



Interface Solutions for SSD based storage Applications

Dec. 2014

Public Version

NXP Secure Interface Solutions & Power

Signal Management

SIGNAL SWITCHES

- USB Type-C
- Thunderbolt
- PCIe
- SATA, SAS
- Memory Interfaces
- USB
- DisplayPort (DP)
- HDMI
- MHL
- MIPI
- CSI/DSI
- VGA
- Audio

GENERAL PURPOSE SWITCHES

- Analog

SIGNAL INTEGRITY

- HDMI/DVI Level Shifters
- USB 3.0 Redrivers

ADAPTERS, BRIDGES & UARTs

- DP – VGA
- DP – LVDS
- Inter-bus Bridges (I²C, SPI & UART)
- UARTs

VOLTAGE REFERENCE & DETECTION

- Voltage Comparators

LEVEL TRANSLATION

- GTL
- General Purpose

RF/IF

- LNAs, Mixers, Switches
- Transceivers

Security

- Authentication

Power

DISTRIBUTION & PROTECTION

- Load Switches
- Surge Protection/e-Fuses
- USB Power Switches
- USB PD / Type-C

CHARGING

- Wireless Charging
- Rapid Battery Charging

POWER Management

- Battery Management with PMIC

POWERLINE COMMUNICATION

- Modems

POWER Conversion

- DC-DC, Buck/Boost

Bus Enablers & Peripherals

I²C-bus ENABLERS

- Bus Buffers
- Level Translators
- Muxes & Switches
- Bus Controllers

I²C-bus PERIPHERALS

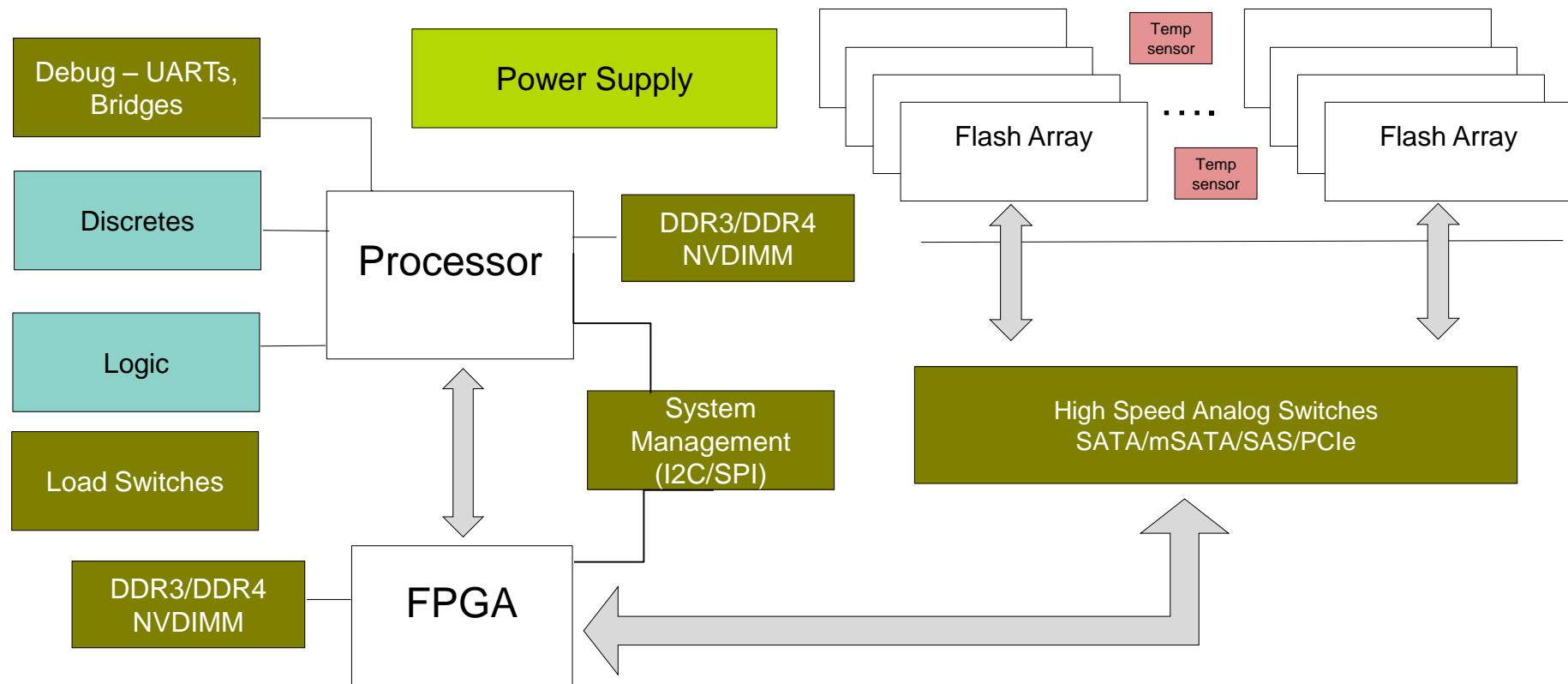
- General Purpose I/Os (Expanders)
- Temperature Sensors
- LED Controllers
- Stepper Motor Controller
- Real Time Clocks
- LCD Display Drivers
- Capacitive Touch Switches & Proximity Sensors
- EEPROMs & DIP Switches
- Data Converters

OTHER BUSES(SPI, ETC.)

