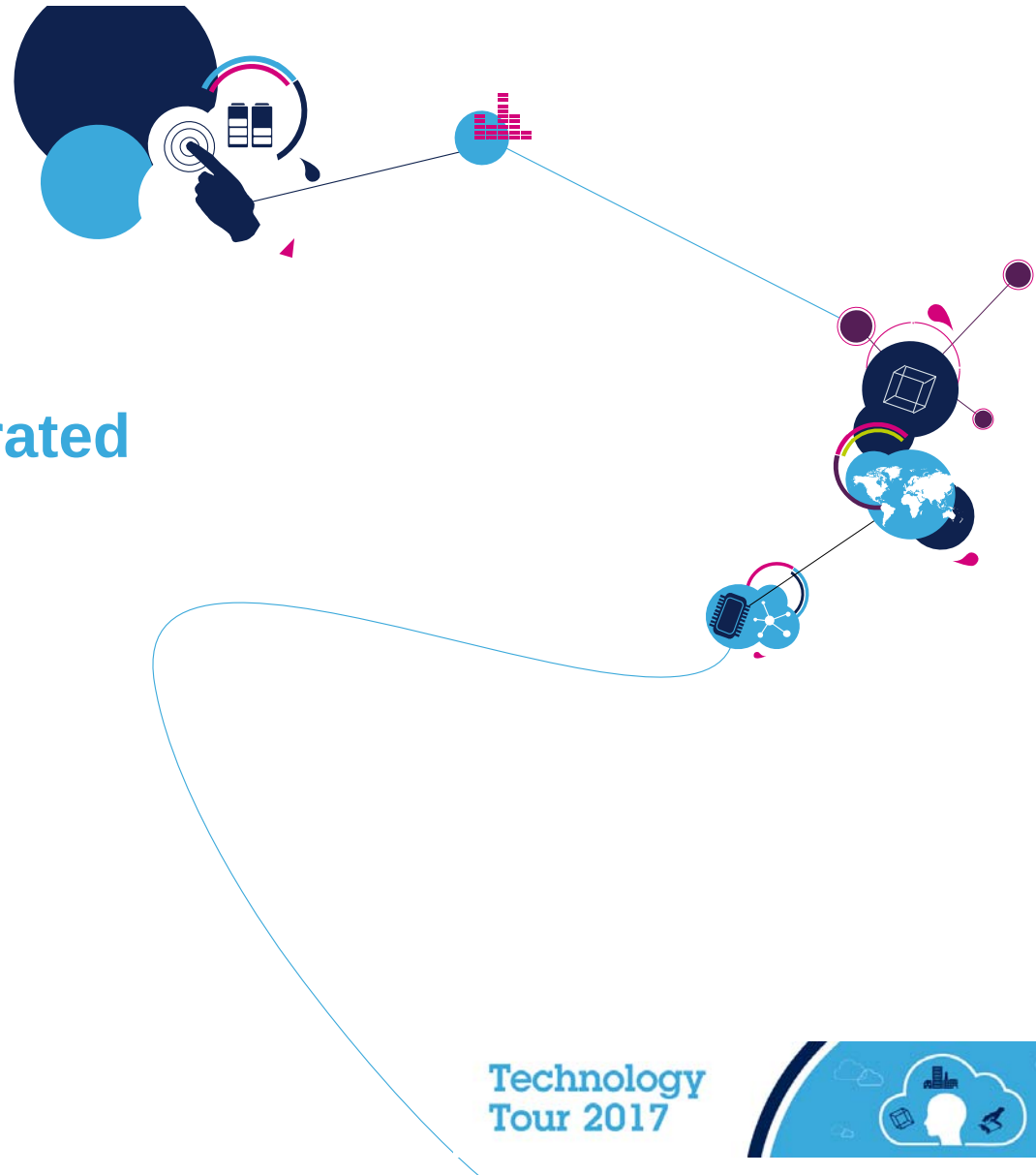


Baluns & Protection ESD Protection and RF Integrated Passives

Wayne Salata – Applications Engineer



Technology
Tour 2017



Agenda

2

- ESD Protection for High Speed Applications
- ESD and Common Mode Filters for USB Type C
- RF Integrated Passive Devices
- Target Applications & Product Examples
- Benefits vs Competition
- Q&A

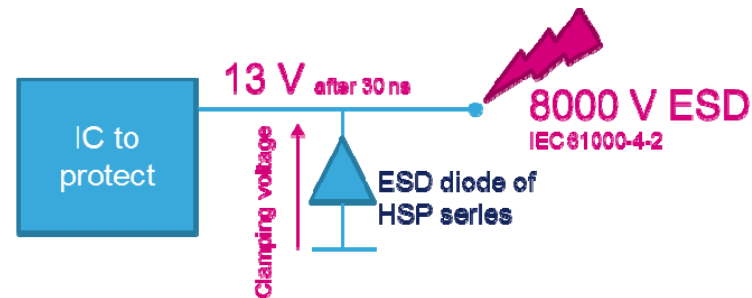
Where is ESD Protection Needed?

3

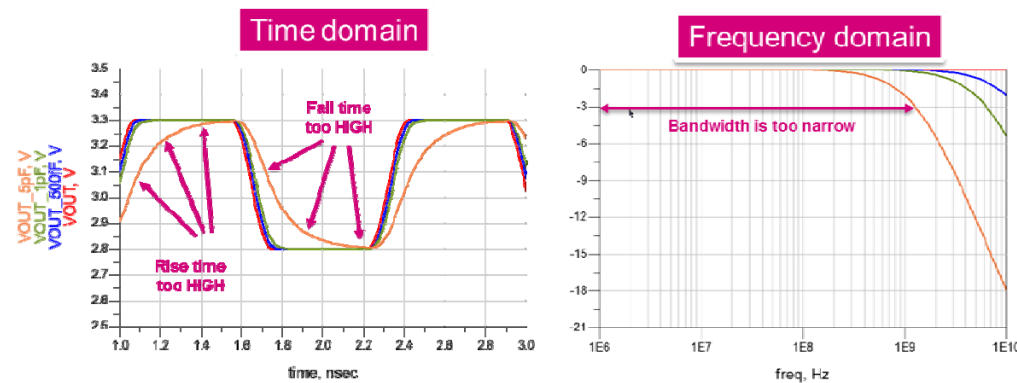


What is Important for ESD Protection?

- Clamping Voltage



- Parasitic ESD Capacitance



ESD Selection Criteria

5

- **V_{BR} Breakdown voltage** higher than operating signal
Above this voltage, the ESD protection devices will enter Clamping mode
- **f_c Cut-off frequency** higher than high-speed signal bandwidth defined by the rise time value
- **$C_{I/O \text{ to GND}}$ Low parasitic capacitance** (a consequence of high bandwidth) minimizing the impact on transmission line impedance
- **R_d Dynamic resistance & V_{CL} Clamping voltage** to keep the protected IC safe

Example of HSP051-4M10

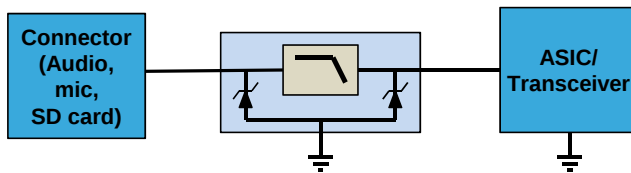
Symbol	Test conditions		Min.	Typ.	Max.	Unit
V_{BR}	$I_R = 1 \text{ mA}$		4.5	5.8		V
I_{RM}	$V_{RM} = 3.6 \text{ V}$			10	100	nA
V_{CL}	$I_{PP} = 1 \text{ A}$, 8/20 μs				10	V
V_{CL}	IEC 61000-4-2, +8 kV contact ($I_{PP} = 16 \text{ A}$), measured at 30 ns			13		V
R_d	Dynamic resistance, pulse duration 100 ns	I/O to GND		0.48		Ω
		GND to I/O		0.96		
$C_{I/O - I/O}$	$V_{I/O} = 0 \text{ V}$, $F = 200 \text{ MHz}$ to 9 GHz			0.2	0.3	pF
$C_{I/O - GND}$	$V_{I/O} = 0 \text{ V}$	$F = 200 \text{ MHz}$ to 2.5 GHz		0.4	0.55	pF
		$F = 2.5 \text{ GHz}$ to 9 GHz		0.35	0.45	pF
f_C	-3dB			10		GHz
Z_{diff}	Time domain reflectometry: $t_r = 200 \text{ ps}$ (10 - 90%), $Z_0 = 100 \Omega$		85	100	115	Ω

