

Integrated Discretes

Interface conditioning and interface protection in mobile appliances

Rev. 7.02 — 21 September 2009

Brochure

Document information

Info	Content
Keywords	Integrated Discretes, EMI filter, ESD protection, chip scale package (CSP), level shifting, memory card, SD memory card, MMC, T-flash, audio, microphone, LCD interface
Abstract	This document presents a short, compressed overview about NXP Semiconductors Integrated Discretes device family typical used in mobile appliances such as • cellular phones • smart phones • portable media players • wireless modems

Revision history

Rev	Date	Description
7.02	20090921	Minor editorial update
7.01	20090914	Minor editorial update
7.0	20090828	General update
6.1	20081013	Products for USB2.0 added, IP4223CZ6, IP3219
6.0	20080910	New compilation with editorials and new products added
5.6	20070814	Editorial changes, drawings replaced
5.5	20070525	Editorial changes
5.4	20070417	Editorial changes
5.3	20070330	IP4253CZyy and IP4254CZyy added, editorial changes
5.2	20061207	High dense capacitor devices added
5.1	20061127	New compilation with editorials

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1. Summary

The Cellular handset industry is facing two very different challenges; first, to compete in the low-end market for high volume limited feature mobile phone models, and second, in the mid to high end market where features are one of the key elements in brand marketing.

1.1 Low end mobile phone handsets

For the low end, reduction of cost is of the highest importance. Integration is of major benefit, in both reduction in size of the overall phone, and also in reducing the component count and thereby the total cost of the phone.

The continuing trend towards miniaturization combined with the drive for more product features makes integrating components into electronic devices increasingly difficult. This is further compounded by requirements to limit EMI/RFI interference and also to provide high level ESD protection.

An obvious solution to space constrained applications is to integrate multiple components into a single package; NXP Semiconductor Integrated Discretes use thin film on silicon techniques to combine active and passive components into monolithic silicon solutions. These devices range from simple ESD protection arrays to complex audio interfaces incorporating many functions. The use of Chip Scale packaging maximizes the space utilization; space savings of up to 95 % are achievable compared to equivalent discrete solutions. Products in CSP packages can be placed on the PCB with normal high speed placement equipment. The CSP package has been designed to meet all reliability tests without the need for underfill.

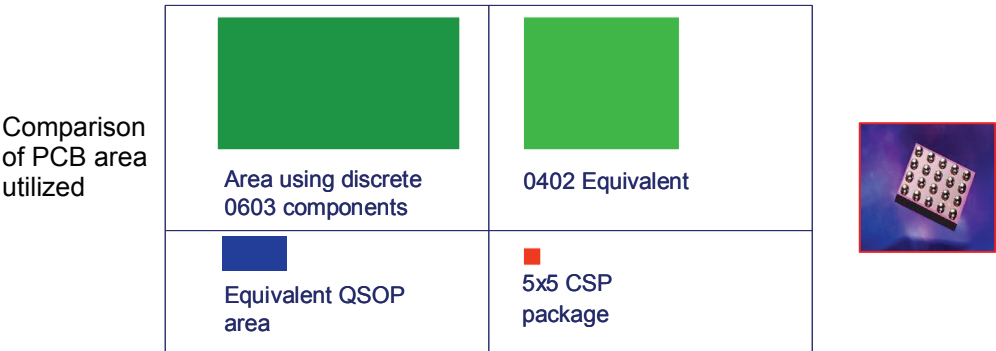


Fig 1. PCB area comparison of different package type for a 10-channel filter

A further benefit of the combination of thin film integration and Chip Scale packing is the improvement in filter performance. Devices using this combination and a multi layer board provide the maximum broadband attenuation of unwanted frequencies.

1.2 Mid and high end handsets

Whilst cost remains an important metric for any phone model the introduction of value added services require high and mid range phones to pack increased electronics into the same case sizes as preceding models. Here miniaturization plus performance are the leading requirements. The performance improvements of Integrated Discretes are of added benefit to a layout that has had to be optimized to fit into a limited space at the expense of filtering.

2. Introduction

NXP Integrated Discretes has developed solutions for use in many areas of cellular phone design focusing on the following key application areas:

1. ESD protection
2. EMI/RFI filtering
3. Termination
4. Low ohmic/over voltage tolerant analog switches
5. Level shifters

By the use of Integrated Discretes all of these applications can be fulfilled with just one single piece of silicon. The following sections will highlight the main features that are integrated into Integrated Discretes products

2.1 ESD protection

There are several system level tests required for phone certification; one of these is IEC61000-4-2 for Electrostatic Discharge protection.

Level 4 of this specification is one of the most stringent and requires the device to withstand contact discharges of at least 8 kV or, if contact discharge cannot be applied air discharges of 15 kV.

These discharges generate very high instantaneous currents that require specially designed devices to withstand these surges. The peak current for IEC61000-4-2 at 8 kV is between 27 and 33 amps.

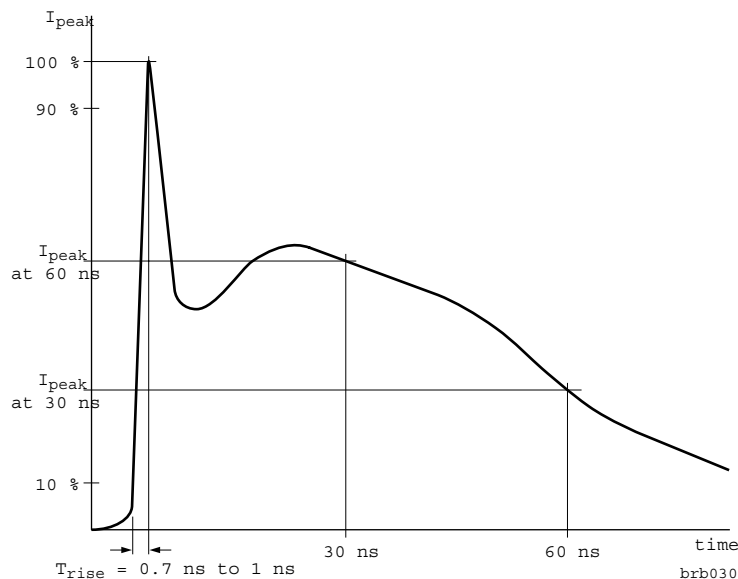


Fig 2. ESD-pulse according the IEC61000-4-2 standard, $I = f(t)$

2.2 EMI/RFI Filtering

An important area for any certification of electronic appliances is the amount of unwanted radiation coming from e.g. the phone and accessories connected to it. This is particularly important for the oscillator frequency output and its harmonics. This also has relevance for the audio circuits where the induced voltages can cause audible interference if not filtered sufficiently. The values quoted in this report represent typical figures when the devices are used as recommended in the datasheet. Please refer to the individual datasheet for full information.

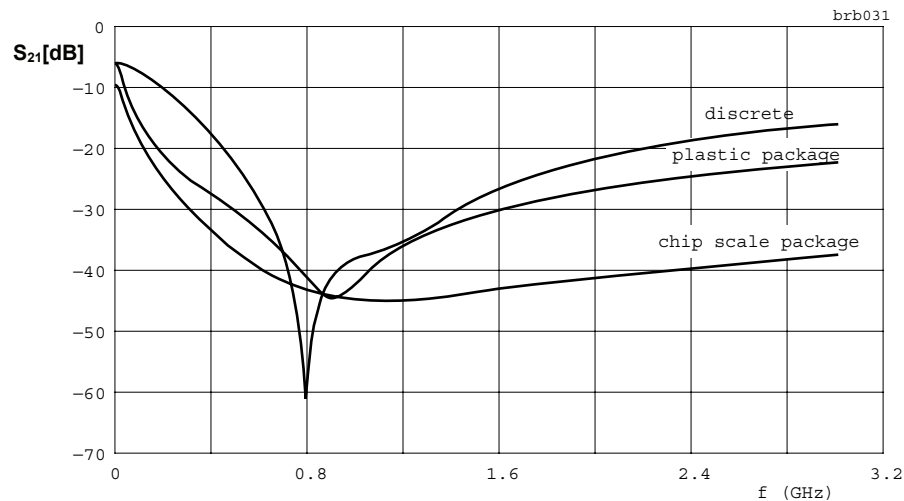


Fig 3. Filter performance comparison between a discrete, a plastic and a CSP packaged EMI filter

The Chip Scale Package, as well as the NXP leadless plastic package provide an excellent filter performance over a broad frequency range up to a few GHz. This outstanding performance is achieved by minimizing the lead inductance of the ground connection. Due to this, all relevant frequencies for mobile phones from 800 MHz up to 2.4 GHz can be filtered with one EMI filter and an ESD protection device.

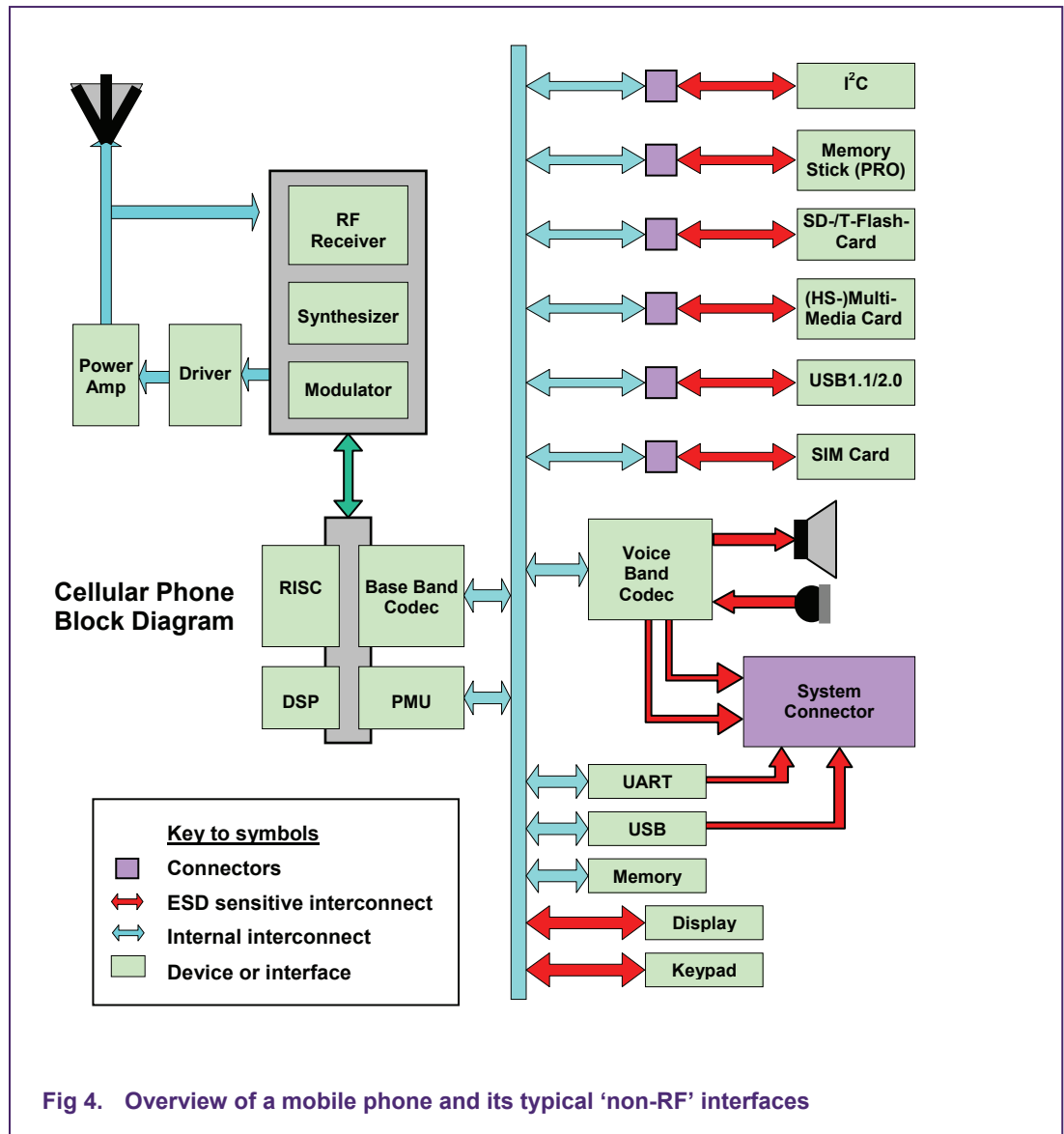
2.3 Termination

In addition to providing the above functions the filter components may also be used for impedance matching between the baseband controller and external devices such as USB appliances. Further components may also be integrated to provide bias voltages.

