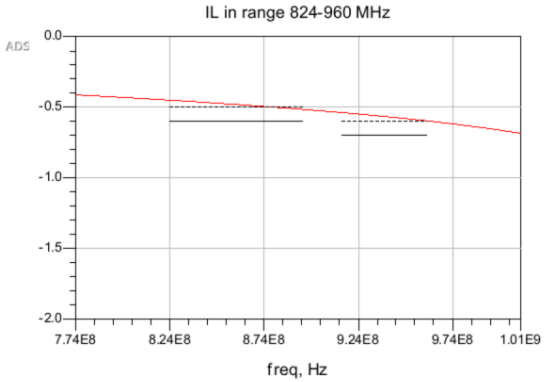
Filter 1 (GSM800/900)

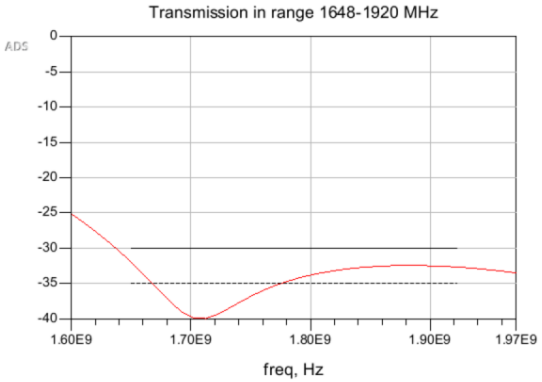
Parameter	Freq(MHz)	Target Spec/max	Typ	Unit
Insertion Loss	824 - 894	0.6	0.5	dB
	915 - 960	0.7	0.6	dB
Attenuation	1648 -1830	30	35	dB
	1830 - 1920	30	35	dB
	2472 - 2745	25	30	dB
	2745 - 2880	25	30	dB
Return Loss	824 - 915	10	25	dB
	915 - 960	10	20	dB

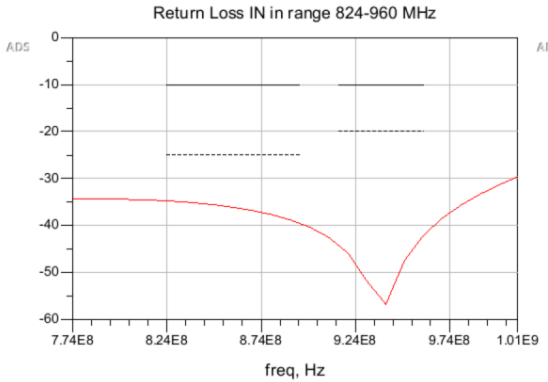


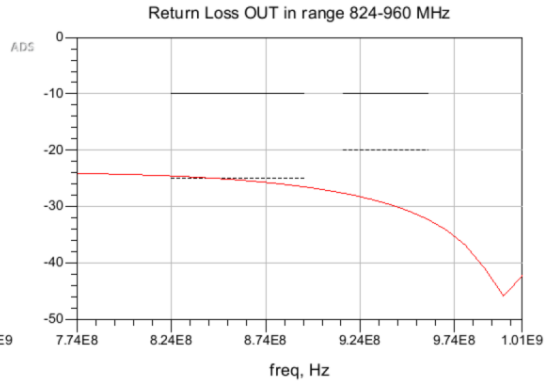
Die-size < 1mm²











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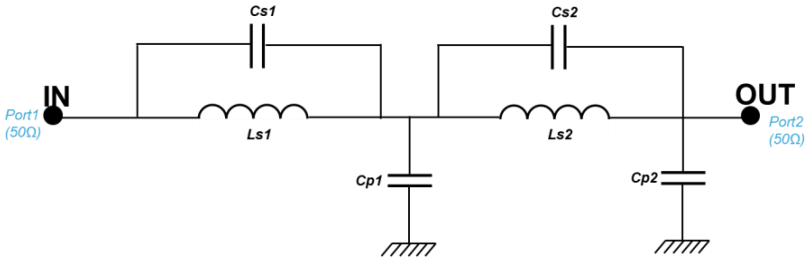
Filters for GSM 1800-1900

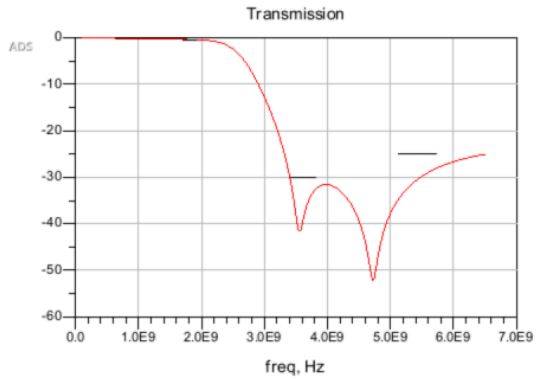
Specifications

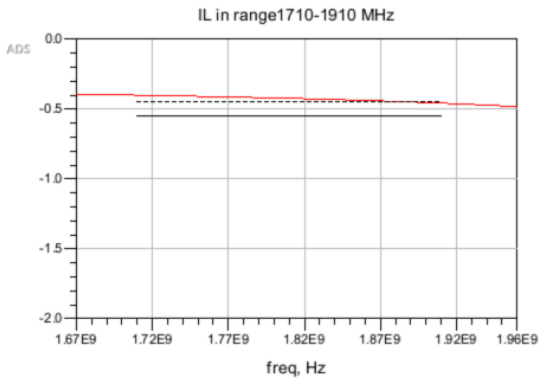
Filter 2 (GSM1800/1900)