Common Mode and EMI Filters

6

EMIF series

ElectroMagnetic Interference Filter



Application:

- Audio: microphone, headset, speaker
- Display and camera (parallel interface)
- Keypad and data lines
- SIM card / SD card

Function:

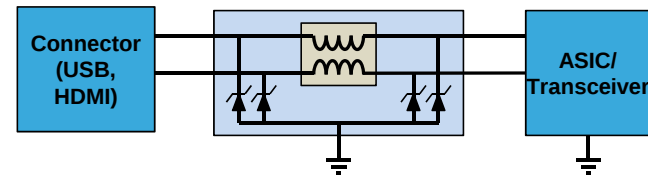
- Rejection of EMI from WiFi/cellular signals on I/O lines
- ESD Protection on I/O lines

Package:

- single line or multi lines
- plastic package/QFN or CSP flipchip.

ECMF series

ESD protected Common Mode Filter



Application / function :

- USB
- HDMI
- MIPI D-PHY, M-PHY
- MHL

Function:

- Rejection of Common mode noise from WiFi/cellular signals on differential I/O lines
- ESD Protection on I/O lines

Package:

- single line or multi lines
- plastic package/QFN or CSP flipchip.

ESD Protection Line up

7

POWER RAILS

CLAMP GEN3

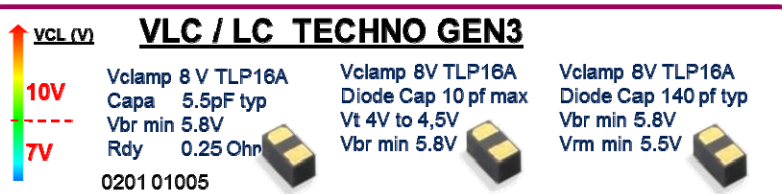
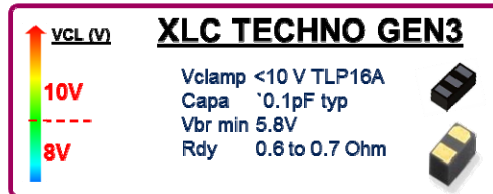
CLAMP GEN2