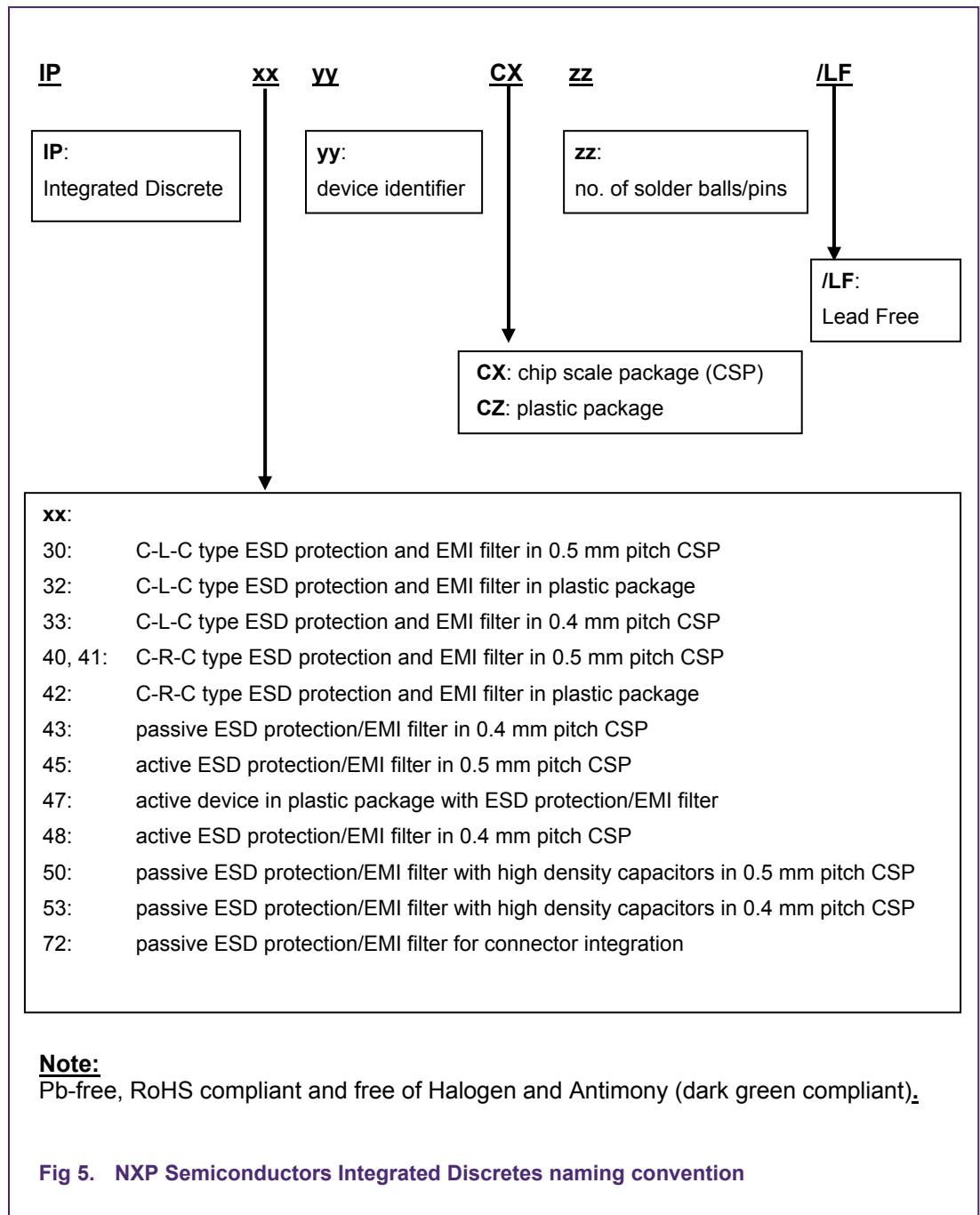
Based on the above features the ideal applications for Integrated Discretes are interfaces between the baseband processing and external devices or connectors.

3. Application Areas Overview

Here is a typical block diagram of a mobile phone. Some of these blocks are present in every handset, like the microphone, others are only present in the mid and high tier models. The areas indicated in red are potential interfaces that can benefit from today's Integrated Discretes products; these areas are described in more detail below. Most of these interfaces are, but not exclusively, close to the base band or the power management unit (PMU) or their interfaces respectively.



4. Integrated Discretes naming convention



5. Overview of available Integrated Discretes ESD protection and EMI filter circuits

The following tables list a selection of Integrated Discretes (IDs), ESD protection devices and EMI filters with integrated ESD protection functionality described in this document.

Table 1 and Table 2 list devices to be used with different types of memory cards, such as SIM-, MMC-, SD-Cards or the Memory Stick PRO. USB related EMI filter/ESD protection devices are shown in Table 3 and Table 4.

A reference for HDMI interface devices is given in Table 5.

A selection of audio interface devices is listed in Table 6 which does not mean, that these devices are used exclusively for this purpose. They can be found in many varied application areas and various appliances in the communications, computer and consumer markets.

Table 7 to Table 9 provide a summary of different multi-channel, multi purpose EMI filter/ESD protection devices, ranging from 1 to 10-channels in CSP and/or plastic package.

General protection diode arrays in Wafer-Level CSP are listed in Table 10, while the plastic packaged devices – especially low capacitance devices - are shown in Table 11. The lowest diode capacitance values can be found in this table.

Active devices including high-level ESD-protection according the IEC61000-4-2 standard are summarized in Table 12.

Most devices presented in this document, far exceed the IEC61000-4-2 level 4 requirements of 8 kV contact or 15 kV air discharge.

Typically NXP's Integrated Discretes are qualified using 1000 pulses of $\pm 15\text{kV}$ contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges).

Table 1. Memory Card EMI-filter, ESD-protection and biasing for: SIM-, MMC-, SD-Cards, T-Flash or Memory Stick PRO in CSP

Type name	Channel small signal equivalents	Digital interface clock speed ^[1]	remark
Chip Scale Package	R_{channel}	C_{channel}	
Devices are typically tested with 1000 pulses of ±15 kV contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges)			
IP4044CX8/LF	47 Ω, 100 Ω	35 pF	SIM-Card EMI-filter and ESD protection. Foot print compatible to IP4064CX8, 0.5 mm pitch
IP4064CX8/LF	47 Ω, 100 Ω	<20 pF	SIM-Card EMI-filter and ESD protection. Foot print compatible to IP4044CX8, 0.5 mm pitch
IP4364CX8/LF	47 Ω, 100 Ω	<20 pF	SIM-Card EMI- filter and ESD protection in 0.4 mm pitch, similar to IP4064CX8
IP4366CX8/P	47 Ω, 100 Ω	<12 pF	SIM-Card EMI- filter and ESD protection in 0.4 mm pitch, footprint compatible to IP4364CX8
IP4365CX11/P	47 Ω, 100 Ω	<12 pF	SIM-Card EMI- filter and ESD protection with 3 additional single diodes in 0.4 mm pitch
IP4051CX11/LF	47 Ω +pull-up	25 pF	MMC- interface ESD protection, EMI filter device with integrated pull-up resistors, 0.5mm pitch
IP4060CX16/LF	50 Ω +pull-up	18 pF	MMC-High-Speed Mode compatible ESD protection, EMI filter with integrated pull-up resistors, 0.5mm pitch
IP4052CX20/LF	40 Ω+pull-up	18 pF	SD-/T-Flash card interface ESD protection, EMI filter device with integrated pull-up resistors in 0.5 mm pitch
IP4351CX11/LF	47 Ω +pull-up	25 pF	MMC- interface ESD protection, EMI filter device with integrated pull-up resistors, 0.4 mm pitch
IP4350CX24/LF	15 Ω+pull-up	8.8 pF	SD-/T-Flash card interface ESD protection, EMI filter device with integrated pull-up resistors in 0.4 mm pitch to be used with IP4852CX24 or without IP4852CX24 if no level-shifting is required, identical footprints
IP4352CX24/LF	40 Ω+pull-up	18 pF	
IP4852CX25/LF	-	> 52 MHz	Active SD-/T-Flash card interface level-shifter (1.8V (core) ↔ 2.9 V (card)) in 0.4 mm pitch. To be used with IP4352CX24 if ESD protection and EMI filtering is needed
IP4853CX24 IP4863CX24	40 Ω+pull-up	18 pF	Active SD-/T-Flash card interface level-shifter (1.8 V (core) ↔ 2.9 V (card)) in 0.4 mm pitch with a Power Supply Unit (V _{battery} to 2.9 V SD-Card supply), integrated EMI filter and ESD protection up to ±15 kV contact discharge. This device is an integration of IP4352CX24 and IP4853CX24 plus a PSU.

¹ Using a 50 Ω source and ~ 20 pF load impedance

Table 2. Memory Card EMI-filter, ESD-protection an biasing for: SIM-, MMC-, SD-Cards, T-Flash or Memory Stick PRO in plastic package

Type name	Channel small signal equivalents	Digital interface clock speed ^[2]	Remark
Plastic package	R _{channel}	C _{channel}	
IP4252CZ8-4 IP4252CZ12-6 IP4252CZ16-8	40 Ω	12 pF	SD-/T-Flash card interface ESD protection, EMI filter device in 0.4 mm pitch plastic package
IP4281CZ10	-	0.7 pF	SD-/T-Flash card, MMC or MemoryStick interface ESD protection in 0.5mm pitch plastic package
IP4264CZ8-20	47 Ω, 100 Ω	20 pF	SIM-Card EMI-filter and ESD protection in a 0.4 mm pitch plastic package, compatible to IP4264CZ8-40
IP4264CZ8-40	47 Ω, 100 Ω	40 pF	SIM-Card EMI-filter and ESD protection in a 0.4 mm pitch plastic package, compatible to IP4264CZ8-20

² Using a 50 Ω source and ~ 20 pF load impedance

Table 3. USB1.1 and USB 2.0 Interface EMI filter/ESD protection devices in CSP

Type name	Channel small signal equivalents	Channel signal	USB Speed compliance	Remark
Chip Scale Package	R _{channel}	C _{channel}		
IP4056CX8/LF	33 Ω , 1.3 k Ω	35 pF	Full-Speed	Devices are typically tested with 1000 pulses of ± 15 kV contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges)
IP4057CX10/LF	33 Ω , 1.3 k Ω	30 pF	Full-Speed	USB1.1 interface compliant EMI filter, ESD protection and termination device, 0.5 mm pitch CSP
IP4058CX8/LF	33 Ω , 1.5 k Ω	35 pF	Full-Speed	USB1.1 interface compliant EMI filter, ESD protection and termination device, 0.5 mm pitch CSP
IP4158CX8/LF	17 Ω , 1.5 k Ω	35 pF	Full-Speed	USB1.1 interface compliant EMI filter, ESD protection and termination device, 0.5 mm pitch CSP
IP4065CX11/LF	33 Ω , 1.3 k Ω	27 pF	Full-Speed	USB1.1 interface compliant EMI filter, ESD protection and termination device, 0.5 mm pitch CSP
IP4078CX6/LF	33 Ω	35 pF	Full-Speed	USB1.1 interface compliant EMI filter, ESD protection and termination device, 0.5 mm pitch CSP
IP4059CX5/LF	-	3 pF	High-Speed	USB2.0 High-Speed compliant ESD protection, 0.5 mm pitch CSP
IP4358CX6	-	1.3 pF	High-Speed	USB2.0 dual differential channel High-Speed compliant ESD protection in 0.4 mm pitch CSP
IP4359CX4/LF	-	1.5 pF	High-Speed	USB2.0 High-Speed compliant ESD protection in 0.4 mm pitch CSP
IP4368CX9/P	33 Ω , 1.5 k Ω , 18.5 k Ω	17 pF	Full-Speed	USB1.1 interface compliant EMI filter, ESD protection and termination device, 0.4 mm pitch CSP

Table 4. USB1.1 and USB 2.0 Interface EMI filter/ESD protection devices in plastic package

Type name	Channel capacitance	USB Speed compliance	Remark
Plastic package			
IP4220CZ6	1 pF	High-Speed	USB2.0 High-Speed compliant ESD protection in plastic package, SC-74
IP4221CZ6-S	1 pF	High-Speed	USB2.0 High-Speed compliant ESD protection in plastic package, MO-252
IP4221CZ6-XS	1 pF	High-Speed	USB2.0 High-Speed compliant ESD protection in plastic package
IP4223CZ6	1.5 pF	High-Speed	USB2.0 High-Speed compliant ESD protection in plastic package, SC-74
IP4242CZ6	1 pF	High Speed	USB2.0 High-Speed compliant ESD protection in plastic package, MO-252
PRTR5V0U4Y	1 pF	High-Speed	USB2.0 High-Speed compliant ESD protection in plastic package, SC-88
PRTR5V0U4D	1 pF	High-Speed	USB2.0 High-Speed compliant ESD protection in plastic package, SC-74
Integrated common mode filter			
IP3219CZ6	1.5 pF	High-Speed	USB2.0 High-Speed compliant ESD protection with integrated common mode filter in plastic package

Table 5. HDMI Interface ESD protection and conditioning devices

Type name	Channel small signal equivalents	Remark
Chip Scale Package		
	R_{channel}	C_{channel}
These devices are typically tested with 1000 pulses of ± 15 kV contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges)		
IP4309CX9	-	35 pF
IP4310CX8	1.75 k Ω , 100 k Ω	20 pF
IP4281CZ10	-	0.7 pF
IP4282CZ6	-	0.7 pF
IP4283CZ10-TB	-	0.6 pF
IP4284CZ10-TB	-	0.5 pF
Remark		
HDMI transmitter 8-channel TMDS channel ESD-protection device		
HDMI transmitter DDC, hot plug and CEC ESD-protection and biasing device		
4x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT1059 package		
2x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT886 package		
4x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT1059 package		
4x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT1059 package		

Table 6. Audio path EMI Filter and ESD protection devices

Type name	Channel small signal equivalents			Loudspeaker		Microphone		Integrated biasing resistors
	R _{channel}	L _{channel}	C _{channel}	≤ 8 Ω	≥ 8 Ω	Single-Ended	Differential	
IP3047CX6	0.25 Ω	3 nH	280 pF	x	x		x	-
IP3048CX5	0.25 Ω	3 nH	280 pF	x	x		X	-
IP4027CX20/LF	10 Ω, 100 Ω		225 pF, 75 pF		X		X	1.1 kΩ pull-up/-down
IP4047CX6/LF	0.95 Ω		2x 140 pF	X				-
IP4048CX5/LF	10 Ω		2x 100 pF		X			-
IP4049CX5/LF	68 Ω		2x 47 pF				X	-
IP4055CX6/LF	470 Ω		35 pF			X	X	-
IP4355CX6/LF	470 Ω		<20 pF			X	X	-
IP4363CX10/LF	15 Ω, 95 Ω		65 pF, 33 pF		X	X		2 kΩ pull-up/-down
IP5002CX8/LF	2.2 kΩ, 4.4 kΩ		3 nF +1 nF			X		-
IP5003CX9/LF	1.05 kΩ		1 nF			-	X	1 kΩ pull-up/-down
IP5004CX6/LF	1 kΩ		1 nF			-	X	-
IP5306CX8/LF	2 kΩ		1.7 nF			-	X	2 kΩ pull-up + 1 kΩ pull-down
IP5307CX8/LF	2.2 kΩ		1.7 nF (+9 nF AC-coupling capacitors)			-	X	2 kΩ pull-up + 1 kΩ pull-down
IP5006CX11/LF	2.25 kΩ		4 nF			X	X	1 kΩ pull-up/-down
IP5020CX16/LF	20 Ω, 5 Ω		0.3 nF, 0.4 nF				X	1.5 kΩ pull-up/-down
IP5040CX11/LF	10 Ω		5 nF		X			-
IP5311CX5/LF	15 Ω		5 nF		X			-

Table 7. C-L-C based multi-channel EMI filter and ESD protection devices 2-, 4-, 6-, 7-, 8-, 10-channels in 0.5 and 0.4 mm pitch, CSP