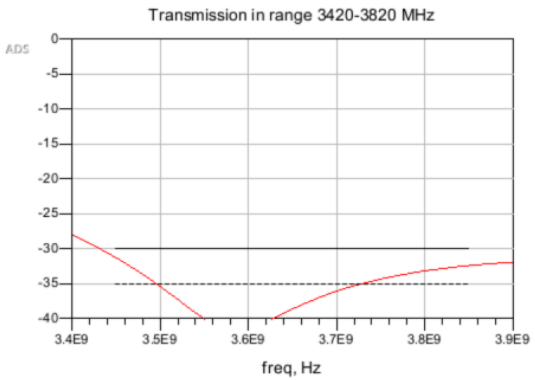
Insertion Loss	1710 - 1910	0.55	0.45	dB
Attenuation	3420 - 3820	30	35	dB
	5130 - 5730	25	30	dB
Return Loss	1710 - 1910	10	20	dB

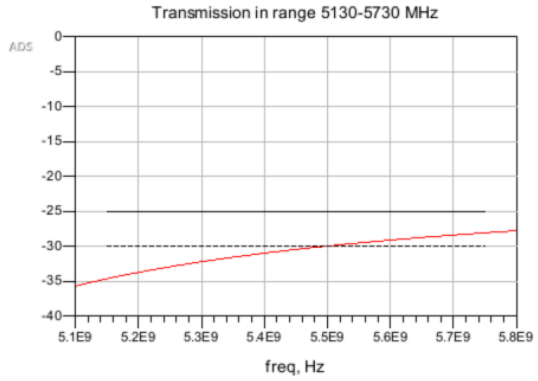


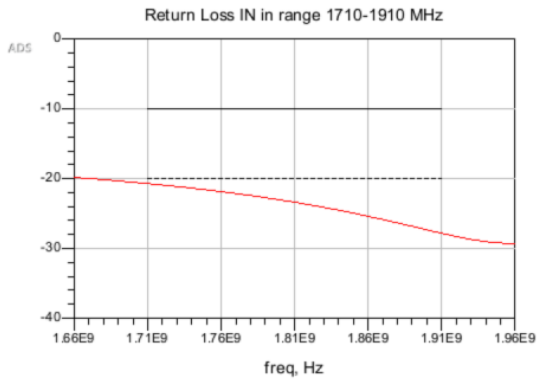
Die-size < 0.7mm²

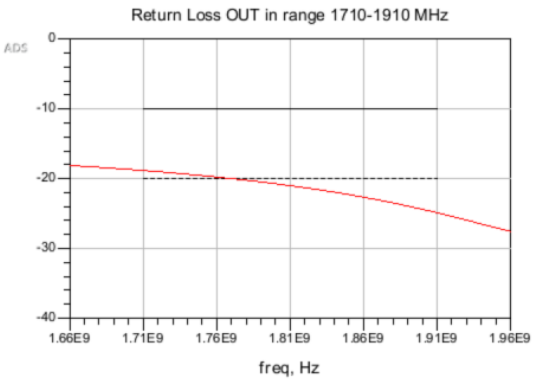












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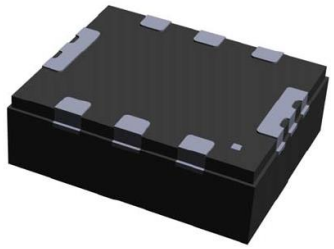
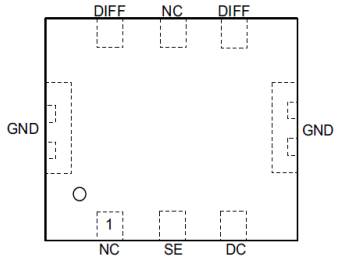
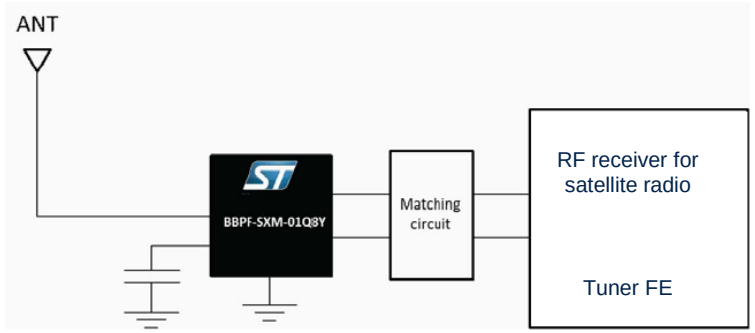
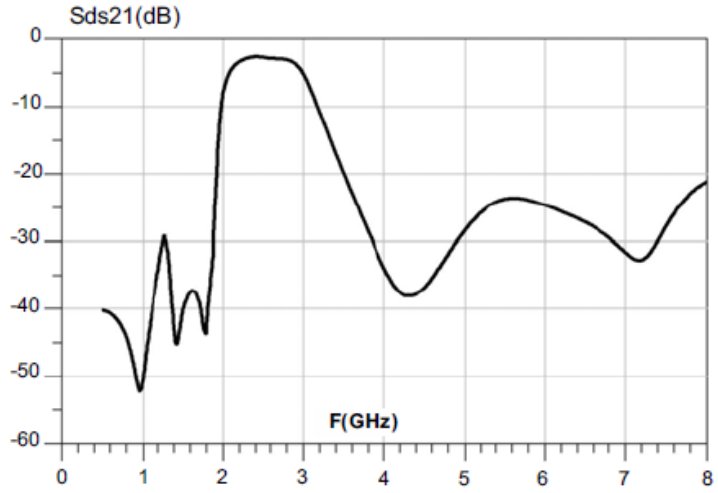
2.3GHz Band Pass filter for Satellite Radio
automotive grade

- 50Ohm IN 100Ohm OUT
- Low Insertion Loss / Low phase imbalance
- Harmonic rejection:
  - 880-960MHz >40dB
  - 1.7-1.9GHz 22dB
  - 3.8 – 4.8GHz >30dB
- Automotive Grade QFN package









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Sub-GHz, Bluetooth® LE and Wi-Fi Product overview

RF IC Supplier	IC name	Matched Balun	Freq (MHz)	Integrated Filter	Size	Package
STMicroelectronics	Spirit I	BALF-SPI-01D3	868-915	Yes	1.4 x 2.0mm	CSP
	S2-LP	BALF-SPI2-01D3	868-915	Yes	2.1 x 1.5mm	CSP
	BlueNRG-MS	BALF-NRG-01D3	2400	Yes	1.4 x 0.85mm	CSP
	BlueNRG-2	BALF-NRG-02D3	2400	Yes	1.4 x 0.85mm	CSP (<0.35mm height available)
Atmel	ATWINC-1500A	BAL-WILC10-01D3	2400	No		CSP
TI	CC1101	BAL-CC1101-01D3	868-915	No		CSP
	CC2540/43/45, CC2530/31/33	BAL-CC25-01D3	2400	Yes		CSP