- Bus Buffers
- Level Translators
- General Purpose I/Os (Expanders)
- Real Time Clocks
- LCD Display Drivers



General Block Diagram – SSD based storage system

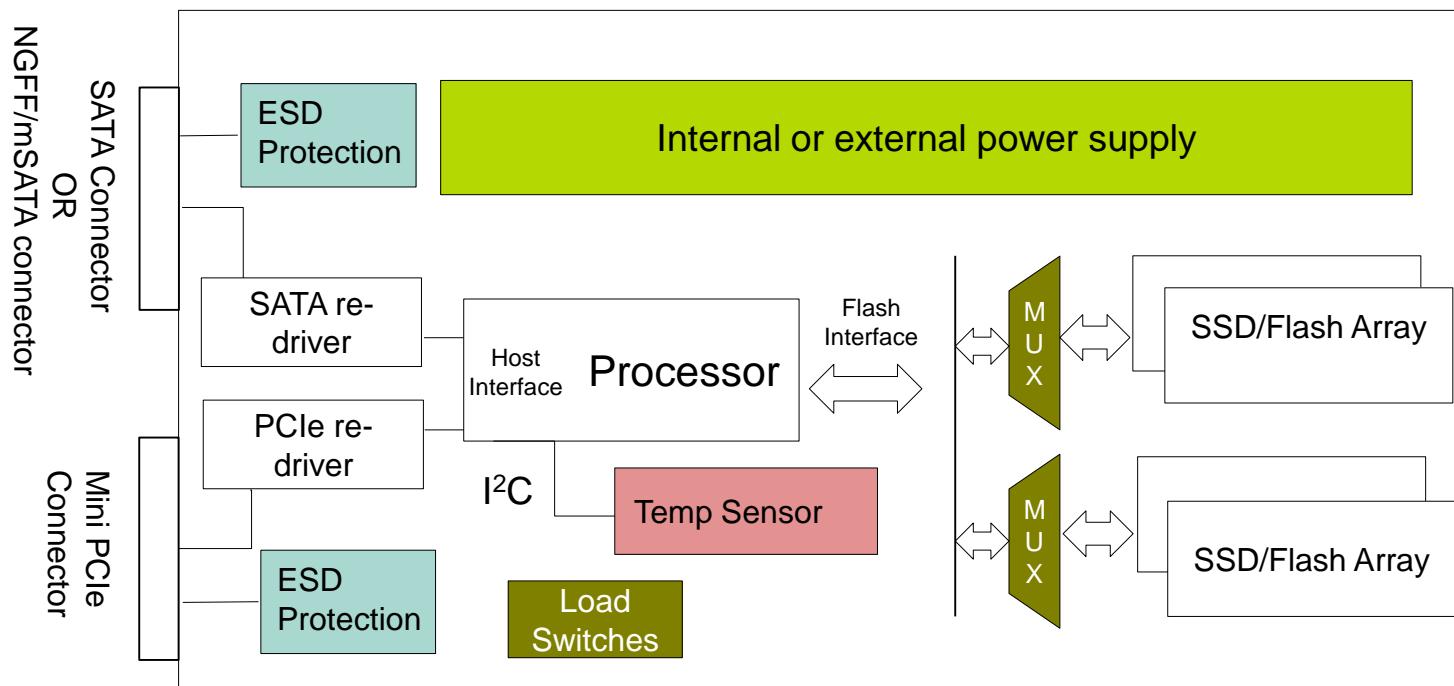


█ Interface █ Standard Products █ Sensors and Actuators

█ Power █ Processing

General Block Diagram: Internal SSD Drive

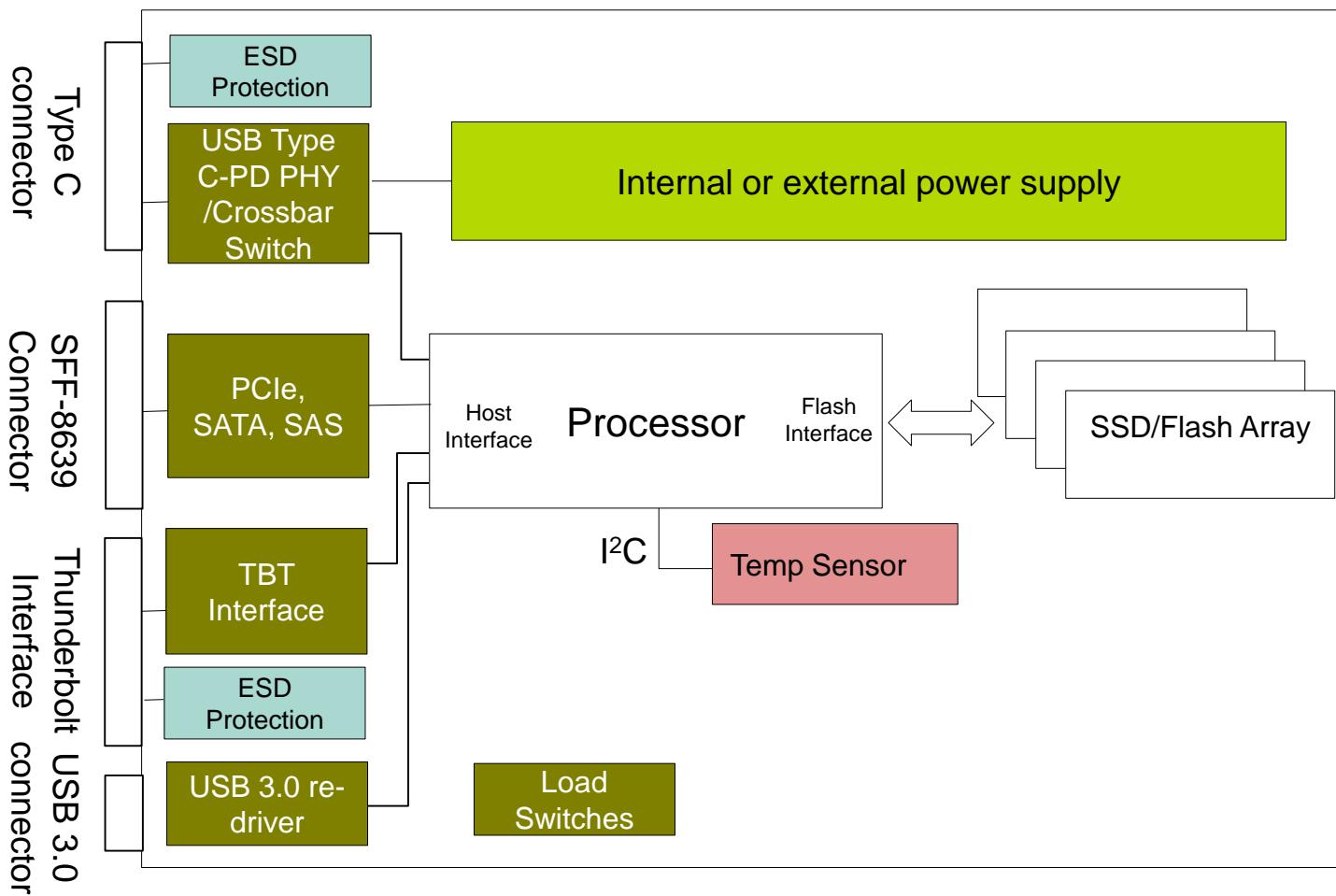
Storage
SSD
External
SSD



- Interface
- Power
- Standard Products
- Processing
- Sensors and Actuators

General Block Diagram: External SSD Drive

Storage SSD
Internal SSD



Interface

Standard Products

Sensors and Actuators

Power

Processing