CLAMP GEN1

NON SNAP BACK

High Vbr Diodes ESD Single

Miniature High Power EOS Single



3.1 type



2.0 4K/2K



DP



SD3.0 / SIM



I2C



AUDIO



DC

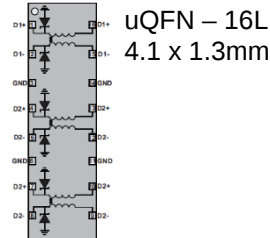
Common-Mode & EMI-Filter Lineup

8

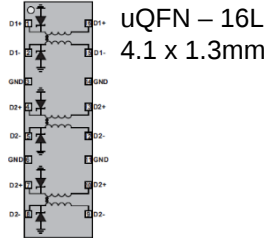
Number of Lines

6x

ECMF06-6HSM10



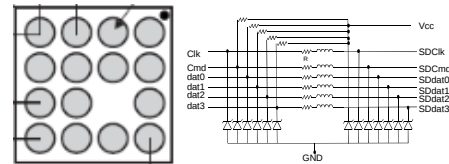
ECMF06-6HSM10



EMIF06-USD04F3 SD CARD

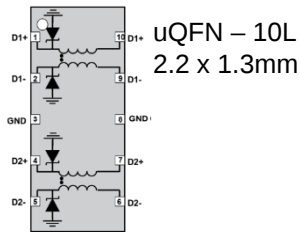
6-line TVS + filter + pullup

CSP 1.5 x 1.5mm

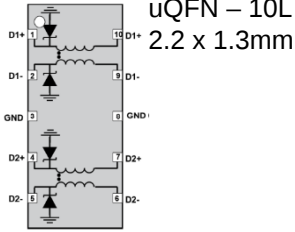


4x

ECMF4-20A42N10

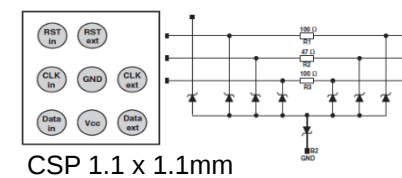


ECMF4-20A42N10



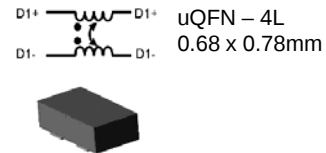
EMIF03-SIM03F3 Sim Card

3-line TVS + filter + Vcc

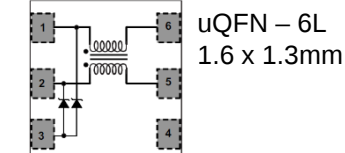


2x

CMF2-20A60H3

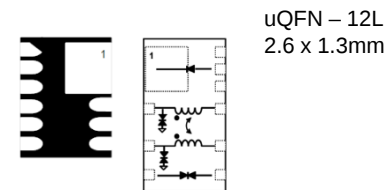


ECMF02-2HSMX6



ECMF02-0730V12M12

2-line ECMF+ ID + Vbus



USB 3.1

HDMI 2.0 /MIPI /SD 4.2

SD 3.0 / SIM

USB 2.0 & Vbus

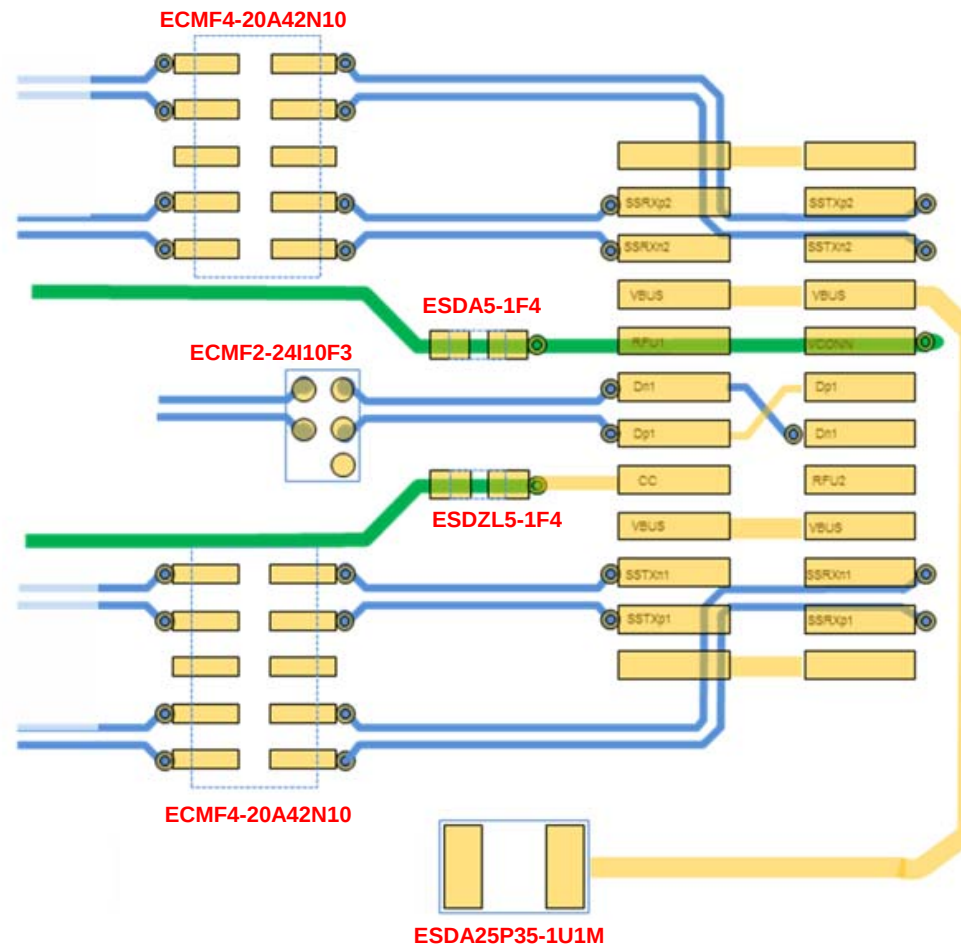
ESD Protection + Common Mode Filter

9

For USB TYPE C



BOM 1



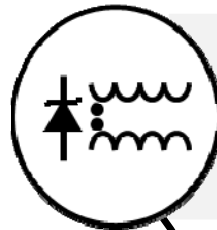
ESD Protection + Common Mode Filter

10

BOM 1

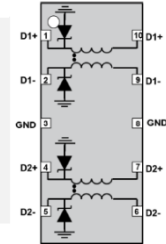
For USB TYPE C

Tx Rx

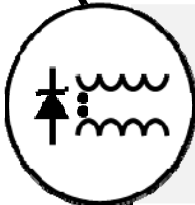


ECMF4020A42N10

- 4-line CMF FILTERS and combined TVS ESD for USB 3.1
- Clamping Voltage: 11V / 10 Gbps Diff Bandwidth
- Common Mode Rejection: -25dB @ 2.5GHz, -12dB @ 5GHz
- 1.35 x 2.2 mm

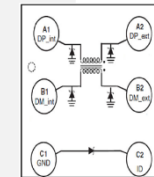


D+ D-

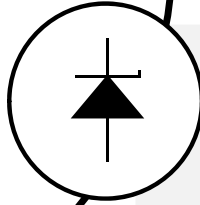


ECMF2-24I10F3

- 2-line CMF FILTERS + TVS ESD for USB 2.0
- Clamping Voltage: 15V / 2 Ghz Diff Bandwidth
- Common Mode Rejection: -17dB @ 2.5GHz, -17dB @ 5GHz
- 1.3 x 09 mm

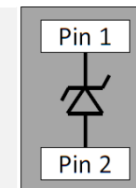


Vbus

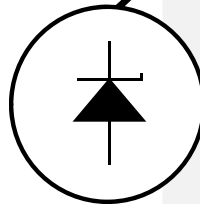


ESDA25P35-1U1M

- Single Line TVS designed for Vbus IEC61000-4-5
- Peak Pulse Power 1400W 8/20us waveform
- Compliant 20V USB PD
- 1.6 mm x 1.0 mm



CC
Vconn



ESDA5-1F4

- Single line TVS ESD for Vconn line in 0201 package
- Clamping Voltage: 9V / Line Cap 110pF / 30KV IEC



ESDZL5-1F4

- Single line TVS ESD for CC line in 0201 package
- Clamping Voltage: 8V / Line Cap 10pF / 12KV IEC



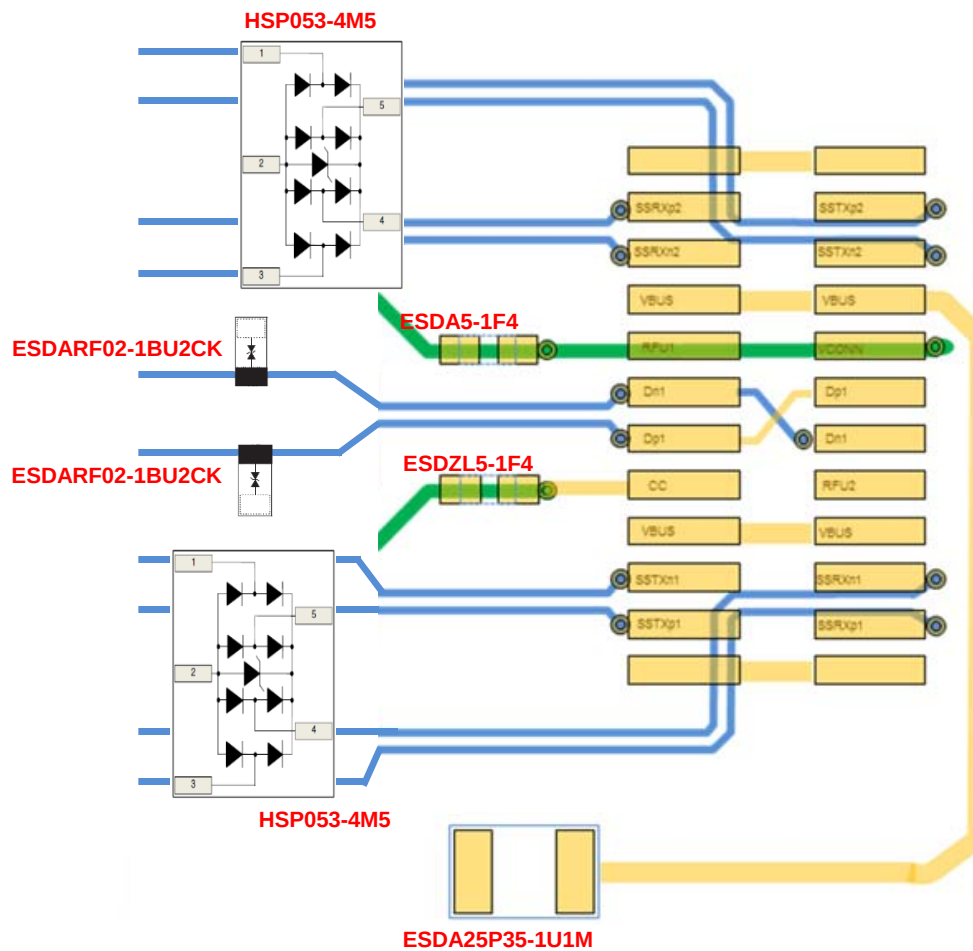


BOM 2

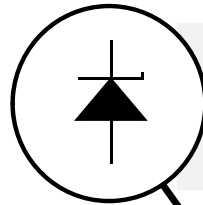
ESD Protection

For USB TYPE C

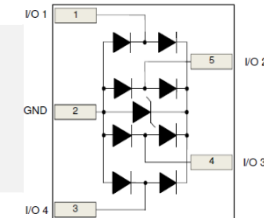
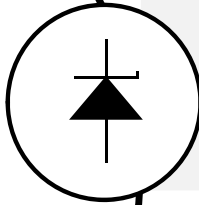
11



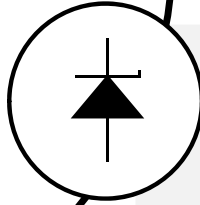
For USB TYPE C

Tx Rx**HSP053-4M5**

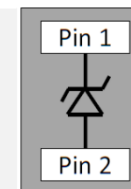
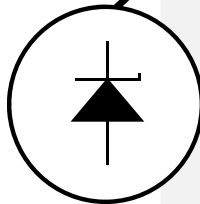
- 4-line TVS ESD for USB 3.1
- Clamping Voltage: 10V / 20 Gbps Diff Bandwidth
- 1.3 x 0.8 mm

D+ D-**ESDARF02-1BU2CK**

- Single Line TVS designed for USB 2.0 in 0201 package
- Clamping Voltage: 10V / Line Cap 0.2 pF
- 8 kV Protection

Vbus**ESDA25P35-1U1M**

- Single Line TVS designed for Vbus IEC61000-4-5
- Peak Pulse Power 1400W 8/20us waveform
- Compliant 20V USB PD
- 1.6 mm x 1.0 mm

CC
Vconn**ESDA5-1F4**

- Single line TVS ESD for Vconn line in 0201 package
- Clamping Voltage: 9V / Line Cap 110pF / 30KV IEC