Type name	Channel small signal equivalents		-3 dB frequency ^[3]	remark
Chip Scale Package	R _{channel}	(L _{channel})	C _{channel}	Devices are typically tested with 1000 pulses of ±15 kV contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges)
IP3053CX5 IP3053CX10 IP3053CX15 IP3053CX20	^[4] 100 Ω	35 nH	47 pF	150 MHz 2-, 4-, 6-, 8-channel C-L-C-type EMI filter and ESD protection, 0.5 mm pitch, footprint compatible with IP3088CXxy
IP3088CX5 IP3088CX10 IP3088CX15 IP3088CX20	^[4] 18 Ω	40 nH	65 pF	175 MHz 2-, 4-, 6-, 8-channel C-L-C-type EMI filter and ESD protection, 0.5 mm pitch footprint compatible with IP3053CXxy
IP3328CX24	10 Ω	33 nH	55 pF	350 MHz 10-channel C-L-C-type EMI filter and ESD protection, 0.4 mm pitch, Footprint compatible with IP4338CX24/LF and IP3338CX24/LF
IP3348CX5 IP3348CX10 IP3348CX15 IP3348CX20	^[4] 10 Ω	15 nH	38 pF	400 MHz 2-, 4-, 6-, 8-channel C-L-C-type EMI filter and ESD protection, 0.4 mm pitch
IP3337CX18/LF	125 Ω	60 nH	25 pF	200 MHz 7-channel C-L-C-type EMI filter and ESD protection, 0.4 mm pitch, Footprint compatible with IP4337CX18/LF
IP3338CX24/LF	125 Ω	60 nH	25 pF	200 MHz 10-channel C-L-C-type EMI filter and ESD protection, 0.4 mm pitch, footprint compatible with IP4338CX24/LF and IP3328CX24

3. R_{source} = R_{load} = 50 Ω

4. IP3xxxCX5: 2-channel, IP3xxxCX10: 4-channel, IP3xxxCX15: 6-channel, IP3xxxCX20: 8-channel

Table 8. C-R-C based multi-channel EMI filter and ESD protection devices, 1-, 4-, 6-, 7-, 8-, 10-channels in 0.5 and 0.4 mm pitch, CSP

Type name	Channel small signal equivalents	-3 dB frequency ³	remark
IP4032CX25/LF IP4033CX25/LF	80 Ω	100 MHz	10-channel CRC-type EMI filter/ESD protection, footprint compatible to IP4033CX25
IP4035CX24/LF	1 k Ω	22 MHz	10-channel CRC-type EMI filter/ESD protection for key-pad interfaces
IP4337CX18/LF	70 Ω	240 MHz	7-channel CRC-type EMI filter/ESD protection, 0.4 mm pitch, footprint compatible with IP3337CX18/LF
IP4338CX24/LF	70 Ω	240 MHz	10-channel CRC-type EMI filter/ESD protection, 0.4 mm pitch footprint compatible with IP3338CX24/LF and IP3328CX24
IP4040CX25/LF	84 Ω	365 MHz	10-channel CRC-type EMI filter/ESD protection
IP4041CX25/LF	200 Ω	105 MHz	10-channel CRC-type EMI filter/ESD protection
IP4053CX15/LF	100 Ω	120 MHz	6-channel CRC-type EMI filter/ESD protection, footprint compatible with IP4153CX15
IP4153CX15/LF	100 Ω	210 MHz	6-channel CRC-type EMI filter/ESD protection, low capacitance version of IP4053CX15
IP4353CX15/LF	100 Ω	120 MHz	6-channel CRC-type EMI filter/ESD protection, 0.4mm pitch
IP4054CX15/LF	100 Ω	85 MHz	4-channel CRC-type EMI filter/ESD protection + 4 single protection diodes
IP4307CX4/LF	75 Ω	155 MHz	1-channel CRC-type EMI filter/ESD protection with one common ground
IP4088CX20/LF	100 Ω	120 MHz	8-channel CRC-type EMI filter/ESD protection, easy to route
IP4110CX20/LF	200 Ω , 30 Ω , 0.8 Ω	various	8-channel CRC-type EMI filter/ESD protection, easy to route for mobile-phone bottom connectors, including, 4bit data-bus, microphone and loudspeaker channels

Table 9. C-L-C and C-R-C based multi-channel EMI filter and ESD protection devices, 1-, 2-, 4-, 6- and 8-channels in 0.4 mm pitch plastic package

Type name	Channel small signal equivalents	$R_{channel}$ ($L_{channel}$)	$C_{channel}$	-3 dB frequency ^[6]	remark
Plastic package					
Devices are typically tested with 1000 pulses of ± 15 kV contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges)					
C-L-C type					
IP3253CZ8-4 IP3253CZ12-6 IP3253CZ16-8	^[6] (18 nH)	36 pF	275 MHz	4, 6, 8 –channel	CLC-type EMI-filter & ESD protection in a plastic package (QFN-type)
IP3254CZ8-4 IP3254CZ12-6 IP3254CZ16-8	^[6] (12 nH)	50 pF	335 MHz	4, 6, 8 –channel	CLC-type EMI-filter & ESD protection in a plastic package (QFN-type)
C-R-C type					
IP4251CZ8-4 IP4251CZ12-6 IP4251CZ16-8	^[6] 100 Ω	15 pF	330 MHz	4, 6, 8 –channel	CRC-type EMI-filter & ESD protection in a plastic package (QFN-type)
IP4252CZ8-4 IP4252CZ12-6 IP4252CZ16-8	^[6] 40 Ω	18 pF	300 MHz	4, 6, 8 –channel	CRC-type EMI-filter & ESD protection in a plastic package (QFN-type)
IP4253CZ8-4 IP4253CZ12-6 IP4253CZ16-8	^[6] 200 Ω	45 pF	110 MHz	4, 6, 8 –channel	CRC-type EMI-filter & ESD protection in a plastic package (QFN-type)
IP4254CZ8-4 IP4254CZ12-6 IP4254CZ16-8	^[6] 100 Ω	45 pF	130 MHz	4, 6, 8 –channel	CRC-type EMI-filter & ESD protection in a plastic package (QFN-type)
IP4256CZ3-M IP4256CZ5-F IP4256CZ6-W	100 Ω	30 pF	200 MHz	1, 2 –channel	CRC-type EMI-filter & ESD protection in SOT883 (M), SOT886 (F) or SOT665 (W)

5. $R_{source} = R_{load} = 50 \Omega$

6. IPx25xCZ8: 4-channel, IPx25xCZ12: 6-channel, IPx25xCZ16: 8-channel version

Table 10. General ESD protection diodes in CSP packages

Type name	C _{Channel} 0 V _{DC bias} (2.5 V _{DC bias})	No of protection channels	Single diodes	Bi- directional diodes	V _{BR} (min)	remark
Chip Scale Package						
Devices are typically tested with 1000 pulses of ±15 kV contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges)						
IP4042CX5/LF	30 pF (19 pF)	4	X		+5.5	4x single diode with one common ground, footprint compatible with IP4142CX5/LF
IP4142CX5/LF	14 pF (9 pF)	4	X		+5.5	4x single diode with one common ground, footprint compatible with IP4042CX5/LF
IP4043CX5/LF	16 pF	4		X	±14	4x back-to-back diode with one common ground, 0.5 mm pitch CSP
IP4343CX5/LF	16 pF	4		X	±14	4x back-to-back diode with one common ground in 0.4 mm pitch
IP4332CX5/LF	24 pF (15 pF)	4	X		+5.5	4x single diode with one common ground, footprint compatible with IP4332CX5/LF
IP4342CX5/LF	48 pF (30 pF)	4	X		+5.5	4x single diode with one common ground, footprint compatible with IP4332CX5/LF
IP4358CX6	1.3 pF	4	X		+6	4x single diode low capacitance ESD-protection in 0.4 mm pitch CSP
IP4309CX9	1.3 pF	8	X		+6	8x single diode low capacitance ESD-protection in 0.4 mm pitch CSP
IP4359CX4/LF	1.3 pF	2	X		+6	2x single diode low capacitance ESD-protection in 0.4 mm pitch CSP
IP4361CX4	0.6 pF	1		X	+16	1x ultra-low capacitance ESD protection (bidirectional configuration) in 0.4 mm pitch CSP
	1.4 pF	2	X		+16	2x ultra-low capacitance ESD protection (unidirectional configuration) in 0.4 mm pitch CSP
IP4085CX4/LF	240 pF	1	X		+16	Single power diode to protect charger interfaces from wrong polarity, 0.5 mm pitch
IP4385CX4/LF	450 pF	1	X		+7	Single power diode to protect charger interfaces from wrong polarity, 0.4 mm pitch
IP4386CX4/LF	220 pF	1	X		+16	Single power diode to protect charger interfaces from wrong polarity, 0.4 mm pitch
IP4387CX4/LF	260 pF	1	X		+10	Single power diode to protect charger interfaces from wrong polarity, 0.4 mm pitch
IP4302CX2/LF	10 pF	1		X	±14	Single back-to-back (bidirectional) diode, size is 0.7 mm x 0.52 mm
IP4303CX4/LF	10 pF	2		X	±14	2x back-to-back diode with one common ground
IP4305CX4/LF	19 pF, 7 pF	1+2	X		±5.5	1x bi-directional diode + 2 Schottky diodes, in one 0.4 mm CSP
IP4306CX2/LF	65 pF	1	Schottky		+22	1x power Schottky diode in 0.4 mm CSP

Table 11. Low capacitance and general ESD protection diodes in plastic packages

Type name	C _{channel} 0 V _{DC bias} (2.5 V _{DC bias})	No of protection channels	V _{BR} (min)	remark
Plastic package				
Devices are typically tested with 1000 pulses of ±15 kV contact discharges according the IEC61000-4-2 model and far exceed the specified level 4 (8 kV contact discharges)				
IP4221CZ6-S	1 pF	4(+1)	+6	4x ultra-low capacitance ESD protection device for USB, Ethernet etc. Leadless SOT886 package
IP4221CZ6-XS	1 pF	4(+1)	+6	4x ultra-low capacitance ESD protection device for USB, Ethernet etc. Leadless SOT891 package
IP4281CZ10	0.7 pF	4	+6	4x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT1059 package
IP4282CZ6	0.7 pF	2	+6	2x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT886 package
IP4283CZ10	0.6 pF	4	+6	4x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT1059 package
IP4284CZ10	0.5 pF	4	+6	4x ultra-low capacitance ESD protection device for HDMI etc. Leadless SOT1059 package
PESD5V0F1BL	0.4 pF	1	+6	1x femto Farad bidirectional ESD protection device in leadless SOD882 package
PRTR5V0U4Y	1 pF	4(+1)	+6	4x ultra-low capacitance ESD protection device for USB, Ethernet etc. in a SOT363 package
PRTR5V0U4D	1 pF	4(+1)	+6	4x ultra-low capacitance ESD protection device for USB, Ethernet etc. in a SOT457 package
PRTR5V0U6S	1 pF	6(+1)	+6	6x ultra-low capacitance ESD protection device for USB, Ethernet etc. in SO8 (SOT96) package
PRTR5V0U8S	1 pF	8(+1)	+6	8x ultra-low capacitance ESD protection device for USB, Ethernet etc. in TSSOP10 (SOT552) package

Table 12. Active devices with high-level ESD-protection to IEC61000-4-2

Type name	Integrated active function	remark
IP4559CX25/LF	Voltage clamping at USB 1.1 bus to V _{signal} max < 3.9 V	data channels with pull-up/-down resistors
IP4501CX15/LF	Power switch with current limitation	data channels with pull-up/-down resistors
IP4559CX17/LF IP4571CX17/LF	Source selector with over voltage protected analog switches	data channels with pull-up/-down resistors
IP4524CX27/LF	Several high current / low ohmic switches with automatic voltage detection, driver stages	-
IP4826CX12/LF	Several high current / low ohmic switches with automatic voltage detection, driver stages	-
IP4852CX25/LF	Active (micro-)SD-/Trans-Flash interface level-shifter (1.8 V (core) ↔ 2.9 V (card)) in 0.4 mm pitch. to be used with IP4352CX24 if ESD protection and EMI filtering is needed	-
IP4853CX24 IP4863CX24	Active (micro-)SD-/Trans-Flash card interface level-shifter (1.8 V (core) ↔ 2.9 V (card)) in 0.4 mm pitch with a Power Supply Unit (V _{battery} to 1.8 V SD-Card supply), integrated EMI filter and ESD protection up to ±15 kV contact discharge. This device is an integration of IP4352CX24 and IP4853CX24 plus a PSU(LDO).	-

6. Application Areas

6.1 External Memory Cards: SIM, SD-Card, T-Flash, MMC etc.

6.1.1 SIM Card Interface

P4044CX8/LF, IP4064CX8/LF, IP4364CX8/LF, IP4365CX11/P, IP4366CX8/P, IP4264CX8-20, IP4264CZ8-40

These devices provide all the necessary components for EMI-filtering and ESD-protection of the Subscriber Identity Module, which requires 3 digital lines and additional protection for the supply rail. An important feature of the integrated digital lines is the close matching of the resistors and the low capacitance to maintain the rise times within the specified limit and to avoid group delay. ESD protection at the input and output provides a high level of surge limitation due to the two stage ESD protection around the pi-filter structure with ESD protection/clamping diodes at both sides of each data channel.

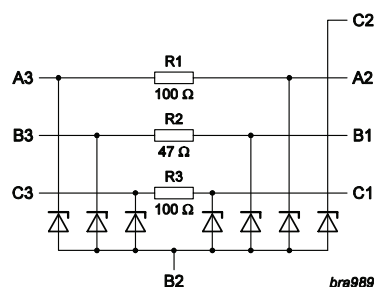


Fig 6. SIM-Card EMI-filter and ESD-protection schematic

	IP4044CX8/LF	IP4064CX8/LF IP4364CX8/LF	IP4366CX8/P	IP4264CZ8-20	IP4264CZ8-40
R_{line}	47 Ω , 100 Ω	47 Ω , 100 Ω	47 Ω , 100 Ω	47 Ω , 100 Ω	47 Ω , 100 Ω
C_{line} ($V_{bias}=0$ V)	35 pF	< 20 pF	10 pF	20 pF	40 pF
Package	0.5 mm pitch CSP	0.5/0.4 mm pitch CSP	0.4 mm pitch CSP	0.4 mm pitch plastic	0.4 mm pitch plastic

6.1.2 IP4051CX11/LF & IP4351CX11/LF Multi Media Card Interface

Another external memory device is the Multi Media Card for storage and transfer of downloaded data. The IP4051CX11/LF (0.5 mm pitch) and the IP4351CX11 (same footprint with reduced package size due to 0.4 mm pitch) have been carefully optimized to achieve the balance between ESD performance and channel capacitance to allow for fast rise-times. The extremely close channel-to-channel matching inherent in wafer level integration provides the optimum performance for this interface.