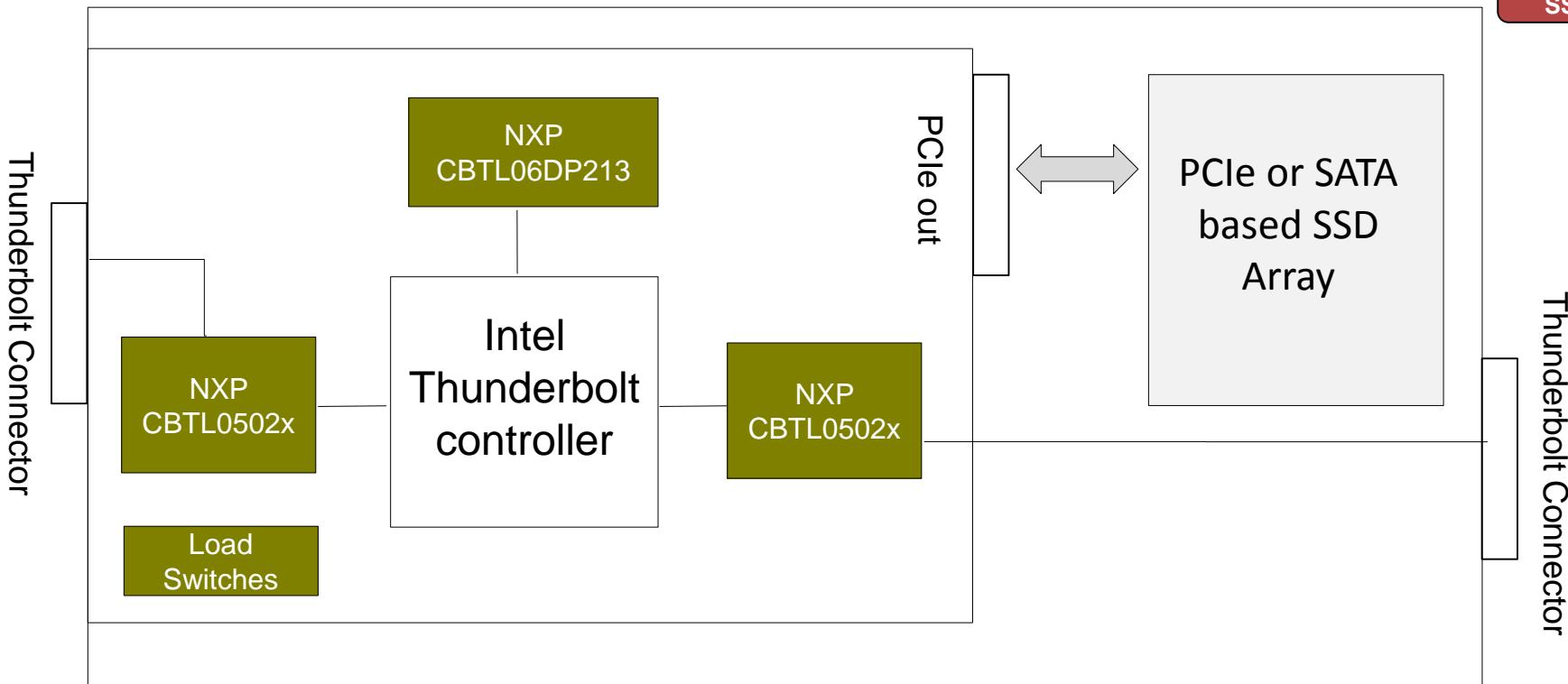
System can have USB, USB Type C, SFF-8639, or TBT interface

General Block Diagram: Thunderbolt based SSD Drive

Storage
SSD

External
SSD

Internal
SSD



- Interface
- Standard Products
- Sensors and Actuators
- Power
- Processing

Storage Analysis



7mm HDD



MSATA SSDs



NGFF



BGA

	7mm HDD	MSATA SSD	NGFF SSD	BGA SSD
Weight	90~100g	Under 10g	Under 10g	Under 5g
Dimension	70*100*7mm	51*30*4.85mm (Standard type)	42*22*3.85mm (Standard type)	Depends on Vendor
Advantages	Replaceable Lowest price, Largest capacity	Replaceable, small, current solution for lightweight UB	Replaceable, thin, Smaller and Lighter than MSATA	Thin, smallest, and lightest, best for mobile and tabs
Disadvantages	Large and heavy, Requires bracket, Best for performance and budget laptops	Price Capacity	Price Capacity	Price Fixed system capacity

Opportunity for switches like CTL02043...

Grantley-based Storage Server

NXP Interface Solutions for: Grantley Storage Server Platform – Emerald Point CRB

Intel Reference Design	PCA9574PW 8 bits of GPIO W/ Interrupt	PCA9511AD Hot swappable I ² C and SMBus buffers	PCA9617ADP 1MHz, 0.8V to 2.5 / 3.3 /5 V translator	GTL2014PW 4-bit LVTTL to GTL transceiver	GTL2034PW 4-bit GTL to GTL Buffer
Emerald Point Rev c	1	4	5	7	1