**ESDZL5-1F4**

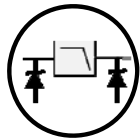
- Single line TVS ESD for CC line in 0201 package
- Clamping Voltage: 8V / Line Cap 10pF / 12KV IEC



EMI Filter + ESD

for Audio

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ESD

ESD
+
Filtering

ESDALC14-1BF4
22pF, 0.3x0.6 = 0.18 mm²



0201 package

ESDALC8-1BF4
30pF, 0.3x0.6 = 0.18 mm²



0201 package

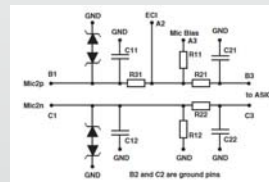
ESDA14V2-2BF3
12pF, 0.77x0.77 = 0.6 mm²



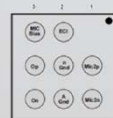
ESDAVLC8-4BN4
4.5pF, 0.8x1 = 0.8 mm²



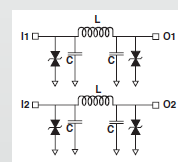
ESDAVLC5-4BU4
5.6pF, 0.53x0.93 = 0.5 mm²



EMIF02-MIC06F3
Fc=50kHz, 1.2x1.2 = 1.44 mm²



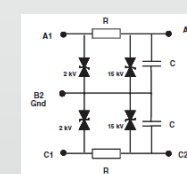
Microphone



EMIF02-SPK03F2
Fc=20MHz, Rdc=0.07Ohm
0.89x1.26 = 1.12 mm²



Loudspeaker

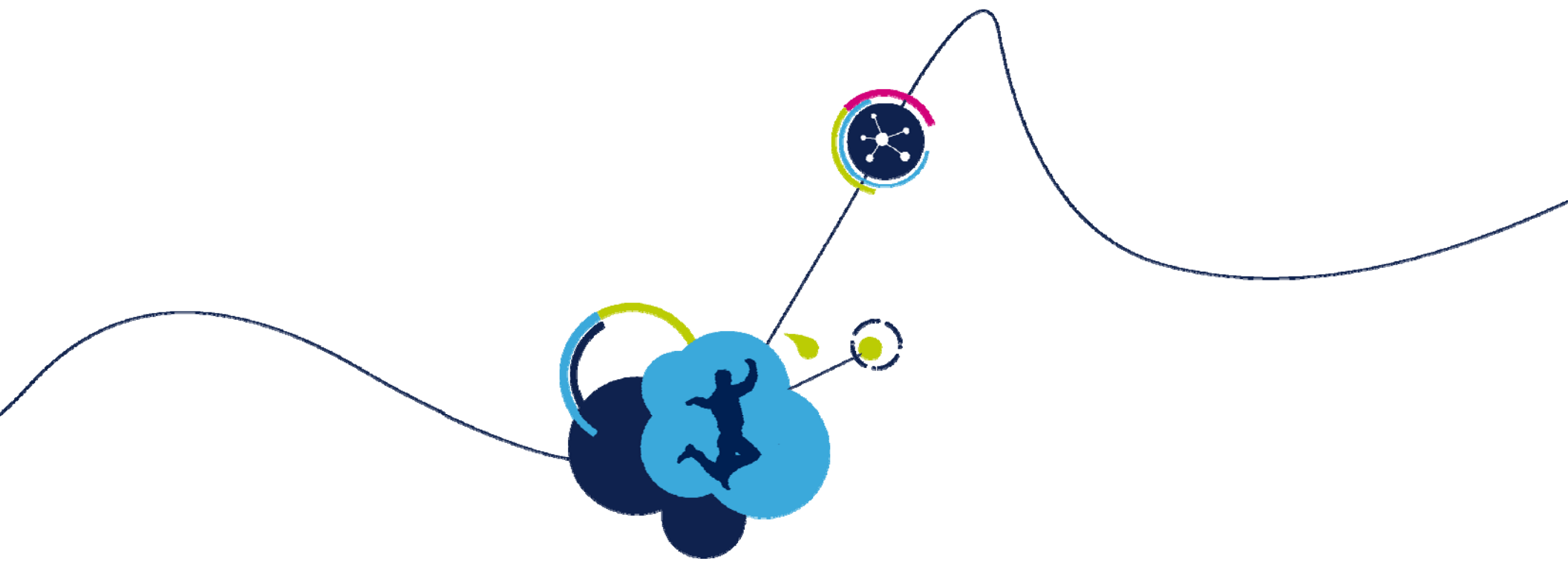


EMIF02-AV01F3
Fc=50kHz, 0.77x1.17 = 0.9 mm²



3.5mm Jack Headset



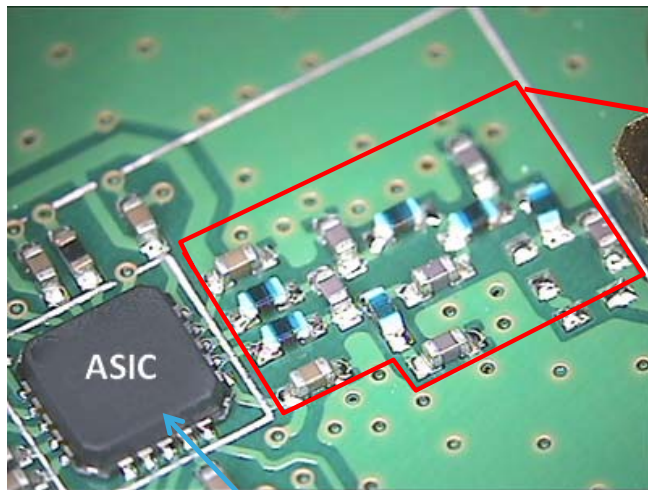


RF Integrated Passives

What is IPD?

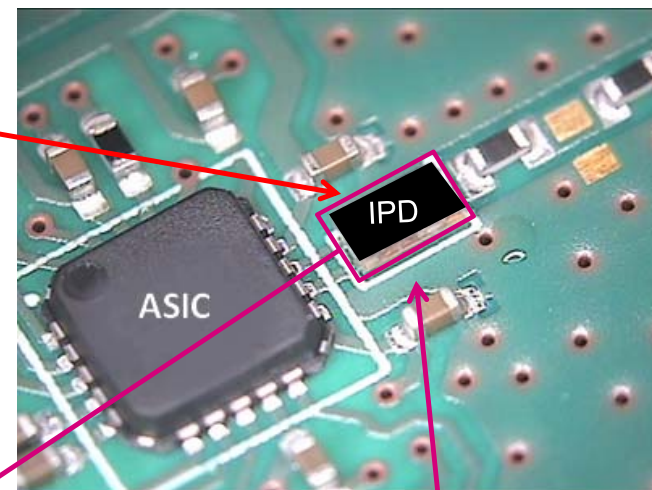
15

THIS IS NOT IPD



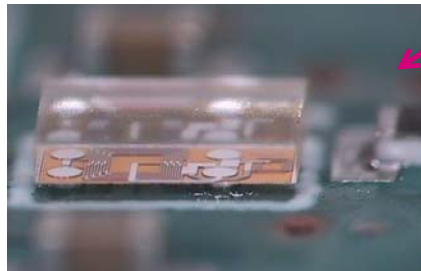
Application Specific Integrated Circuits