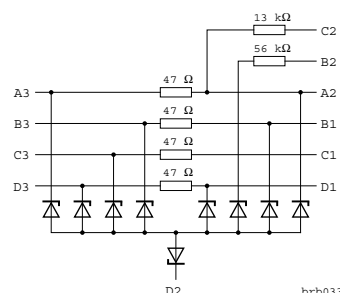


Fig 7. IP40(3)51CX11/LF schematic and device depicted with solder balls facing up

	IP4051CX11/LF	IP4351CX11/LF
R_{line}	47 Ω	47 Ω
R_{pull}	13k Ω , 56 k Ω	13k Ω , 56 k Ω
$C_{line}(V_{bias}=0$ V)	25 pF	20 pF

6.1.3 IP4052CX20/LF (micro-)SD-Card & T-Flash Interface

Mechanically similar to the Multi-Media Card, the SD (Secure Digital) or T-Flash Card is also used for data transfer and storage. It offers a fast 4-bit (nibble-wise) data transmission and also a SPI compatible operation mode. While the similarity in size allows for using one slot for both types, the interface looks quite different, so that the SD-/T-Flash Card requires different filters. The line capacitance is lower than the one integrated in IP4051CX11/LF and all required pull-up resistors for the SD-/T-Flash card are also integrated.

IP4052CX20/LF	
R_{line}	40 Ω (pull-up: 1 k Ω , 25 k Ω , 50 k Ω)
C_{line}	18 pF ($V_{DC} = 0$ V, typical))

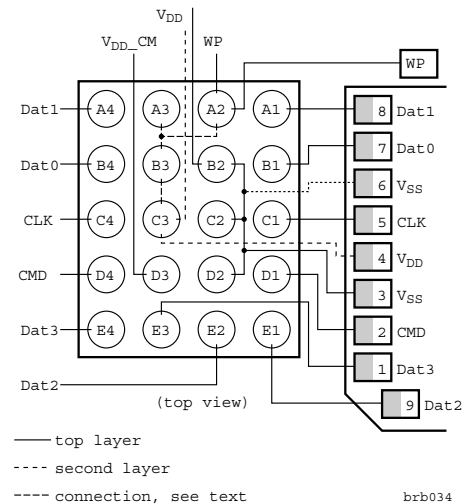


Fig 8. IP4052CX20/LF application proposal

6.1.4 IP4350CX24/LF & IP4352CX24/LF SD-Card, MMC, T-flash Interface

IP4350CX24/LF and IP4352CX24/LF are a 0.4 mm pitch devices, similar to the IP4052CX20/LF. They contain 9 channels protected by rail-to-rail diodes at the card holder interface side. IP4350CX24/LF can also be used with MultiMediaCards. All required pull-up and pull-down resistors are integrated. The device is optimized to be used with the NXP Integrated Discretes SD-Card level shifter IP4852CX25/LF.

	IP4350CX24/LF	IP4352CX24/LF
R_{line}	15 Ω	40 Ω
R_{pull}	4.7 k Ω , 50 k Ω	15 k Ω , 50 k Ω
C_{line} ($V_{bias}=0$ V)	< 9 pF	< 20 pF

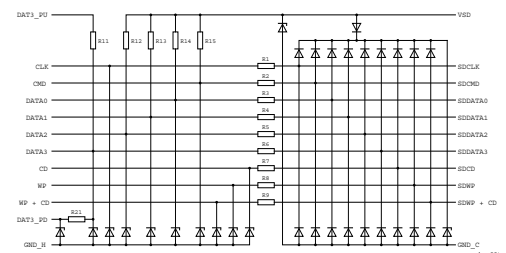


Fig 9. IP4350(2)CX24/LF schematic drawing

6.1.5 IP4252CZ8-4, IP4252CZ12-6, IP4252CZ16-8 SD-Card, MMC, T-flash Interface

IP4252CZyy devices are C-R-C EMI-filters and ESD protection devices in 4-, 6-, 8- leadless packages with 0.4 mm pitch.

IP4252CZyy	
R_{line}	40 Ω
C_{line} ($V_{bias} = 2.5$ V)	12 pF

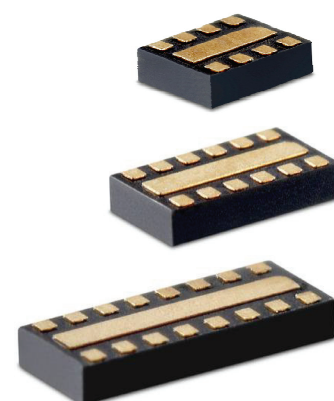


Fig 10. IP4252CZyy leadless packages

6.1.6 IP4852CX25/LF SD-Card/T-Flash level shifter

This device is a fully integrated 1.8 V ↔ 2.9 V active level shifter optimized for the SD-Card / T-Flash interfaces. In case a low voltage processor has to interface a memory card still requiring voltages of 2.9 V and above, this device contains bidirectional push-pull drivers for clock speeds up to 50-60MHz. The low voltage side can operate in the range of 1.62 V to 1.9 V while the high voltage side works at 2.5 V to 3.5 V. The device has a 0.4 mm pitch and a package size of just 2.0 x 2.0 mm².

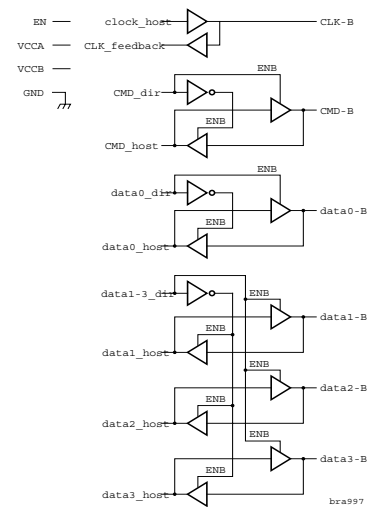


Fig 11. IP4852CX25/LF schematic drawing

6.1.7 IP4853CX24, IP4863CX24 (micro-)SD-Card / T-Flash active level shifter with PSU (LDO)

The following functions are integrated into these only 2.0 x 2.0 mm² large devices:

- High speed 1.8 V ↔ 2.9 V active level shifter
- EMI-filter
- IEC61000-4-2.level 4 compliant ESD-protection
- Memory-Card supply (2.9 V LDO) from battery
- 2.01 x 2.01 mm² device size

It is optimized for the SD-Card / T-Flash interfaces. In case a low voltage processor has to interface a memory card still requiring voltages of 2.9 V and above, this device contains bidirectional push-pull drivers for clock speeds up to 50-60MHz. The low voltage side can operate in the range of 1.62 V to 1.9 V while the high voltage side works at 2.5 V to 3.5 V.

The device also contains a LDO that delivers 2.9 V for the memory card from a battery voltage of up to 5 V. It is a 0.4 mm pitch device with a package size of just 2.01x2.01 mm².

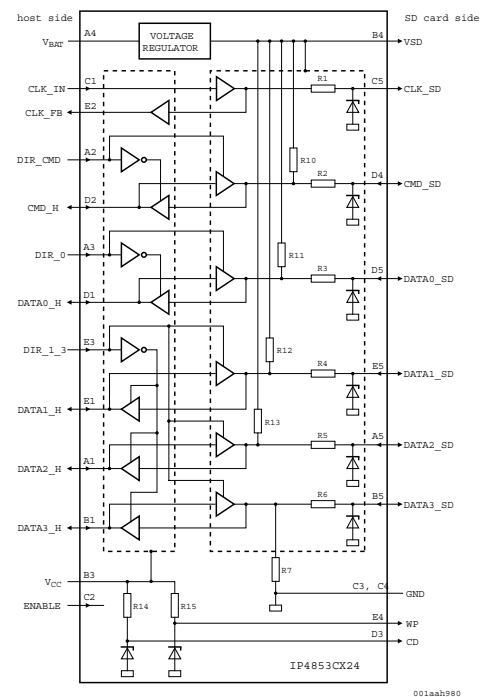


Fig 12. IP4853CX24, IP4863CX24 schematic

6.2 USB Interfaces

In order to achieve a low line capacitance and meet the capacitance requirements of the USB specification NXP Integrated Discretes has developed a wide range of different protection devices.

6.2.1 USB 1.1 & USB2.0 OTG (at Full Speed)

IP4056CX8/LF, IP4058CX8/LF, IP4158CX8/LF and IP4078CX6/LF, IP4368CX9/P

IP4056CX8/LF, IP40(1)58CX8/LF, IP4078CX6/LF and IP4368CX9/P are very small 6-9 ball devices with footprints specifically matching to the USB connector. They are suitable for low speed and full speed data rates as well as for USB OnTheGo (OTG) with external pull down resistor switching.

For transceivers with an increased integrated series resistance on-chip, IP4158CX8/LF contains lower channel resistor values of 17 Ω only and is pin-compatible with IP4058CX8/LF.

IP4368CX9/P also contains two 18.5 k Ω biasing resistors

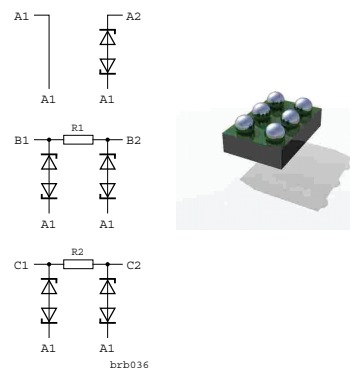


Fig 14. IP4078CX6/LF Schematic view and device package drawing

	IP4056CX8/LF	IP4058CX8/LF	IP4158CX8/LF	IP4078CX6/LF	IP4368CX9/P
$R_{D+}, D-$	= 33 Ω	33 Ω	17 Ω	33 Ω	33 Ω
R_{bias}	= 1.3 k Ω	1.5 k Ω	1.5 k Ω	-	1.5 k Ω , 18.5 k Ω
C_{line}^7	= 30 pF	35 pF	35 pF	35 pF	17 pF

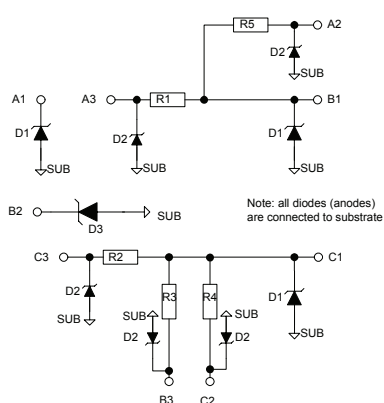


Fig 13. IP4368CX9/P Schematic view and

⁷ $V_{DC} = 0 V$

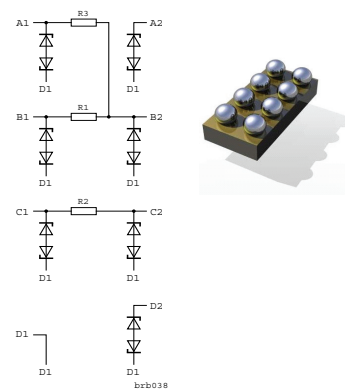


Fig 15. IP4058CX8/LF, IP4158CX8/LF Schematic view and package drawing

6.2.2 USB2.0 (High Speed, Full Speed & Low Speed)

IP4059CX5/LF, IP4358CX6, IP4359CX4/LF

The most recent development in the field of physical transmission of USB technology is the USB2.0 High Speed (HS) standard. This operation mode requires as low as possible line capacitances, especially for protection devices and allows no series resistors in the data lines. IP4059CX5/LF and IP4358CX6 can be used to protect the full USB interface including D+, D-, Vbus and ID while IP4359CX4/LF is optimized absolutely minimized in area to protect D+, D- only.

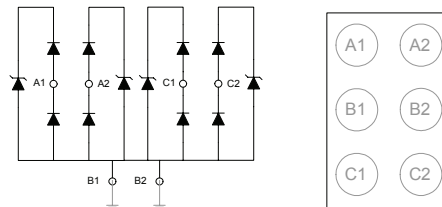


Fig 16. IP4358CX6 Schematic view and package drawing

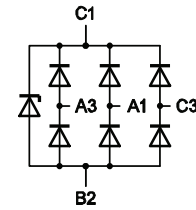


Fig 17. IP4059CX5/LF Schematic view and package drawing

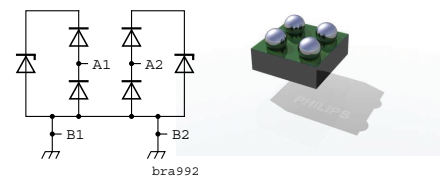


Fig 18. IP4359CX4/LF Schematic view and package drawing

	IP4059CX5/LF	IP4358CX6	IP4359CX4/LF
C _{line}	= 3 pF	1.3 pF	1.4 pF
no. of channels	= 3	4	2
Pitch	= 0.5 mm	0.4 mm	0.4 mm

IP4220CZ6, IP4221CZ6-S, IP4221CZ6-XS, IP4223CZ6, IP4242CZ6

These devices are 4-channel channel low capacitance ESD-protection devices in different plastic packages. All devices except IP4223CZ6 sport just 1 pF C_{line}.

Supported packages are SC-74, MO252 the very well known and widely spread SC-74 plastic package.

While IP4220CZ6 is a 1 pF per line ESD-protection, IP4223CZ6 is a 1.5 pF_{max} device.

IP3219CZ6

IP3219CZ6 is the first silicon based ESD-protection device with an integrated common mode filter based on a ferrite core. The device comes in a 2.3 x 3.5 x 0.85 mm³ sized plastic package and is specified to protect against ESD-strikes up to 8 kV contact and 15 kV air discharges according IEC-61000-4-2, level 4.

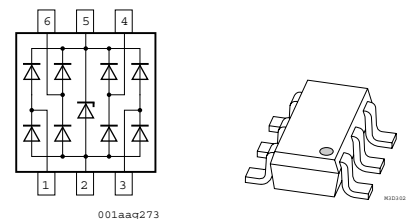


Fig 19. Schematic + SC-74 package drawing

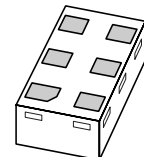


Fig 20. MO-252 package drawing

6.2.3 HDMI interface ESD-protection and conditioning

IP4309CX9, IP4310CX8

These two 0.4 mm pitch CSP devices cover the full HDMI interface with respect to ESD-protection of all pins and biasing of DDC lines and hotplug.

IP4309CX9 contains 4x2 low capacitance ESD-protection diodes while IP4310CX8 is covering the lower speed communication interface.