Storage
SSD

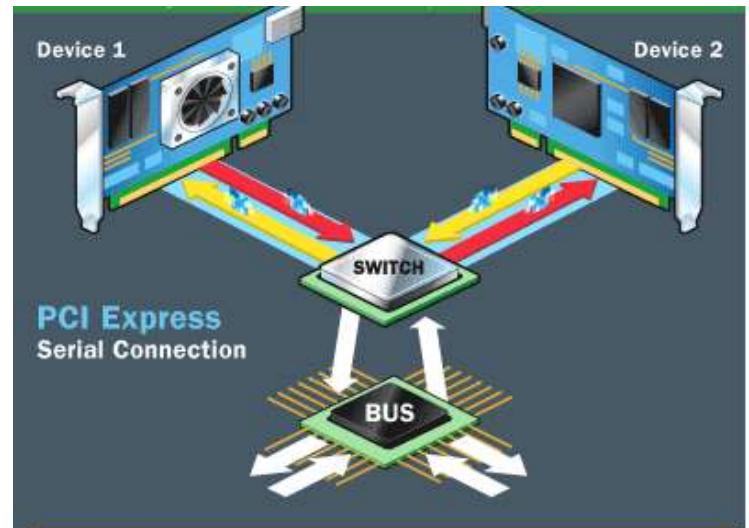
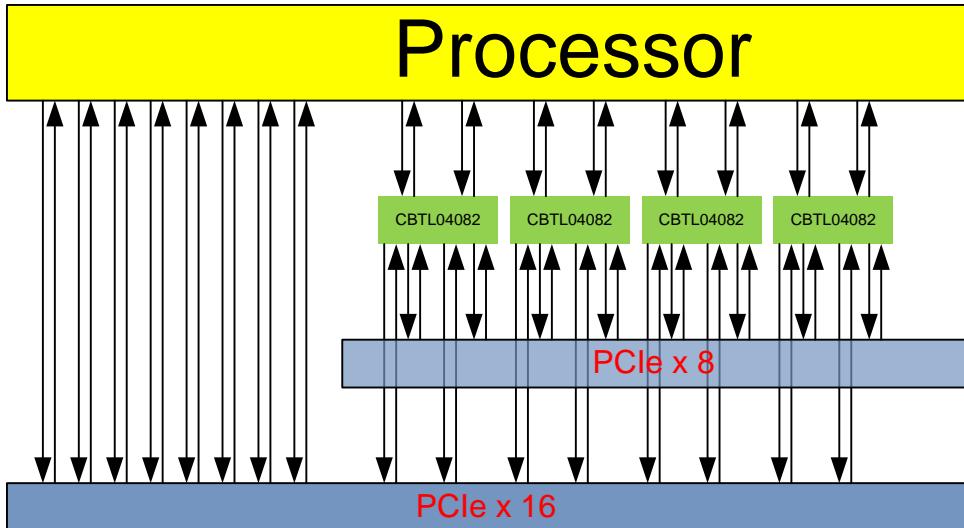
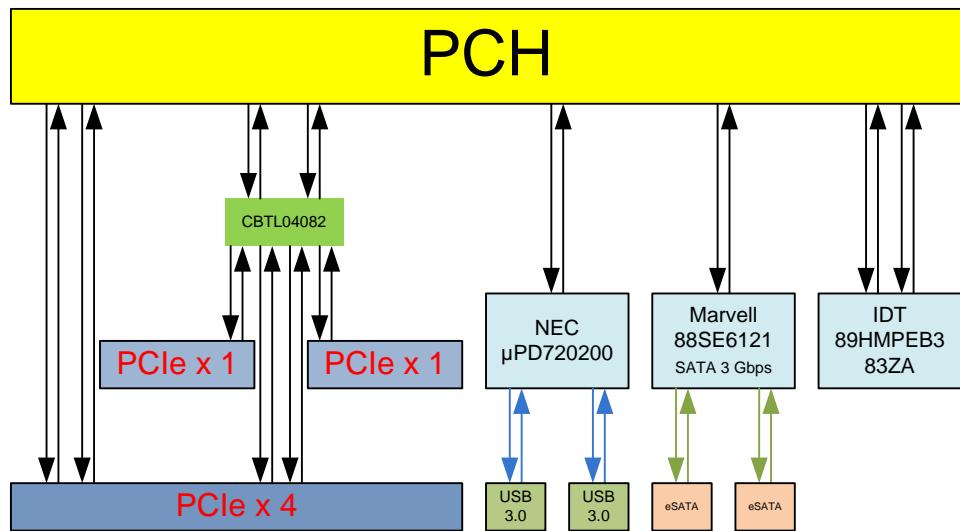
External
SSD

Internal
SSD

High Speed Analog Switching Solutions

High Speed Signal Switches for PCIe Slot Configuration

- ▶ PCIe Slot Configuration
 - x16 → x8 → x4 → x2 → x1



NXP High Speed Analog Switches

General Purpose



	BANDWIDTH	CHANNELS	SUPPLY VOLTAGE	INSERTION LOSS	CROSSTALK	OFF-ISOLATION	PART#
PCIe Gen 2, USB 3.0	5 Gbps	4	1.8V	-2dB at 3 GHz	-23 dB at 3 GHz	-23 dB at 3 GHz	CBTU04082B
	5 Gbps	4	3.3V	-1.2dB at 2.5GHz	-30dB at 2.5GHz	-25dB at 2.5GHz	CBTL04082A/B
	5 Gbps	2	3.3V	-0.9dB at 2.5GHz	-30dB at 2.5GHz	-25dB at 2.5GHz	CBTL02042A/B
PCIe Gen3, USB 3.0, Display Port v1.2	8 Gbps	4	1.8V	-2.8dB at 4 GHz	-30dB at 4GHz	-30dB at 4GHz	CBTU04083B
	8 Gbps	4	3.3V	-1.3dB at 4GHz	-29dB at 4GHz	-20dB at 4GHz	CBTL04083A/B
	8 Gbps	2	3.3V	-1.3dB at 4GHz	-35dB at 4GHz	-20dB at 4GHz	CBTL02043A/B
	10 Gbps	1	3.3V	-1.3dB at 4GHz	-35dB at 4GHz	-20dB at 4GHz	CBTL01023