THIS IS IPD

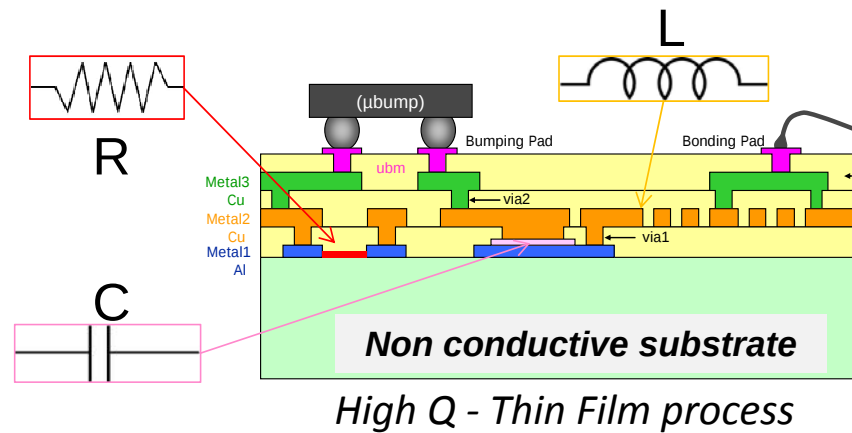
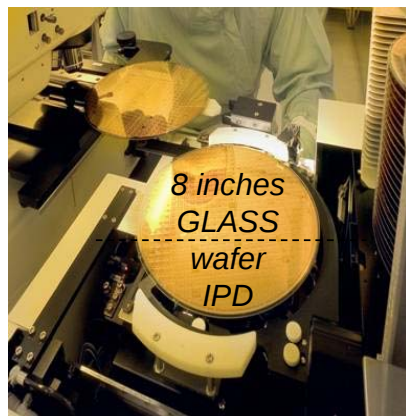
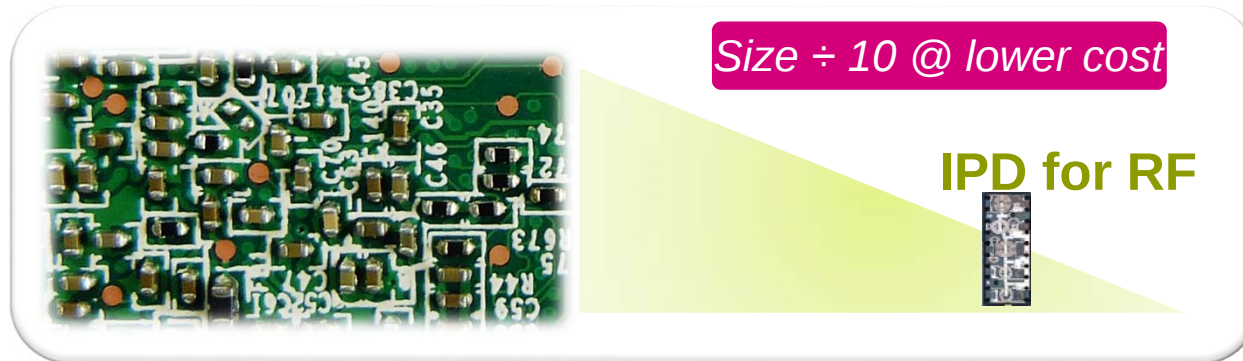


RF Integrated Passives Devices

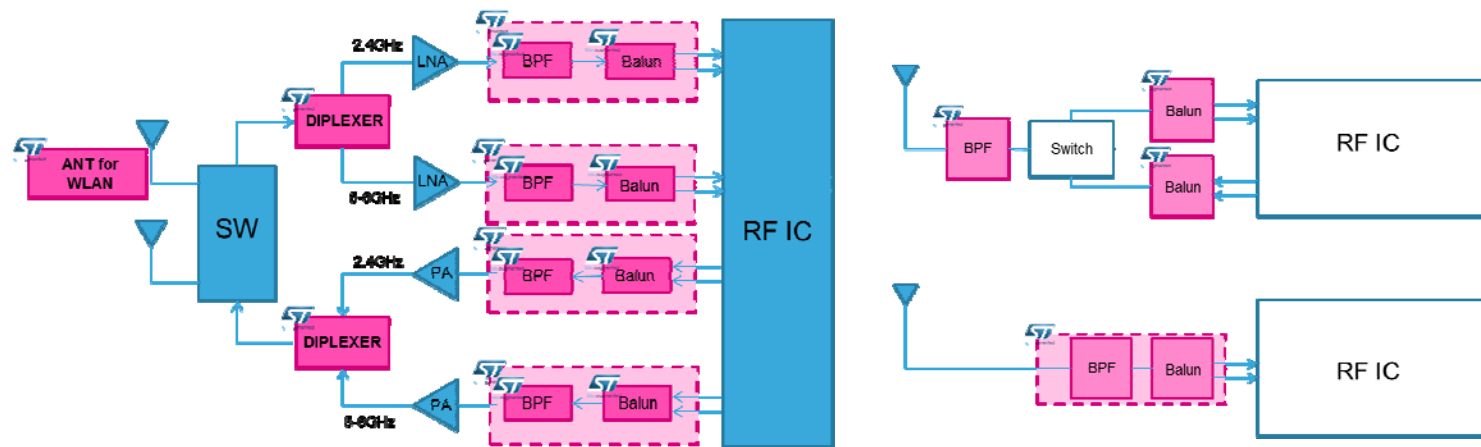
- Design **simplification**
- **Performance** optimization
- System **integration**
- **Reliability** improvement
- BOM **reduction**
- Successful **development** story



IPD Technology 16



IPD for Wireless Connectivity 17

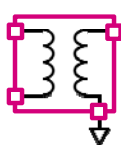


WHAT WE DO

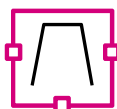
ANTENNA



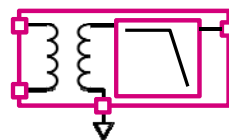
BALUN



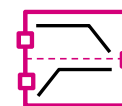
FILTER



BALUN+FILTER



DIPLEXER



Baluns

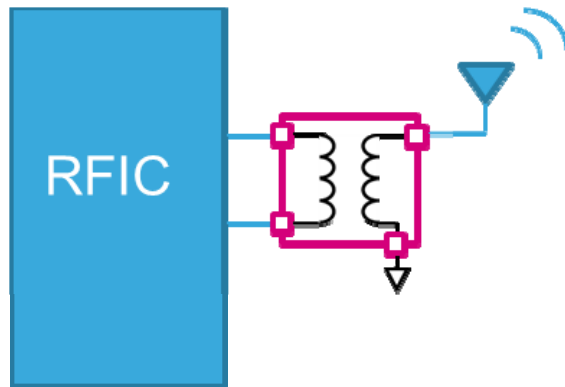


Simplify.connectivity



Why Use a Balun?

19



- Baluns transform an differential input to a single ended output and vice versa
- Typically between RF Transceiver and antenna
- Required at the output of most Bluetooth and SubG transceivers
- ST balun with integrated filter
- Baluns help to
 - improve RF signal integrity
 - provide optimal output power
 - improve overall battery life
- Some SoC solutions may not require external balun

Balun for BLUENRG (QFN/WLCSP)

BETTER. CHEAPER. SMALLER.



BALF-NRG-01D3

1 SIMPLIFY THE RF COMPLEXITY

- ▶ 1 component versus **8** components
- ▶ Fits QFN & WLCSP version

2 SHRINK BALUN MATCHING PCB OCCUPATION

- ▶ 1.2 mm² versus **32 mm²**
- ▶ No need for twisty layout

3 INCREASED PERFORMANCES

- ▶ Same Pout as SMD solution

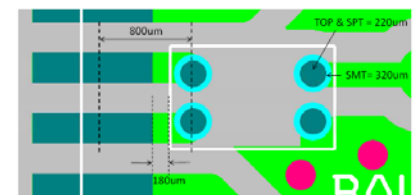
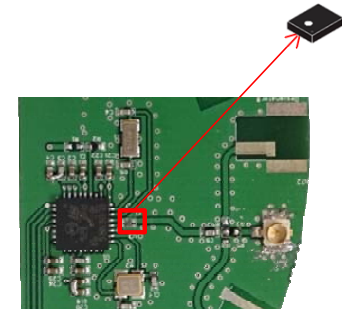
4 IMPROVED FILTERING