**IP4281CZ10, IP4282CZ6, IP4283CZ10,
IP4284CZ10**

In case leadless packages are preferred, NXP offers various low capacitance solutions for the TMD5 line ESD-protection.

While the IP428xCZ10 packages offer 2 x 2 channel protection, IP4282CZ6 does offer 2 ESD-protection channels. All types support an easy PCB routing using straight line running under the package to avoid problems in TDR measurement results. Therefore, each pin connected to an ESD-protection rail has an opposite pin that is not connected and can be soldered to the same TMDS channel without adding any relevant capacitance.

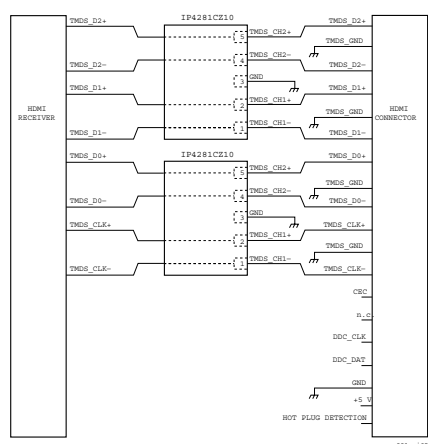


Fig 21. Simplified application schematic for IP428xCZyy based HDMI ESD-protection

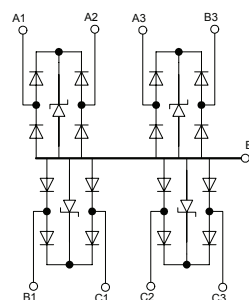


Fig 22. IP4309CX9 schematic view

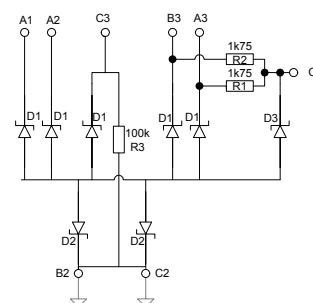


Fig 23. IP4310CX8 schematic view

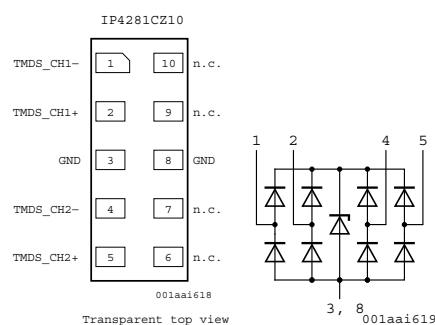


Fig 24. IP428xCZ10 pinning and schematic view

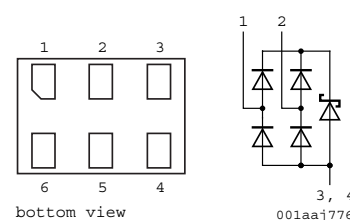


Fig 25. IP4282CZ6 pinning and schematic view

6.3 Audio Interfaces

IP3047CX6, IP3048CX5, IP4027CX20/LF, IP4047CX6/LF, IP4048CX5/LF, IP4049CX5/LF, IP4055CX6/LF, IP4363CX10/LF, IP5006CX11/LF & IP5002CX8/LF, IP5306CX9/LF, IP5307CX9, IP5311CX5/LF, IP5003CX9/LF, IP5004CX6/LF, IP5020CX16/LF, IP5040CX10/LF

In addition to providing all the normal interface requirements the design of an audio interface has also to consider the following issues:

- Filtering of induced signals from long cables (which act like aerials).
- Demodulation of induced signals by non-linear elements.
- Extra ESD protection because of the positioning of the transducers upstream of the protection element.
- Channel resistance, matching of differential channels
- Biasing

6.3.1 IP3047CX6, IP3048CX5, IP4047CX6/LF

IP3047CX6 and IP3048CX5 are C-L-C type EMI-filters and ESD-protection devices for low-ohmic loudspeakers while IP4047CX6/LF is a C-R-C device. The small size allows for maximum placement flexibility. The very low series resistance enables applications of the connected loudspeaker for not only voice but also hands-free and ringing functionality. IP4047CX6/LF is footprint compatible with IP3047CX6.

	IP3047CX6	IP3048CX5	IP4047CX6/LF
L	= 3 nH	3 nH	-
R	= 0.25 Ω	0.25 Ω	0.95 Ω
C _{line}	= 280 pF (V _{DC} = 0 V)	280 pF (V _{DC} = 0 V)	280 pF (V _{DC} = 0 V)

6.3.2 IP4027CX20/LF

IP4027CX20/LF is a full integrated audio interface containing ESD protection, EMI filtering and also biasing etc. for a differential microphone and a differential loudspeaker channel. The integrated back-to-back diodes prevent demodulation/rectification of high-frequency signals.

This device is used on several EMP-mobile phone platforms.

	Microphone	Loudspeaker
R _{channel}	= 100 Ω	10 Ω
C _{channel}	= 75 pF	225 pF

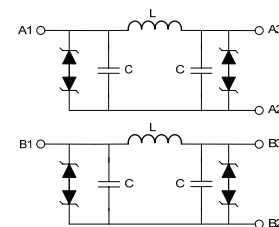


Fig 26. IP3047CX6 Schematic view

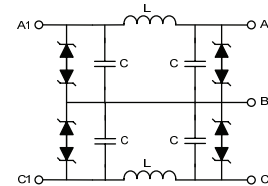


Fig 27. IP3048CX5 Schematic view

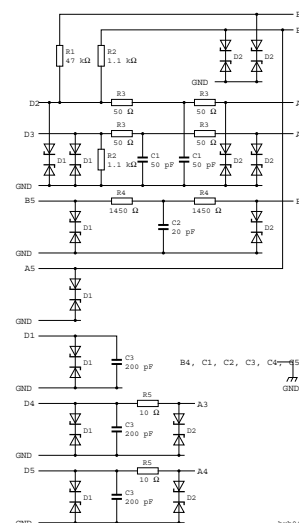


Fig 28. IP4047CX6/LF Schematic view

6.3.3 IP4048CX5/LF & IP4049CX5/LF

These are two small 5 ball devices used for speaker (IP4048) and microphone (IP4049) applications and provide the entire interface and protection components in the smallest space possible, only 1.38 mm x 0.92 mm. The small size allows for maximum placement flexibility.

	IP4048CX5/LF	IP4049CX5/LF
R	10 Ω	68 Ω
C _{line}	100 pF (V _{DC} = 0 V)	33 pF (V _{DC} = 0 V)

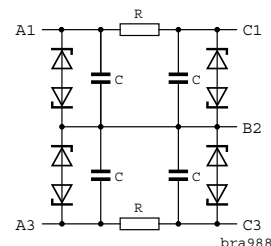


Fig 29. IP4048CX5/LF & IP4049CX5/LF
Schematic view

6.3.4 IP4055CX6/LF & IP4355CX6/LF

These devices have been especially developed to provide higher levels of filtering of induced interference in differential microphone channels. The extra ground ball (compared to e.g. IP4049CX5/LF) provides an excellent broadband filtering of up to a minimum of 35 dB in the range 800 MHz- 2.4 GHz. This is particularly useful for CDMA applications where the oscillator multiplex rate falls within the audio band. Alternatively this device is also useful for adding 2 additional data lines to an existing data interface due to the low line capacitance of 35 pF (IP4055CX6/LF) or <20 pF (IP4355CX6/LF).

	IP4055CX6/LF	IP4355CX6/LF
R	470 Ω	470 Ω
C _{line}	35 pF (V _{DC} = 0 V)	< 20 pF (V _{DC} = 0 V)

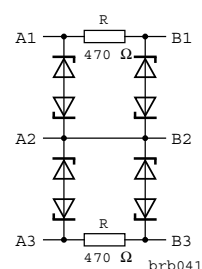


Fig 30. IP4055CX6/LF & IP4355CX6/LF
Schematic view and depiction of
CSP package

6.3.5 IP4363CX10/LF

IP4363CX10/LF is an audio device for a head set interface. It contains a differential channel for the loudspeaker and a single microphone channel that includes the biasing resistors.

IP4363CX10/LF	
R_{speaker}	15 Ω
$R_{\text{microphone}}$	2 k Ω + 2 k Ω pull-up + 95 k Ω pull-up
C_{line}	~65 pF ($V_{\text{DC}} = 0$ V)

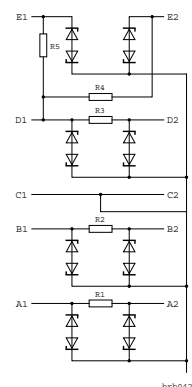
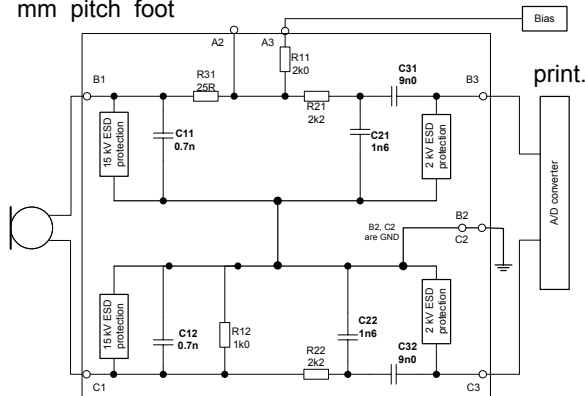


Fig 32. IP4363CX10/LF Schematic view and depiction of CSP package

6.3.6 IP5306CX8/LF & IP5307CX8

These two differential microphone EMI-filter, ESD-protection and biasing devices are excellent examples that show the progression of miniaturization in the Integrated Discretes product portfolio. While IP5306CX8/LF contains ESD-protection and EMI-filtering in combination with a biasing network and a low path filter, IP5307CX8/LF also contains the AC-coupling capacitors (C31 and C32 in Fig 31 and Fig 34) to connect the microphone to an A/D-converter. Both devices share the same 0.4 mm pitch foot



6.3.8 IP5006CX11/LF & IP5002CX8/LF

These are devices specifically for microphone applications and provide audio and RF filtering including bias components.

A special feature of IP5006CX11/LF is the high capacitance density of 20 nF/mm² to integrate two 2 nF capacitors at the 8 kV ESD protected input-pins. The only connections required are a bias voltage, the microphone output(s), the ASIC inputs and ground; all other components are included in the devices including 2 nF and/or 1 nF filter capacitors respectively.

IP5006CX11/LF is for a balanced microphone and IP5002CX8/LF is for a single ended microphone.



Fig 36. Depiction of IP5002CX8/LF & IP5006CX11/LF CSP packages

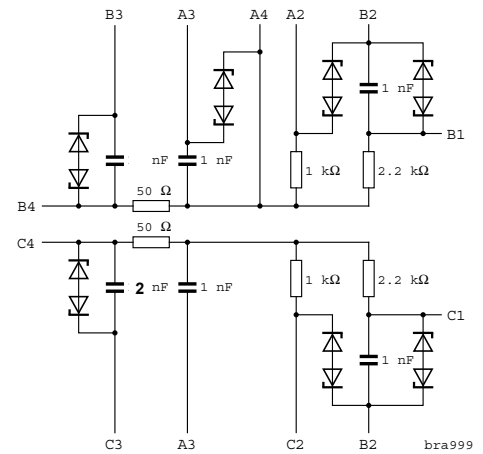


Fig 38. IP5006CX11/LF schematic is shown as an example

6.3.9 IP5003CX9/LF & IP5004CX6/LF

These are devices specifically designed for microphones and provide audio and RF filtering including bias components. Additional capacitors between the two devices can be added to allow a DC-free signal propagation.

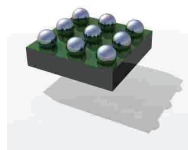


Fig 37. Depiction of IP5003CX9/LF CSP package

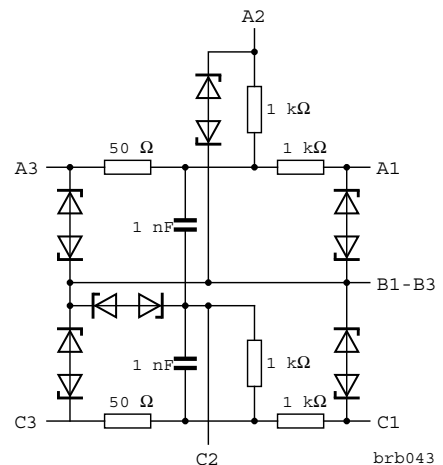


Fig 39. IP5003CX9/LF schematic is shown as an example

6.3.10 IP5020CX16/LF

Another device that includes high capacitance density of 20 nF/mm² (built in the NXP Semiconductors high-K process) integrates four 9 nF AC-coupling capacitors and ± 8 kV ESD protected diodes at the input pins. IP5020CX16/LF is a very advanced dual differential channel microphone device that includes the DC decoupling capacitors to decouple the microphone biasing voltage from the sigma-delta analog to digital converter input biasing. If this device is used, no further discrete capacitors are needed to decouple different DC-voltage domains to obtain an optimum operation point for the A/D-converter and the associated microphones. The back-to-back protection diodes prevent any demodulation of injected EMI-signals, while providing an ESD protection to IEC61000-4-2, level4.

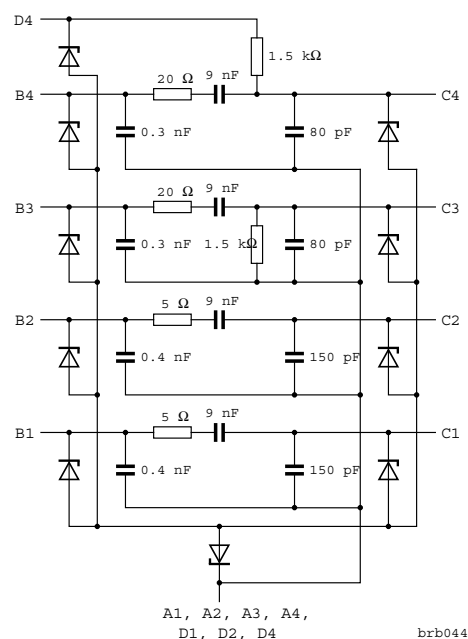


Fig 40. IP5020CX16/LF schematic

6.3.11 IP5040CX11/LF

IP5040CX11/LF is also manufactured using a NXP Semiconductors high dense capacitor process and contains 4 x 5 nF capacitors for RF-filtering. The channel series resistance is only 10 Ω to allow usage in audio, especially loudspeaker signal paths. This device contains high-level ESD-protection withstanding discharges up to ± 15 kV contact!