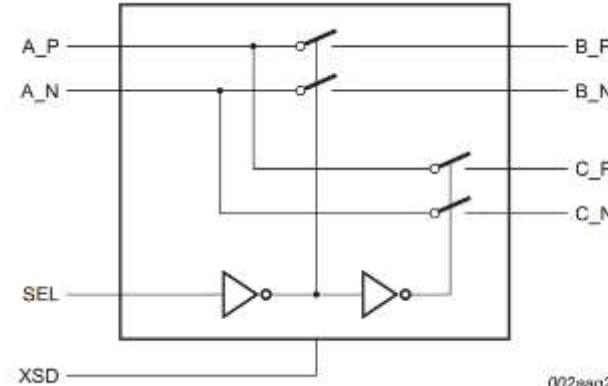


CBTL01023

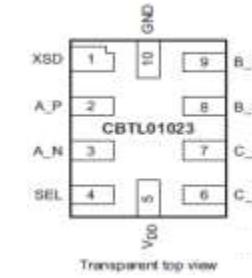
10 Gbps, 3.3V, Mux/De-mux/Switch

Storage
SSD
External
SSD
Internal
SSD

- ▶ Single bidirectional differential channel, 2:1 mux/demux switch
- ▶ High bandwidth: 9 GHz at -3 dB
- ▶ Low insertion loss:
 - -0.5 dB at 100 MHz
 - -1.3 dB at 4.0 GHz
- ▶ Low return loss: -20 dB at 4 GHz
- ▶ Low crosstalk: -35 dB at 4 GHz
- ▶ Low off-state isolation: -20 dB at 4 GHz
- ▶ Low intra-pair skew: 5 ps typical
- ▶ VDD operating range: 3.3 V
 - Standby current less than 1 μ A
- ▶ XQFN10 package



002eag242

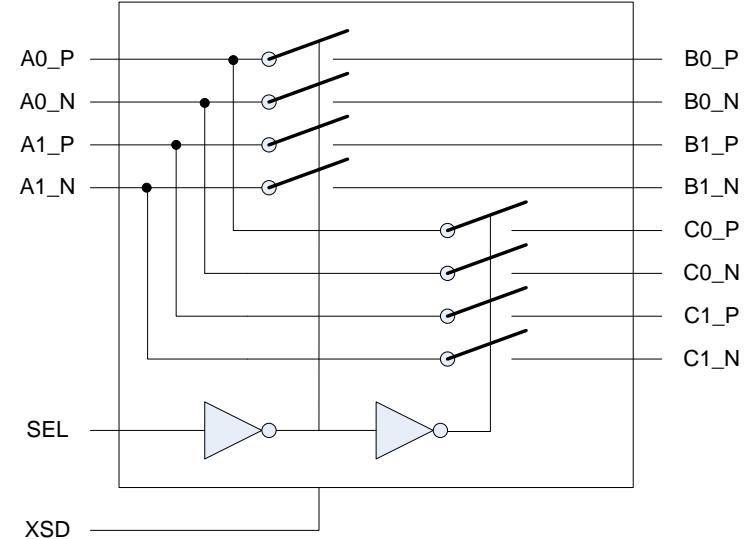


Transparent top view

CBTL02043

10 Gbps, 3.3V, Mux/De-mux/Switch

- ▶ 2 differential channel, 2:1 bi-directional mux/demux
- ▶ Signaling Supported
 - PCIe Gen1 @ 2.5 Gbps
 - PCIe Gen2 @ 5 Gbps
 - PCIe Gen3 @ 8 Gbps
 - USB 3.0 @ 5.0Gbps
 - SATA Gen 2 @ 3.0 Gbps
 - DisplayPort v1.1a @ 2.7 Gbps
 - DisplayPort v1.2 @ 5.4 Gbps
- ▶ **-3dB bandwidth 10 GHz**
- ▶ Low inter-pair skew: 5ps max
- ▶ Low crosstalk: -30dB at 5GHz
- ▶ Off-isolation: -30dB at 5GHz
- ▶ 3.3 V supply voltage
- ▶ DHVQFN 20, 2.5x4.5mm, 0.5mm pitch
- ▶ ESD 6kV HBM, 1kV CDM
- ▶ Two pin-outs available
 - A pin-out optimized for outputs on the opposite side of input
 - B pin-out optimized for outputs on both sides of the package