- ▶ Up to **+10dB Harmonic rejection** versus SMD

5 FASTER DESIGN

- ▶ « Copy-paste » layout recommandation

BALF-NRG-01D3



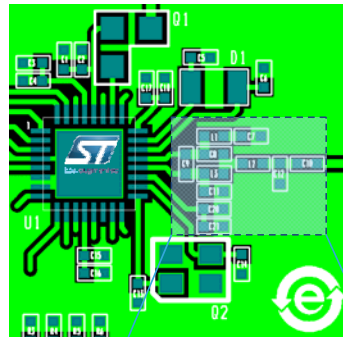
BLUENRG (QFN/WLCSP)

Balun Transformer with integrated harmonic filter



BALF-NRG-01D3

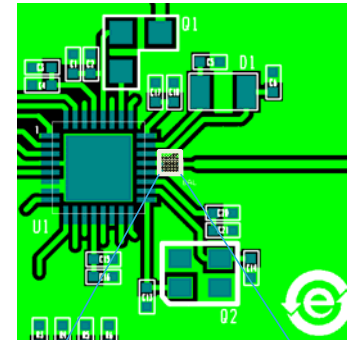
Simplifies & Shrinks IC-to-Antenna matching complexity



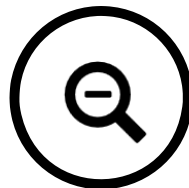
PCB Area for Antenna
SMD matching
8 x 4 mm ~ 32mm²



Replace **8x SMD** by
BALF-NRG01D3



PCB Area for Antenna
BALF-NRG01D3
1.4 x 0.85 mm ~ 1.2mm²



BALF-NRG-01D3 is 30 x smaller

ST Baluns portfolio

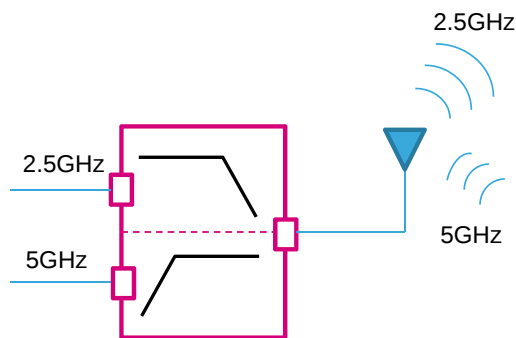
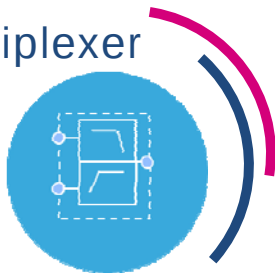
22

RF IC supplier	RF IC	Matched Balun	Frequency (MHz)	Integrated filter	Size	Package
STMicroelectronics 	SPIRIT1	BALF-SPI-01D3	868-915	Yes	1.4mmx2.0 mm	WLCSP
	SPIRIT1	BALF-SPI-02D3	433	Yes	1.4mmx2.0 mm	WLCSP
	SPIRIT2	BALF-SPI2-01D3(*)	868-915	Yes	2.1mm x 1.55 mm	WLCSP
	SPIRIT2	BALF-SPI2-02D3(*)	433	Yes	2.1mm x 1.55 mm	WLCSP
	STLC2690	BALF-2690-02D3	2400	Yes	1.64 mm x 0.94 mm	WLCSP
	BLUENRG BLUENRG-MS BLUENRG-1	BALF-NRG-01D3 BALF-NRG-02D3(*)	2400	Yes	1.4 mm x 0.85 mm	WLCSP
Atmel	ATWINC1500A	BAL-WILC10-01D3	2400	No	0.95mm x 0.95mm	WLCSP
Texas Instrument 	CC1101	BAL-CC1101-01D3	868-915	No	2.0mmx1.0mm	WLCSP
	CC1120 CC1125	BALF-112X-01D3	868-915	Yes	1.95mm x 1.87mm	WLCSP
	CC1120 CC1125	BALF-112X-02D3	433	Yes	1.95mm x 1.87mm	WLCSP
	CC2540/43/45 CC2530/31/33	BAL-CC25-01D3	2400	No	0.9mmx0.9mm	WLCSP
	CC2541	BALF-CC25-02D3	2400	Yes	0.9mmx0.9mm	WLCSP
	CC2650/CC2640 CC2630/CC2620 CC2610	BALF-CC26-05D3	2400	Yes	0.9mmx0.9mm	WLCSP
Nordic Semi 	nRF51822-QFAACx nRF51822-QFABAx nRF51422-QFAA	BAL-NRF01D3	2400	Yes	1.5mmx1.0mm	WLCSP
	nRF51822-CTAx	BALF-NRF01J5(*)	2400	Yes	1.4mmx0.85mm (height<350µm)	Thin WLCSP
	nRF51822-CxAx nRF51422-CxAx	BAL-NFR02D3	2400	Yes	1.4mmx0.9mm	WLCSP
	nRF51822-QFAAHx nRF51822-QFACAx nRF51422-QFAAFx nRF51422-QFACAx	BALF-NRF01E3	2400	Yes	1.5mmx1.0mm	LGA
	nRF51822-QFAAGx nRF51822-QFABBx nRF51422-QFAAEx nRF51422-QFABAx	BALF-NRF01D3	2400	Yes	1.5mmx1.0mm	WLCSP

(*)Available Q3 2017

DIPLEXER AND BAND PASS FILTER

ST.diplexer



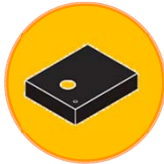
Why Use a Diplexer?

24

- Diplexer used to split RF signal into two frequencies
- Combination of two filters
- Typical Applications:
 - System supports WiFi 2.5/5GHz + BLE
 - System supports WiFi 2.5/5GHz
 - System supports GPS/GLONASS + BLE or WiFi
 - Systems supporting multiple cellular bands
- ST Diplexers can integrate additional filtering for specific band rejection
- Becomes a triplexer when there is need to separate one signal to 3 freq

WLAN 2G/5G Diplexer

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DIP2450-01D3

1 LOW INSERTION LOSS

▶ BELOW 0.5dB

2 ISOLATION

▶ 15dB Out of Band Rejection / Isolation between Bands

3 HARMONICS FILTERING

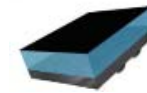
▶ 15dB attenuation @ 2nd & 3rd harmonics

4 ESD PROTECTION

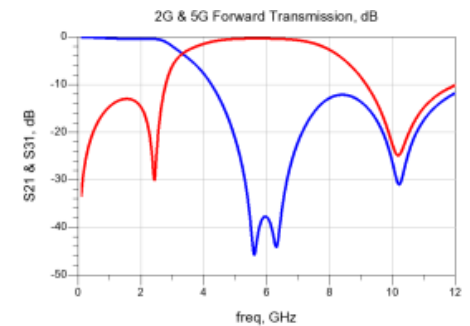
▶ Integrated ESD protection – 15kV

5 SMALL

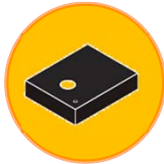
▶ Smaller footprint than LTCC equivalent



1.1 x 1.25 mm²



2.45G WLAN Band Pass Filter



BPF24-01D3

1 LOW INSERTION LOSS

▶ BELOW 1.5dB

2 GPS REJECTION

▶ >30dB Rejection [1573-1578] MHz

3 HARMONICS FILTERING

▶ >30dB Rejection [4900-5830] MHz

4 ESD PROTECTION

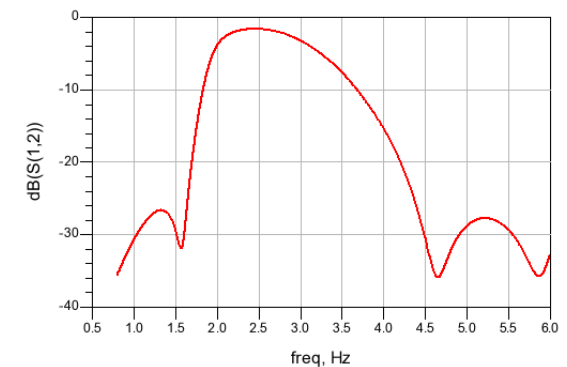
▶ Integrated ESD protection – 2kV

5 SMALL

▶ Smaller footprint than LTCC equivalent



1.1 x 1.0 mm²



Summary of ST Balun & Filter

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	ST	ROHM	TEXAS INSTRUMENTS	TI	dialog	NXP	QUALCOMM	BROADCOM	CYPRESS	SILICON LABS	MICROCHIP	Quantenna Communications	Green Peak	REALTEK	REDPINE SIGNALS
Bluetooth	BAL	BAL	BAL	BAL	BPF	BAL	BPF	BPF	BAL			BPF			
WiFi							BPF	BPF				BPF		BAL	BAL+DIP
ZigBee			BAL							BAL	BAL		DLPF		
Sub-1GHz	BAL		BAL							BAL					