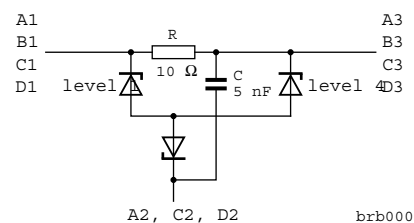


Fig 41. IP5040CX11/LF single channel schematic

7. General Purpose Multi-Channel Interfaces (e.g. Data I/O, LCD)

The typical application areas for these devices are e.g. Data I/Os, LCD-Displays interface or keypad interfaces. Depending on the application area, parameters such as channel resistance and line capacitance are most important. In case where higher clock speeds and very high attenuation of RF-frequencies are required, the NXP C-L-C – coil based EMI-filters and ESD-protections are the devices of choice. Several filters are available in devices with different numbers of channels to enable optimum usage of the PCB area. Nearly all devices withstand ± 15 kV contact ESD-discharges according the IEC61000-4-2 model, far exceeding the level 4. CSP packaged products.

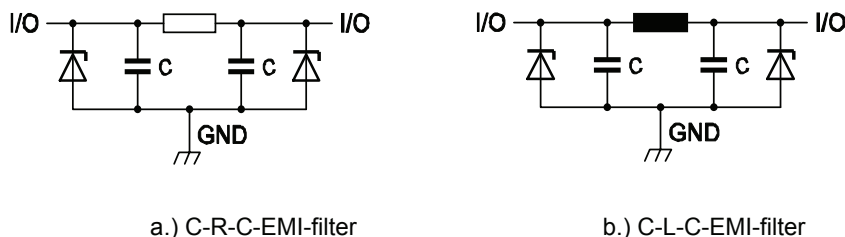


Fig 42. Schematic view of 1 filter channel of a C-R-C (a) and C-L-C (b) based EMI-filter with high-level ESD-protection diodes

Table 13. C-L-C type multi-channel EMI filter and ESD protection devices in CSP

Type name	Channel small signal equivalents			-3dB frequency ^[8] (insertion loss)	remark
	L_{channel}	R_{channel} (L_{channel})	C_{channel} ^[9]		
IP3053CXyy ^[10]	35 nH	100 Ω	25 pF	200 MHz	7-channel CLC -type EMI filter/ESD protection, 0.4 mm pitch, same footprint as IP3088CXyy
IP3088CXyy ^[10]	40 nH	18 Ω	25 pF	200 MHz	7-channel CLC -type EMI filter/ESD protection, 0.4 mm pitch, same footprint as IP3053CXyy
IP3328CX24 ^[10]	33 nH	125 Ω	25 pF	200 MHz	7-channel CLC -type EMI filter/ESD protection, 0.4 mm pitch, same footprint as IP3338CX24/LF and IP4338CX24/LF
IP3348CXyy ^[10]	15 nH	125 Ω	25 pF	200 MHz	7-channel CLC -type EMI filter/ESD protection, 0.4 mm pitch
IP3337CX18/LF	60 nH	125 Ω	25 pF	200 MHz	7-channel CLC -type EMI filter/ESD protection, 0.4 mm pitch, same footprint as IP4337CX18/LF
IP3338CX24/LF	60 nH	125 Ω	25 pF	200 MHz	10-channel CLC -type EMI filter/ESD protection, 0.4 mm pitch, same footprint as IP4338CX24/LF and IP3328CX24

8. $R_{\text{source}} = R_{\text{load}} = 50 \Omega$

9. Capacitance measured at $V_{\text{DC,bias}} = 0$ V

10. IP3xxxCX5: 2-channel, IP3xxxCX10: 4-channel, IP3xxxCX15: 6-channel, IP3xxxCX20: 8-channel

Table 14. C-R-C type multi-channel EMI filter and ESD protection devices in CSP

Type name	Channel small signal equivalents		-3dB frequency ^[11] (insertion loss)	remark
	R_{channel} (L_{channel})	C_{channel} ^[12]		
IP4337CX18/LF	70 Ω	25 pF	240 MHz	7-channel CRC -EMI filter/ESD protection, 0.4 mm pitch, same footprint as IP3337CX18/LF
IP4338CX24/LF	70 Ω	25 pF	240 MHz	10-channel CRC -EMI filter/ESD protection, 0.4 mm pitch, same footprint as IP3328CX24 and IP3338CX24/LF
IP4041CX25/LF	200 Ω	50 pF	105 MHz	10-channel CRC -EMI filter/ESD protection device
IP4307CX4/LF	75 Ω	36 pF	155 MHz	1-channel CRC -ESD protection/EMI filter with one common ground
IP4032CX25/LF	80 Ω	40 pF	100 MHz	10-channel CRC -filter, footprint compatible to IP4033CX25
IP4035CX24/LF	1 k Ω	50 pF	22 MHz	10-channel CRC -EMI filter/ESD protection for key pads
IP4040CX25/LF	84 Ω	14 pF	365 MHz	10-channel CRC -EMI filter
IP4053CX15/LF	100 Ω	60 pF	120 MHz	6-channel CRC -EMI filter/ESD protection device
IP4153CX15/LF	100 Ω	30 pF	210 MHz	6-channel CRC -EMI filter/ESD protection, low capacitance version of IP4053CX15
IP4054CX15/LF	100 Ω	60 pF	85 MHz	4-channel CRC -EMI filter/ESD protection +4 single protection diodes
IP4088CX20/LF	100 Ω	50 pF	120 MHz	8-channel CRC -EMI filter/ESD protection device

Table 15. Multi-channel EMI filter and ESD protection devices in plastic package

Type name [+ /LF]	Channel small signal /equivalents		-3dB frequency ^[13] (insertion loss)	remark
	R_{channel} (L_{channel})	C_{channel} ¹⁴		
IP3253CZyy	(18 nH)	36 pF	275 MHz	4, 6, 8 -channel CLC -EMI-filter & ESD protection in QFN-type package
IP3254CZyy	(12 nH)	50 pF	335 MHz	4, 6, 8 -channel CLC -EMI-filter & ESD protection in QFN-type package
IP4251CZyy	100 Ω	15 pF	330 MHz	4, 6, 8 -channel CRC -EMI-filter & ESD protection in QFN-type package
IP4252CZyy	40 Ω	18 pF	300 MHz	4, 6, 8 -channel CRC -EMI-filter & ESD protection in QFN-type package
IP4253CZyy	200 Ω	45 pF	110 MHz	4, 6, 8 -channel CRC -EMI-filter & ESD protection in QFN-type package
IP4254CZyy	100 Ω	45 pF	130 MHz	4, 6, 8 -channel CRC -EMI-filter & ESD protection in QFN-type package
IP4256CZyy	100 Ω	30 pF	200 MHz	1, 2 -channel CRC -EMI-filter & ESD protection in SOT883, SOT886 and SOT665 package

11. $R_{\text{source}} = R_{\text{load}} = 50 \Omega$ 12. Capacitance measured at $V_{\text{DC_bias}} = 0 \text{ V}$ 13. $R_{\text{source}} = R_{\text{load}} = 50 \Omega$ 14. Capacitance measured at $V_{\text{DC_bias}} = 0 \text{ V}$



Fig 43. package view of IP3xxxCX15, IP40(1)53CX15/LF & IP4054CX15/LF and IP3xxxCX20 & IP4088CX20/LF

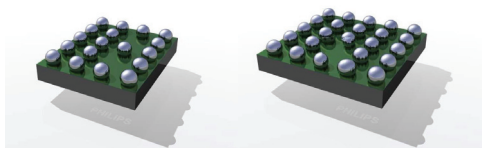


Fig 44. package view of IP4337CX18/LF, IP4338CX24/LF and IP3337CX18/LF, IP3338CX24/LF



Fig 45. 4-, 6- and 8-channel QFN type plastic package, max height 0.5 mm, IP425xCZyy

7.1 Multi purpose diodes and diode arrays

To enable customers to protect small interfaces against ESD without specific requirements of EMI filtering, NXP Semiconductors Integrated Discretes offers a variety of “Multi-Purpose Diode Arrays”. These devices offer 2 to 16 integrated ESD protection diodes in different pin count CSPs.

7.1.1 IP4302CX2/LF

NXP Semiconductors IP4302CX2/LF is a very tiny back-to-back diode in a two ball CSP package. When soldered onto standard solder pads on a PCB, the surface tension moves the device to an upright position.

Built using a 0.4 mm pitch, the total device size is 0.7 mm by 0.52 mm only but still provides protection according to the IEC61000-4-2, level 4 standard.

$$C_{jo} < 10 \text{ pF} (V_{DC_bias} = 0 \text{ V})$$

$$V_{BR} = 14.0 \text{ V}_{min.}$$

7.1.2 IP4303CX4/LF

IP4303CX4/LF is one of the smallest dual back-to-back diode ESD protection Integrated Discrete devices. Built using a 0.4 mm pitch, the total device size is 0.81 mm by 0.81 mm but still provides protection according to the IEC61000-4-2, level 4 standard.

$$C_{jo} < 10 \text{ pF} (V_{DC_bias} = 0 \text{ V})$$

$$V_{BR} = 14.5 \text{ V}_{typ.}$$

7.1.3 IP4306CX2/LF

IP4306CX2/LF is a 2-ball 0.4 mm pitch CSP Schottky power diode. The typical voltage drop at $I_F = 300 \text{ mA}$ is only 500 mV.

$$C_{jo} = 65 \text{ pF} (V_{DC_bias} = 0 \text{ V})$$

$$V_{BR} = >20 \text{ V}_{typ.}$$

7.1.4 IP4307CX4/LF

This is a device optimized for analog video signals, where 75Ω ($\pm 5 \%$) termination / driver impedance is required. The filter characteristic is designed such, that the maximum insertion loss is $>20 \text{ dB}$ @ 800 MHz and above to filter out unwanted influences from mobile phone frequencies. IP4307CX4/LF is a 0.4 mm pitch device.

$$C_{Channel} = 36 \text{ pF} (V_{DC_bias} = 0 \text{ V})$$

$$R_{Channel} = 75 \Omega (\pm 5 \%)$$

$$V_{BR} = 6 \text{ V} - 10 \text{ V}$$

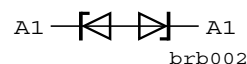
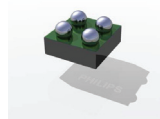


Fig 46. Schematic of IP4302CX2/LF

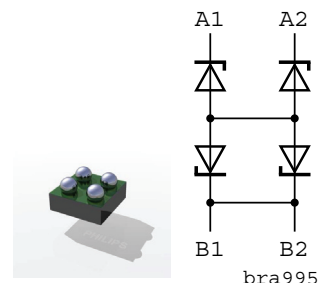


Fig 47. Schematic and CSP package view of IP4303CX4/LF

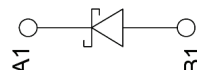


Fig 48. Schematic of IP4306CX2/LF

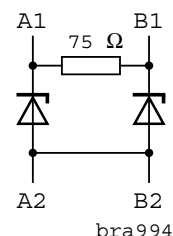


Fig 49. Schematic view of IP4307CX4/LF

7.1.5 IP4042CX5/LF, IP4142CX5/LF, IP4332CX5/LF, IP4342CX5/LF, IP4043CX5/LF, IP4343CX5/LF

Three general-purpose ESD protection arrays for local protection of devices connected to external interfaces. IP4042CX5 & IP4142CX5 have 4 single diodes in an extremely small package. IP4043CX5 (0.5 mm pitch) and IP4343CX5 (0.4 mm pitch) have 4 pairs of back to back diodes to allow AC- signals through. The back-2-back diode pairs also reduce the capacitance to less than 20 pF.

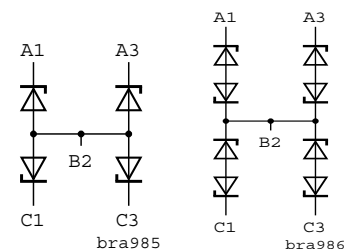


Fig 50. Schematic view of IP40(1)42CX5/LF & IP4332/42CX5/LF & IP40(3)43CX5/LF, IP4343CX5/LF (right)

	IP4042CX5/LF	IP4142CX5/LF	IP4332CX5/LF	IP4342CX5/LF	IP4043CX5/LF	IP4343CX5/LF
$V_{BR(typ.)}$	+7.5 V	+6.8 V	± 7.5 V	+6.8 V	± 16.5 V	± 16.5 V
C_{jo}	< 30 pF	14 pF	< 30 pF	14 pF	< 20 pF	< 20 pF
pitch	0.5 mm	0.5 mm	0.4 mm	0.5 mm	0.5 mm	0.4 mm

7.1.6 IP4085CX4/LF, IP4385CX4/LF, IP4386CX4/LF, IP4387CX4/LF

IP4085CX4/LF and IP4385(6,7)CX4/LF devices are the most robust Integrated Discretes ESD/ TVS diode in a CSP package. Their main purpose is to protect interfaces such as charger interfaces of a PMU from transients and also from wrong polarity connections to the charger interface.

IP4085CX4/LF offers a surge immunity according IEC61000-4-5 (8/20 μ s) up to 60 A. Its reverse clamping voltage is < 20 V at a current of 1 A.

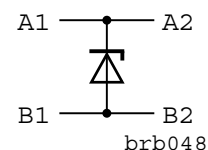


Fig 51. Schematic view of IP4085CX4/LF & IP4385,6,7CX4/LF

	V_{BR}	C_{JO}	Pitch [mm]
IP4085CX4/LF	16 V	160 pF	0.5
IP4385CX4/LF	7 V	450 pF	0.4
IP4386CX4/LF	16 V	160 pF	0.4
IP4387CX4/LF	10 V	290 pF	0.4

8. Active Devices

8.1 General

NXP Integrated Discretes offers a wide variety of different integrated active functions. Depending on the customer requirements, such as operating voltage, power consumption requirements and functionality, different technologies can be used.

Available technologies are:

- Bipolar
- High-Voltage CMOS ($U_{BR} < 60\text{ V}$)
- BiMOS

Examples of integrated functional blocks:

- Switches
- Level-Shifters
- Temperature Sensors
- Reference Sources (Voltage and Current)
- Logic
- Voltage and Current clamping

In most of the devices built using the technologies listed above, the active functions are combined with passive filters and high-level ESD protection. An ESD protection level compliant to IEC61000-4-2, level 4 standard ($\pm 8\text{ kV}$ contact and $\pm 15\text{ kV}$ air discharge) and above can be reached.