Nordic Semi	nRF51822-CxAx nRF51422-CxAx	BAL-NRF02D3	2400	Yes		CSP
	nRF51822-QFAAHx	BALF-NRF01E3	2400	Yes		Bumpless CSP (LTCC-type)

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Sub-GHz, Bluetooth® LE and Wi-Fi Product overview

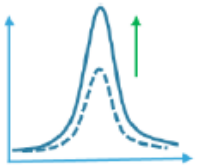
RF IC Supplier	IC name	Matched Balun	Freq (MHz)	Integrated Filter	Size	Package
STMicroelectronics	STM32WB55Cx	MLPF-WB55-01E3	2400-2500	Yes	1.5x1.0mm	Bumpless CSP (LTCC-type)

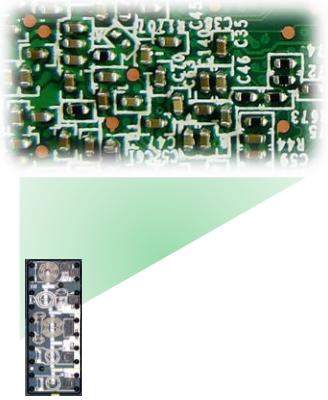
RF IC Supplier	IC name	Matched Balun	Freq (MHz)	Integrated Filter	Size	Package
Ultra wide band	Recommended for DW1000 from DecaWave	BAL-UWB-01E3	3000-8000	No	1.8 x 1.25mm	Bumpless CSP (LTCC-type)

Benefits

Benefits for IPD

5G Evolution™





- Better Performance (especially at sub 6GHz 5G freq) from high Q & low loss
- Higher level of integration, small form factor, PCB space savings
- Overall system level cost saving - SMT + reliability + BOM cost down

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Conclusion

- IPD for sub 6GHz bands, V2X and mmWave
- Mature technology on HRSi / Glass with Cu layers and MIM capacitors
- Multiple packaging options available: WLCSP and bare-die
- Wide range of IPDs already shipping: Filters, Diplexers, xformers etc.
- Integration of RF passives for performance and space optimization