BAL+DIP BALUN+DIPLEXER+FILTER

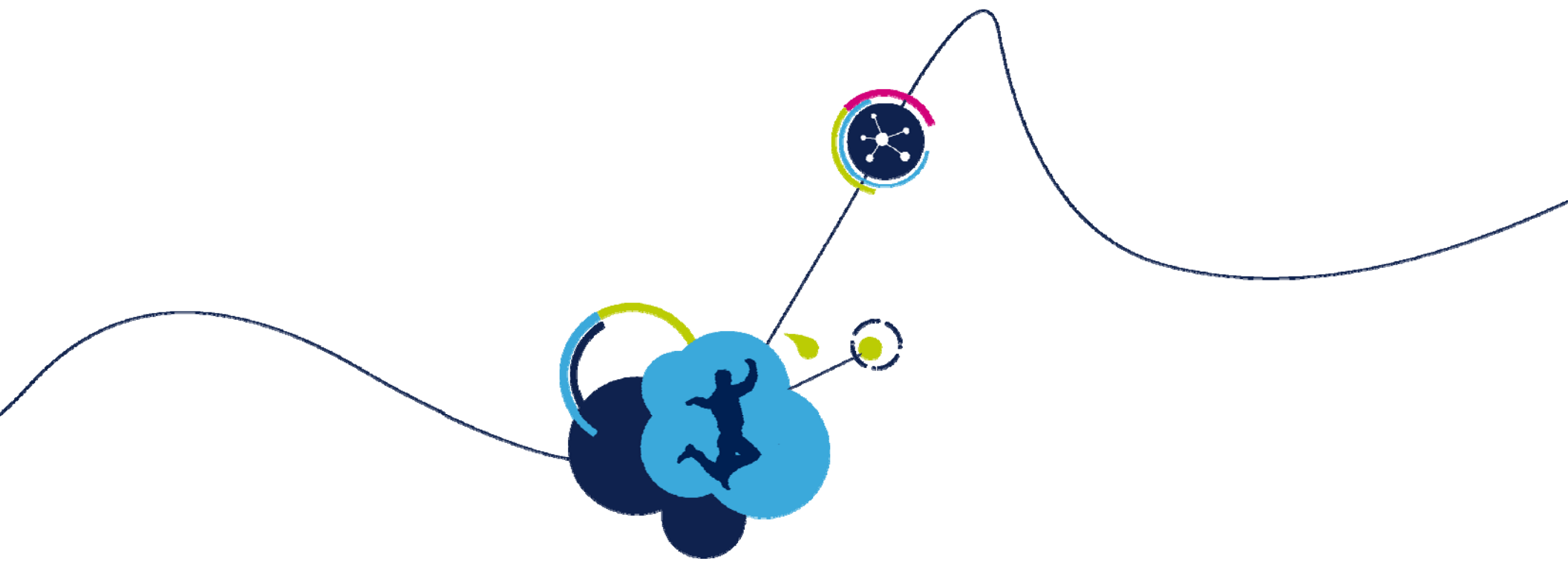
BAL BALUN

BPF Band Pass Filter

 Available

 Planned or On-Going

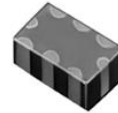
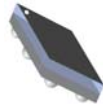
 No Plan



Benefits of RF Integrated Passives

RF IPD Benefits over SMD & LTCC

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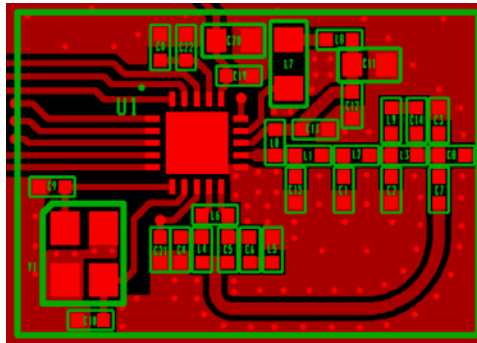
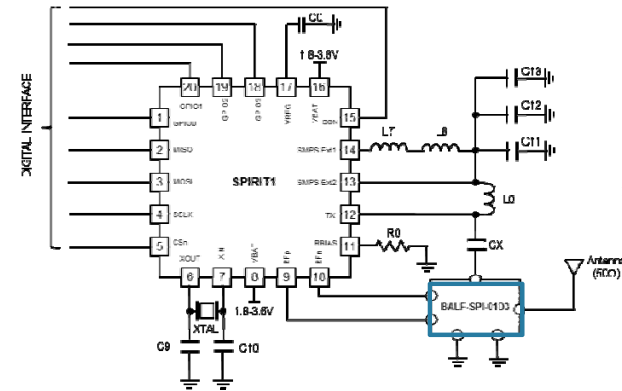
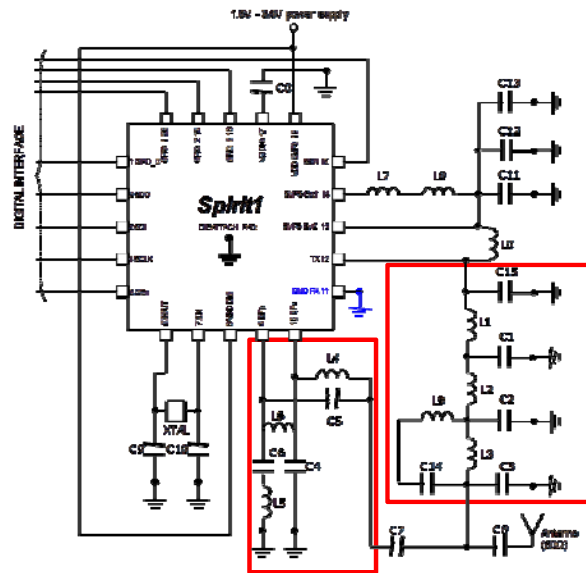
Criteria	IPD	LTCC	SMD
Performance	Excellent	Excellent	Good
Cost	Good	Good	Excellent
Robustness to drop	Excellent	Medium	Good
Size	Excellent	Good	Bad
Implementation simplification	Excellent	Excellent	Bad
Flexibility	Good	Good	Excellent
Temperature variation	Excellent	Good	Bad
Embedding capability	Excellent	Medium	Good