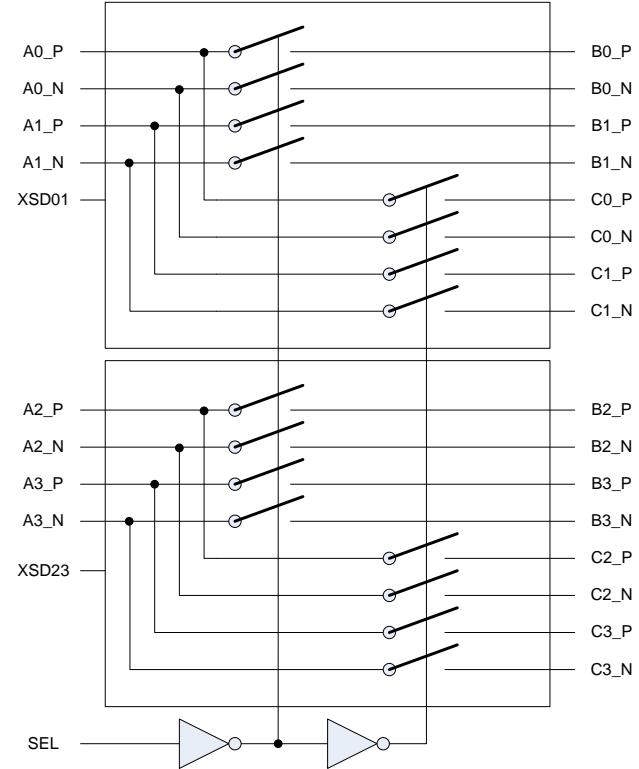
Applications:

- ✓ Computing – Enterprise and Storage
- ✓ Base-station
- ✓ Network infrastructure

CBTL04083

8 Gbps, 3.3V, PCIe Gen3 Mux/De-mux/Switch

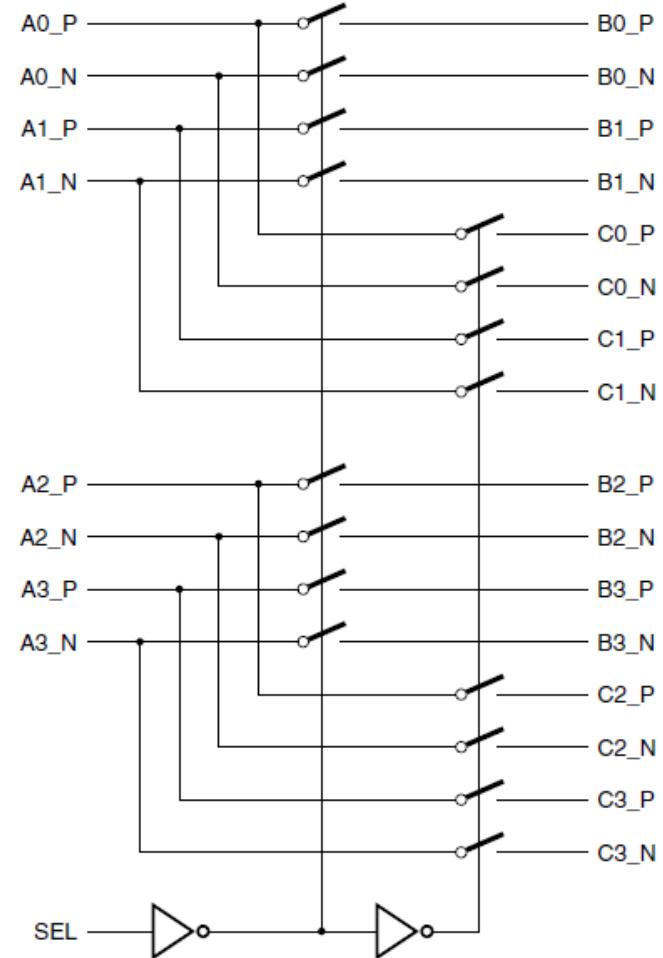
- 4 differential channel, 2:1 bi-directional mux/demux
- Signaling Supported
 - PCIe Gen3 @ 8 Gbps
 - SAS Gen2 @ 6 Gbps
- Insertion loss, equivalent to about 2" of FR4 PCB trace
 - 0.5dB at 100 MHz
 - 1.0dB at 4 GHz
 - 3.0dB at 8 GHz
- Low intra-pair skew: 5ps max
- Low inter-pair skew: 20ps max
- Low crosstalk: -25dB at 4GHz
- Off-isolation: -10dB at 4GHz
- 3.3 V supply voltage
- HQFN42 package
- ESD 2kV HBM, 500V CDM
- Two pin outs available for PCB layout optimization
- Standby current < 10 uA controlled by XSD pin



CBTU04083

8 Gbps, 1.8V, PCIe Gen3 Mux/De-mux/Switch

- ▶ 4 differential channel, 2 : 1 multiplexer/demultiplexer
- ▶ Signaling Supported
 - ▶ PCIe Gen3 @ 8 Gbps
 - ▶ SAS Gen2 @ 6 Gbps
- ▶ Insertion loss -2.8 dB at 4GHz
- ▶ Low crosstalk: -30 dB at 4 GHz
- ▶ Low off-isolation: -30 dB at 4 GHz
- ▶ VDD operating range: 1.65 V to 2.0 V
- ▶ ESD tolerance: 6kV HBM
- ▶ Low bit-to-bit skew: 10 ps max (between positive and negative bits)
- ▶ Low channel-to-channel skew: 35 ps max
- ▶ HVQFN42 package