8.2 Examples of active devices

8.2.1 IP4853CX24 and IP4863CX24

IP4853CX24 and IP4863CX24 are bi-directional high-speed SD-Card (T-Flash) interface that contain a level-shifter, a **Power Supply Unit** (Voltage regulator) delivering the required 2.9 V for the SD-Card and high-level ESD protection and EMI filter in 0.4 mm pitch chip-scale package covering an area of just 4 mm².

The devices can handle the SD-Card high-speed requirements, contains a clock feedback channel to support simple read-data synchronization and offers ESD protection up to ± 8 kV contact discharge according the IEC61000-4-2 standard, level 4.

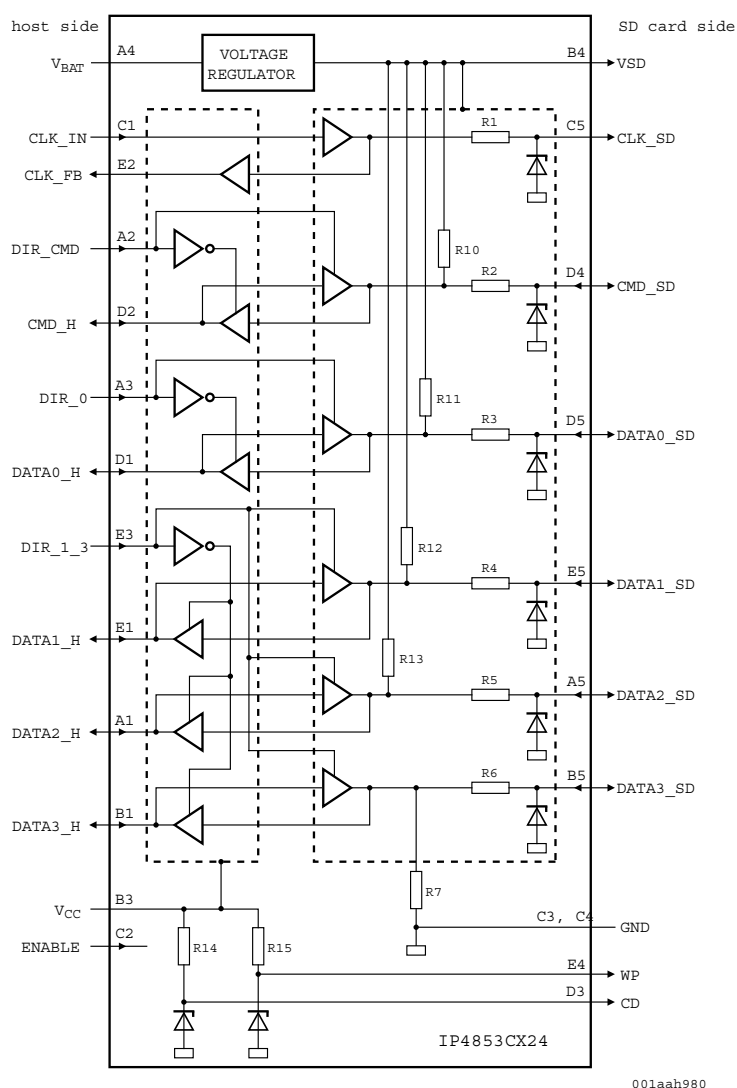


Fig 52. IP4853CX24 & IP4863CX24 schematic view, showing the major building blocks such as drivers, high-level ESD protection, pull-up and filter-resistors

8.2.2 IP4852CX25/LF

IP4852CX25/LF is bi-directional high-speed SD-Card (T-Flash) interface level-shifter in 0.4mm pitch chip-scale package. It converts signal voltages between the host processor side from 1.8 V supplied I/Os to a standard SD-Card (T-Flash) interface compatible level of 3 V and vice versa.

An additional clock feedback loop is provided to compensate possible delays induced by the level-shifters and to receive synchronized clock and data information from the SD-Card to the host processor.

The pin-out is optimized for an application together with IP4350CX24/LF or IP4352CX24/LF ESD protection and EMI filter for SD-Card interfaces.

Each of these devices shows a die size of only ~4 mm²!

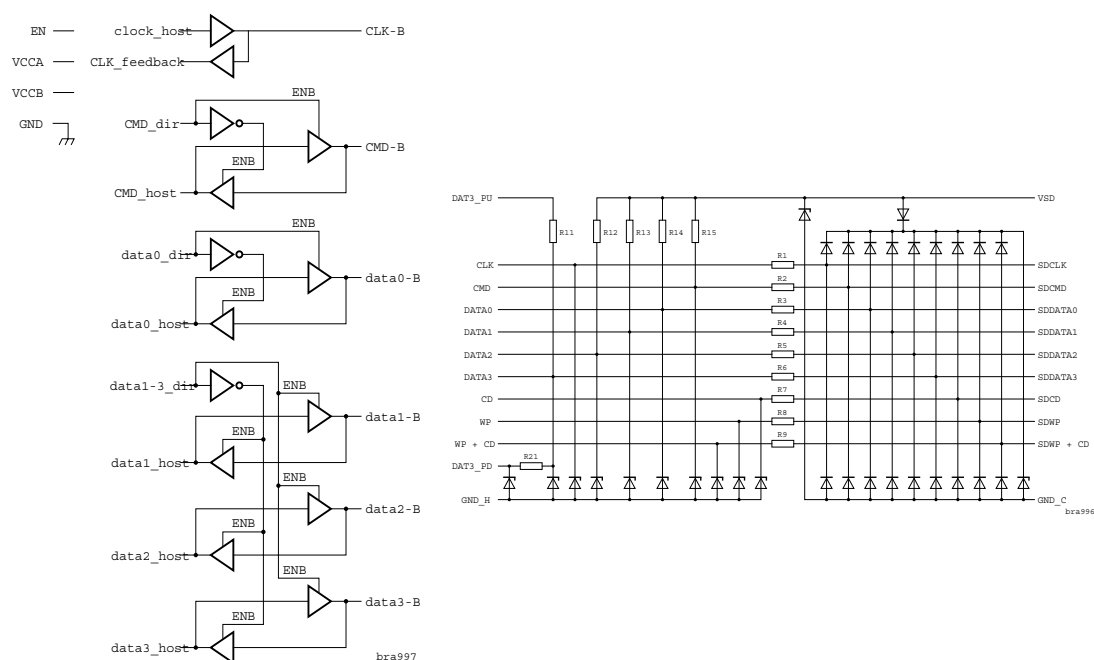


Fig 53. Schematic of IP4852CX25/LF (left) and IP4352CX25/LF (right)

8.2.3 IP4569CX17/LF, IP4571CX17/LF

This device is a combination of passive EMI filters with ESD protection and over voltage protected 'analog' switches. All external pins are IEC61000-4-2, level 4 compliant. The difference between IP4569CX17/LF and IP4571CX17/LF can be found in the pull-up and pull-down resistor configuration.

The integrated transmission gate switches SW1 & SW2 can be operated with voltages much higher than the applied V_{CC} without showing any parasitic diode from any of its I/Os to the supply.

The power consumption is close to leakage currents only.

$R1, R3, R5 = 1 \text{ k}\Omega$
 $R2, R7 = 135 \text{ k}\Omega$
 $R4 = 220 \text{ k}\Omega$
 $R6 = 150 \text{ k}\Omega$
 $C_{line} = 25 \text{ pF} - 40 \text{ pF}$

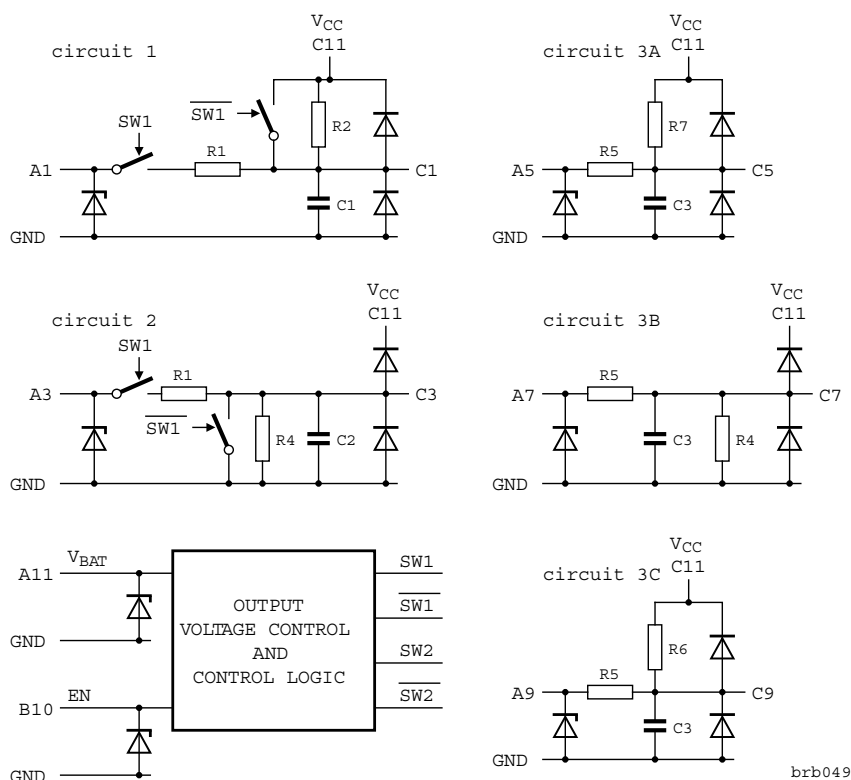
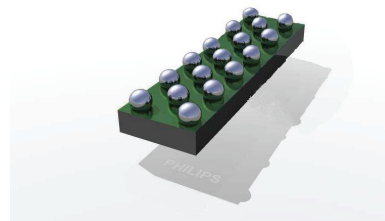


Fig 54. Schematic and CSP package view of IP4571CX17/LF

9. Package & Application

Board layout and device placement are very important, especially for EMI filters and ESD protection devices. Data given in this report is based on using a multi layer printed wiring board with ground connections made directly to a ground plane within the PCB using micro vias.

The small footprints of the devices allow them to be placed in the optimum position close to the external connector or device. This provides the maximum filtering of unwanted signals. In devices for specific applications the pinning is chosen to match with the standard connector for that application e.g. SIM card or USB.

9.1 Grounding

For maximum efficiency of filtering and ESD protection the devices should be connected to a ground plane with a micro via. If this is not possible the connection to the ground plane should be as direct as possible to minimize the inductance; the ground should be directly connected to e.g. the USB connector ground. It should not be on a "spur".

9.2 Chip Scale Package

Example of a 5 x 5 *Wafer-Level* Chip Scale Package outline with **0.5 mm** pitch.

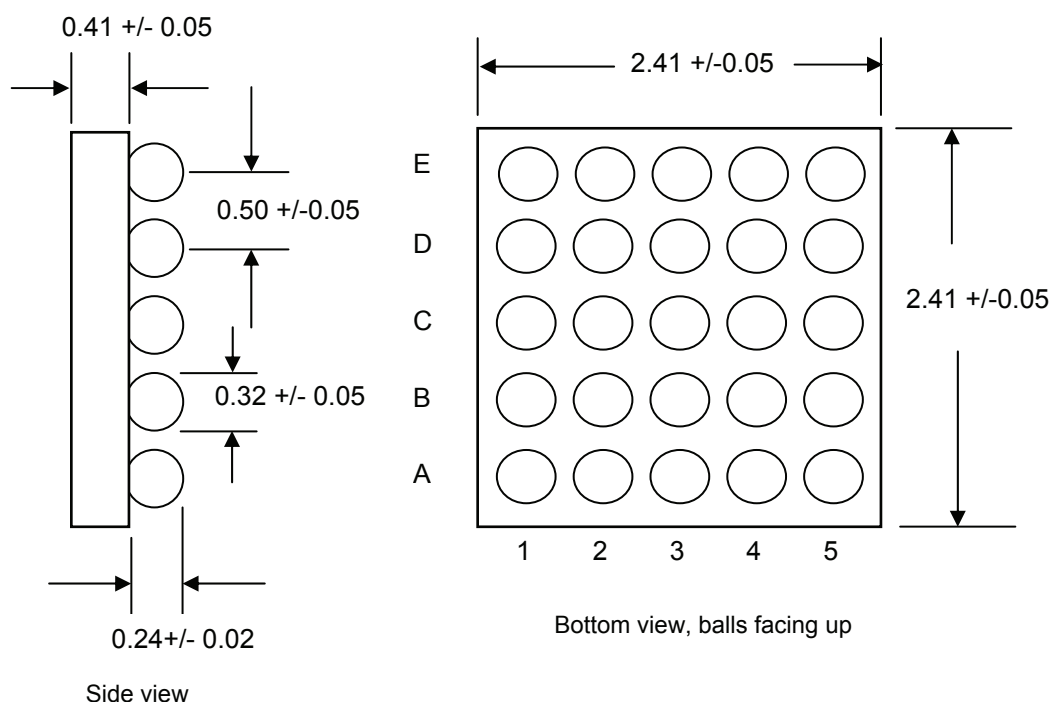


Fig 55. 0.5 mm pitch chip scale package outline

Example of a 5 x 5 *Wafer-Level* Chip Scale Package outline with **0.4 mm** pitch.