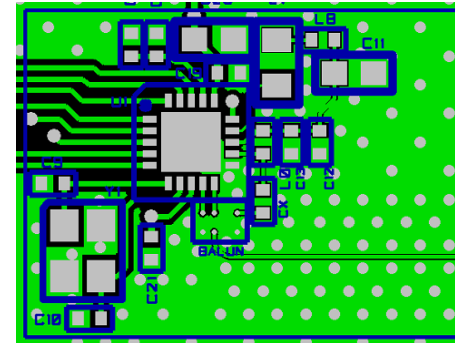
LOWER COST



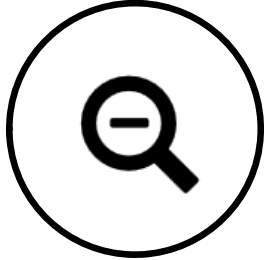
RF IPD - Cost & Space Benefits



More than
20% cheaper

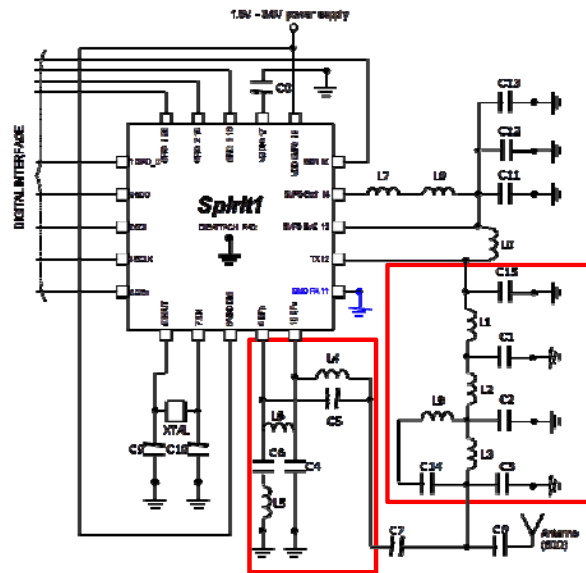


SMALLER

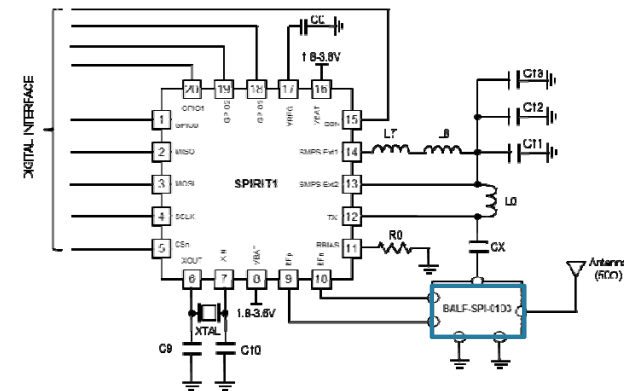
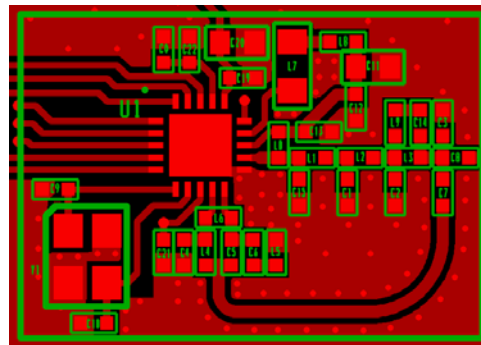


RF IPD - Smaller

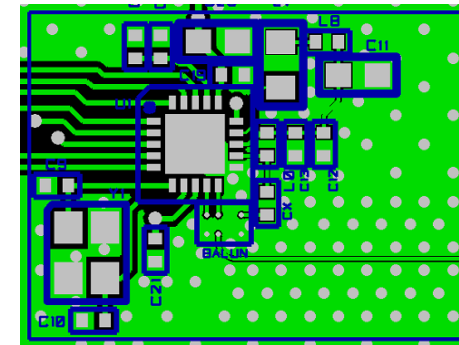
31



37 mm²

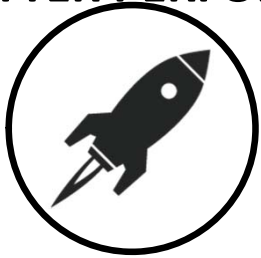


2.8 mm²



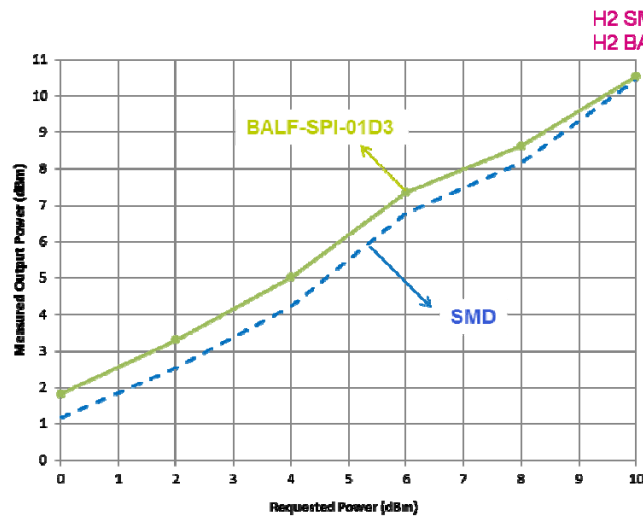
15 x smaller

BETTER PERFORMANCE

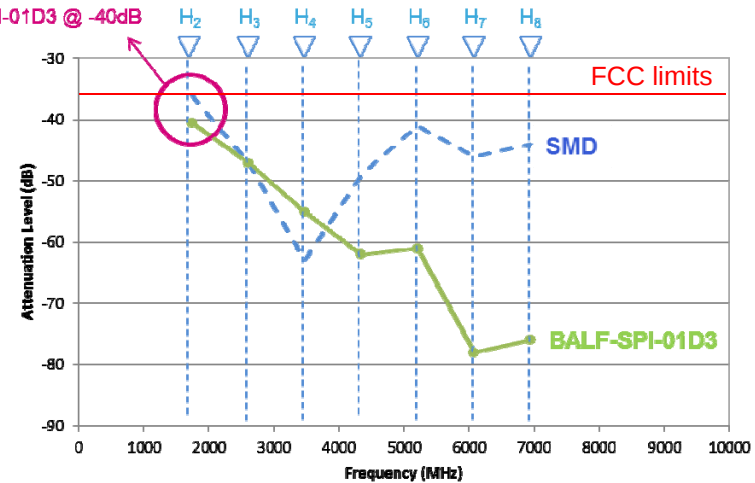


RF IPD - Performance

BETTER PERFORMANCES on HARMONICS & Pout



+1dBm power



+4dB H2 filtering

Summary

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- ESD Protection & Filter products targeting USB Type C, HDMI, SD card, Audio etc.
- RF Integrated Passive Devices (RF IPD) targeting wireless connectivity applications
- RF IPD Product-line: Baluns, Filters, Diplexers etc.
- Clear benefits over competition: Smaller, Better Performance, Better cost optimization

For further information

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Please contact:

Rahul Peravali

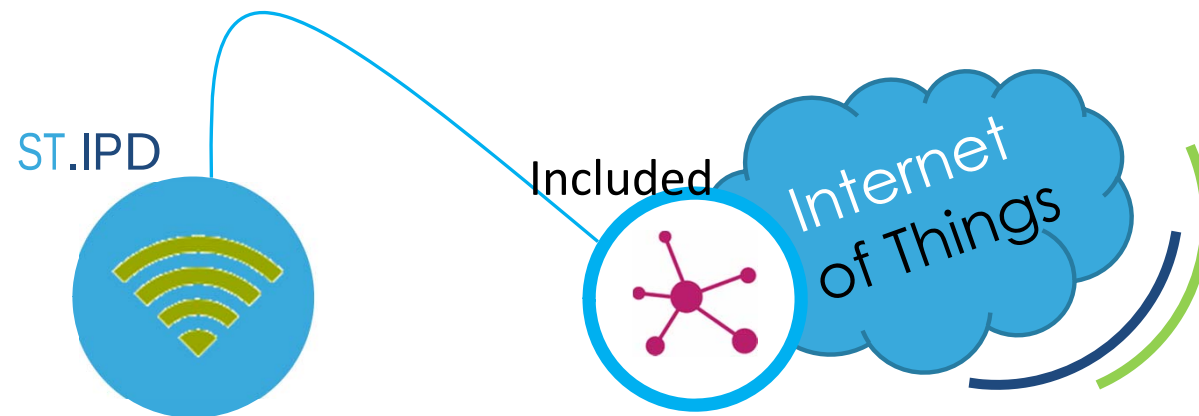
IPAD & Protection marketing
ST Santa Clara

Sylvain Mosquera-Duran

IPAD & Protection marketing
ST Santa Clara



Thank You



life.augmented