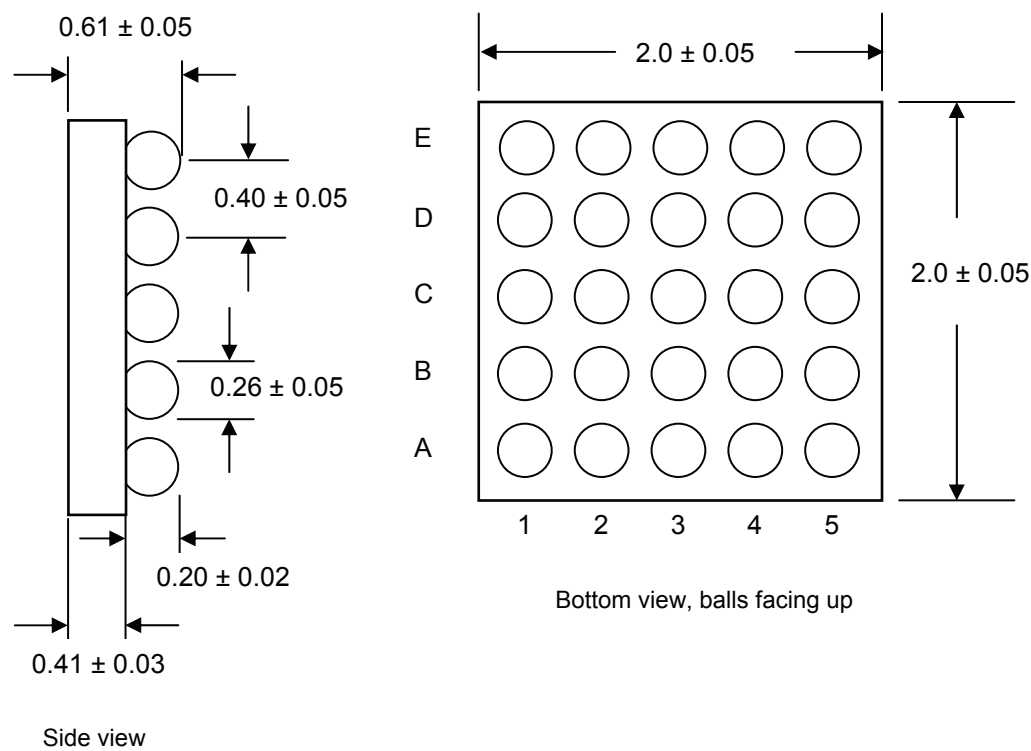


Fig 56. 0.4 mm pitch chip scale package outline

9.2.1 Comparison of *Wafer-Level* CSP with 0.5 mm and 0.4 mm pitch

One possibility to comply with the continuing trend for miniaturization is to reduce the pitch of the solder bumps of the *Wafer-Level* CSP. As long as the integrated components cover less area than given by the size of the footprint, the pitch can be reduced e.g. down to 0.4 mm which reduces the average device size by approximately 20 to 25 %.

A comparison between two electrically identical 10-channel filters, IP4041CX25/LF and IP4341CX25/LF is depicted in the drawing below.

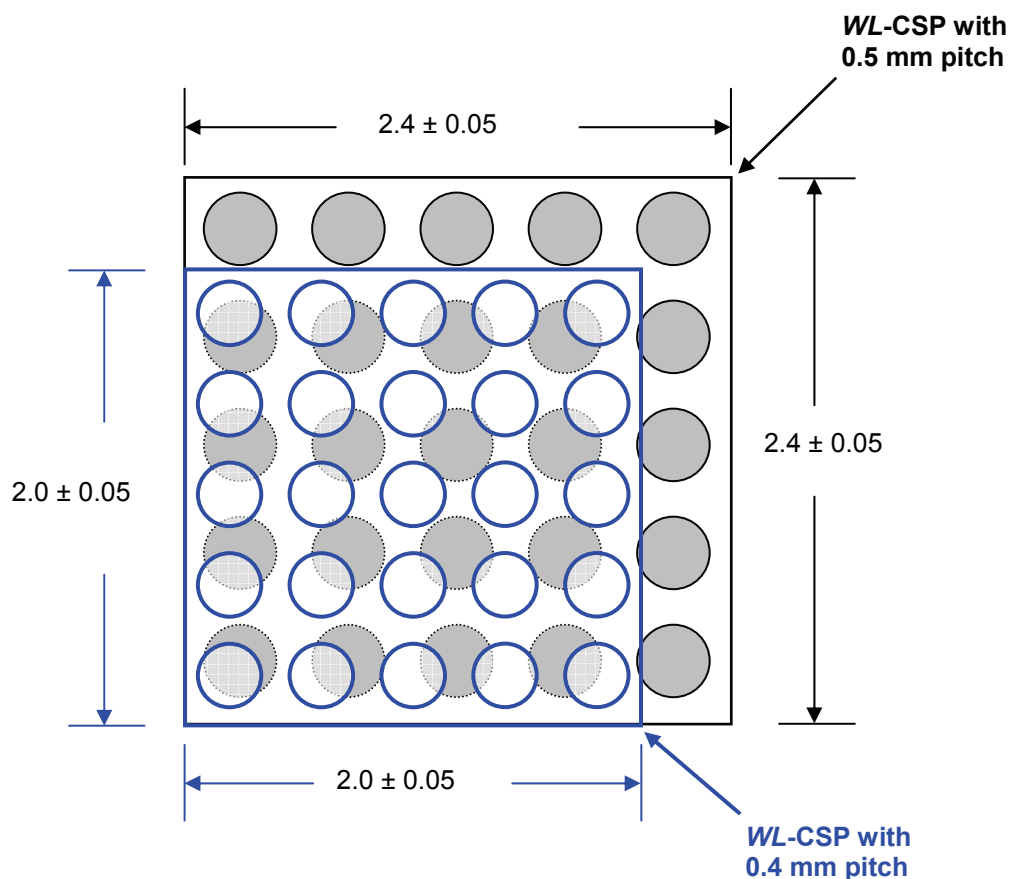


Fig 57. Comparison of a 0.5 mm pitch versus a 0.4 mm pitch chip scale package outline

9.3 Layout Recommendation

- Layout principles for all CSP products in 0.5 mm and 0.4 mm pitch are the same
 - For GND connections, micro vias are placed directly into pads where possible¹⁵ to connect from first layer to second layer
 - Use laser drilled micro vias with a diameter of $\sim 100\ \mu\text{m}$
 - Cu solder pad (solder lands) diameter $200\ \mu\text{m}$
 - Place as much as possible additional micro vias for GND connection
 - Devices support straight on bus routing – try to avoid sharp corner in connected traces, especially if these are conducting high-frequency signals (USB2.0, HDMI, DVI etc.)
- Lead free Wafer-Level CSP footprint (reflow soldering) is shown below:

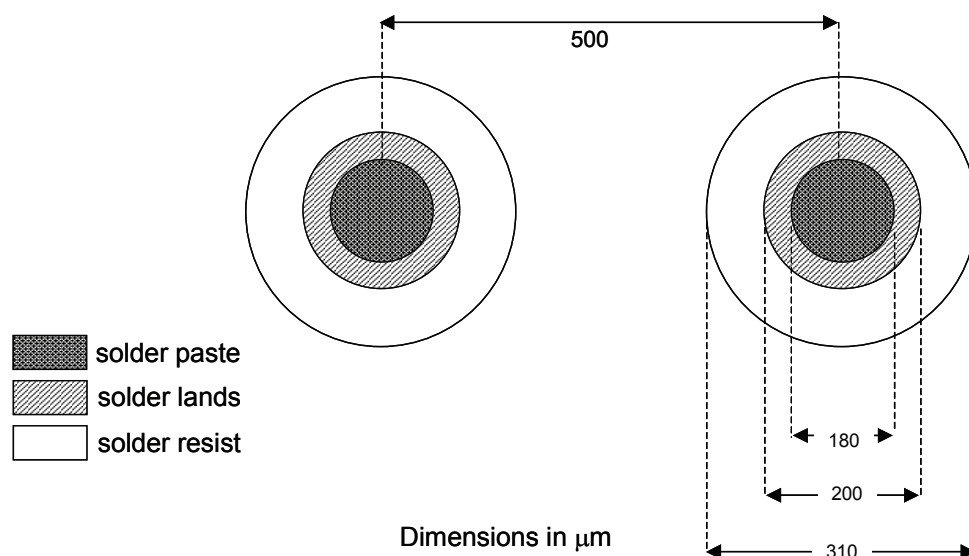


Fig 58. Lead free Wafer-Level CSP footprint (reflow soldering)

9.4 Reliability

Chip Scale packaging has been available for several years. NXP has been supplying these packages since 1998; they have been extensively tested by suppliers and leading customers and by us at our Centre for Manufacturing Technology centre in Eindhoven. These tests have determined the optimum parameters for P.C.B. design, placement and soldering to ensure all applicable reliability tests can be met. It has been proven that all NXP Integrated Discretes devices in *Wafer-Level* CSP up to 6x6 solder balls do not require any under fill. NXP Integrated Discrete products can already be used with lead free soldering processes and most devices are available as lead-content and also as lead-free devices with an identical electrical performance.

¹⁵ If it is not possible to connect the GND layer directly to the device using e.g. micro vias in the pads, try to keep the connecting tracks as short as possible to avoid deterioration of the ESD and/or filter performance

10. Device – application overview table

The table below indicated the major application area for each device shown in this document. Due to their technical parameters, most devices can be used in various other application areas too, even though these are not explicitly stated here.

Table 16. Device- application overview table

Type name	SD-/MMC-Card	SIM card	USB2.0 USB1.1	Loudspeaker	Microphone	Digital interface (LCD, Camera etc.)	LVDS type interfaces	HDMI	Low speed interfaces (e.g. keypad)	Remark
IP3047CX6				X						
IP3048CX5				X						
IP3053CXyy						X				
IP3088CXyy						X				
IP3219CZ6			X				X			
IP3253CZyy						X	X			
IP3254CZyy						X	X			
IP3328CX24						X				
IP3337CX18/LF						X				
IP3338CX24/LF						X				
IP3348CXyy						X				
IP4027CX20/LF				X	X					
IP4032CX25/LF IP4033CX25/LF						X			X	
IP4035CX24/LF									X	
IP4040CX25/LF						X			X	
IP4041CX25/LF						X			X	
IP4042CX5/LF				X	X		X		X	
IP4043CX5/LF				X	X	X	X		X	
IP4044CX8/LF		X								
IP4047CX6/LF				X						
IP4048CX5/LF				X						
IP4049CX5/LF					X					
IP4051CX11/LF	X									

Type name	SD-/MMC-Card	SIM card	USB2.0 USB1.1	Loudspeaker	Microphone	Digital interface (LCD, Camera etc.)	LVDS type interfaces	HDMI	Low speed interfaces (e.g. keypad)	Remark
IP4052CX20/LF	X									
IP4053CX15/LF						X			X	
IP4054CX15/LF						X			X	
IP4055CX6/LF					X					
IP4056CX8/LF			X							
IP4057CX10/LF			X							
IP4058CX8/LF			X							
IP4059CX5/LF			X							
IP4060CX16/LF	X									
IP4064CX8/LF		X								
IP4065CX11/LF			X							
IP4078CX6/LF			X							
IP4085CX4/LF										Power diode
IP4088CX20/LF						X			X	
IP4142CX5/LF				X	X	X	X		X	
IP4153CX15/LF						X			X	
IP4158CX8/LF			X							
IP4220CZ6	X	X	X			X	X			
IP4221CZ6-S	X	X	X			X	X			
IP4221CZ6-XS	X	X	X			X	X			
IP4223CZ6	X	X	X			X	X			
IP4242CZ6	X	X	X			X	X			
IP4251CZyy						X				
IP4252CZyy	X					X				
IP4253CZyy						X			X	
IP4254CZyy						X			X	
IP4256CZyy					X	X			X	

Type name	SD-/MMC-Card	SIM card	USB2.0 USB1.1	Loudspeaker	Microphone	Digital interface (LCD, Camera etc.)	LVDS type interfaces	HDMI	Low speed interfaces (e.g. keypad)	Remark
IP4264CZ8-xx		X								
IP4281CZ10	X	X	X			X	X	X		
IP4282CZ6	X		X				X	X		
IP4283CZ10	X		X				X	X		
IP4284CZ10	X		X				X	X		
IP4302CX2/LF	X		X	X	X	X	X		X	
IP4303CX4/LF				X		X	X			
IP4306CX2/LF										Schottky diode
IP4307CX4/LF										CVBS/TV-out
IP4309CX9	X		X			X	X	X		
IP4310CX8								X		
IP4332CX5/LF				X	X	X	X		X	
IP4337CX18/LF						X				
IP4338CX24/LF						X				
IP4342CX5/LF				X	X	X	X		X	
IP4343CX5/LF				X	X	X	X		X	
IP4350CX24/LF	X									
IP4351CX11/LF	X									
IP4352CX24/LF	X									
IP4353CX15/LF						X			X	
IP4355CX6/LF					X					
IP4358CX6	X		X							
IP4359CX4/LF			X				X			
IP4361CX4			X							
IP4363CX10/LF				X	X					
IP4364CX8/LF		X								
IP4365CX11/P		X	X							

Type name	SD-/MMC-Card	SIM card	USB2.0 USB1.1	Loudspeaker	Microphone	Digital interface (LCD, Camera etc.)	LVDS type interfaces	HDMI	Low speed interfaces (e.g. keypad)	Remark
IP4366CX8/P		X								
IP4368CX9/P		X	X			X	X			
IP4385CX4/LF										Power diode
IP4386CX4/LF										Power diode
IP4387CX4/LF										Power diode
IP4501CX15/LF									X	I ² C, power switch
IP4524CX27/LF						X			X	Active controls
IP4559CX25/LF			X							
IP4569CX17/LF IP4571CX17/LF			X						X	
IP4826CX12/LF									X	Active controls
IP4852CX25/LF	X									Level shifter
IP4853CX24 IP4863CX24	X									Levelshifter, LDO, ESD, EMI
IP5002CX8/LF					X					
IP5003CX9/LF					X					
IP5004CX6/LF					X					
IP5006CX11/LF					X					
IP5020CX16/LF				X						
IP5040CX11/LF				X						
IP5306CX8/LF					X					
IP5307CX8/LF					X					
IP5311CX5/LF				X						
PESD5V0F1BL	X	X	X	X	X	X	X	X		
PRTR5V0U4D	X	X	X			X	X			
PRTR5V0U4Y	X	X	X			X	X			
PRTR5V0U6S	X	X	X			X	X			
PRTR5V0U8S	X	X	X			X	X			

11. References

11.1 NXP Semiconductors Integrated Discretes:

Technical report: Tech_Report_MemoryCards

ESD and Filter guidelines for Integrated Discretes (Application - ESD& Filter)

Filter considerations: (Application - Using ID's Filters and PCB)

Chip Scale Package: (Application - Chip Scale Packaging)

USB1.1 – IP4058CX8, IP4078CX6: (Application – USB chip scale interface IP4058CX8)

USB2.0 – IP4059CX5, IP4220CZ6: (Technical Report – USB2.0 interface protection)

Product datasheet that were available at the release date of this document are:

- IP4853CX24_x.pdf
- IP4064CX8LF_IP4364CX8LF_x.pdf
- IP4264CZ8-20_IP4264CZ8-40_x.pdf
- IP4085_4385_4386_4387_CX4_x.pdf
- IP4251_52_53_54_x.pdf
- IP4280CZ10_x.pdf
- IP4281CZ10_x.pdf
- IP4282CZ6_x.pdf
- IP4283CZ10_x.pdf

'x' indicating the current data sheet version.

Please contact you local sales office to obtain access to data sheets that can not be found on <http://www.nxp.com>

11.2 International Test Standards:

IEC 61000-4-2

MIL-883E Method 3015.7

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