DDR3/4 switching solution

CBTx Bus Switch Value Proposition

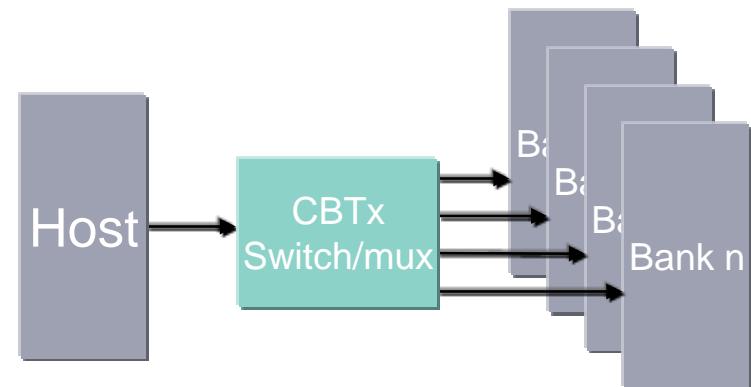
Storage
SSD
Internal
SSD

► Where used?

- Custom memory bus architectures for server or enterprise storage applications
- General purpose bus switching or multiplexing
- Base station and server applications

► Why used?

- Route one bus to one of several destinations depending on system configuration
- Maintain high signal integrity at high speed
- Can be used for failover purposes in servers/base-stations and Flash based memory support in high end servers



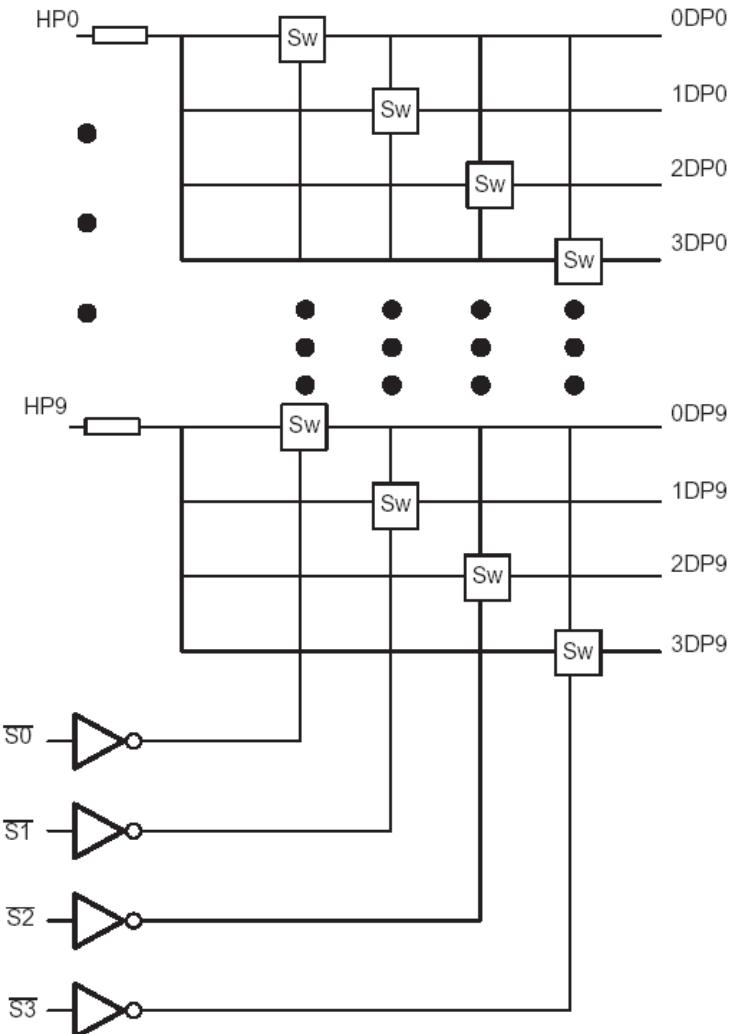
► Why use NXP?

- Unique portfolio of bus switches
- High speed and high signal integrity (800 Mbps)

CBTU/W Bus Memory Mux switches

Features

- ▶ Used for memory interleaving
 - Unbuffered DDR DIMMs
 - Switches on motherboard or module
 - Up to 800 Mbps signaling rate
- ▶ Topologies
 - CBTU4411: 11-bit 1:4 DDR2
 - CBTW28DD14: 14-bit 1:2 DDR3
- ▶ Small package
 - 0.5mm ball pitch TFBGA-64
 - 0.5mm ball pitch LFBGA-72
- ▶ 1.5V/1.8V operation
- ▶ Low On-capacitance
- ▶ Optimized series resistance

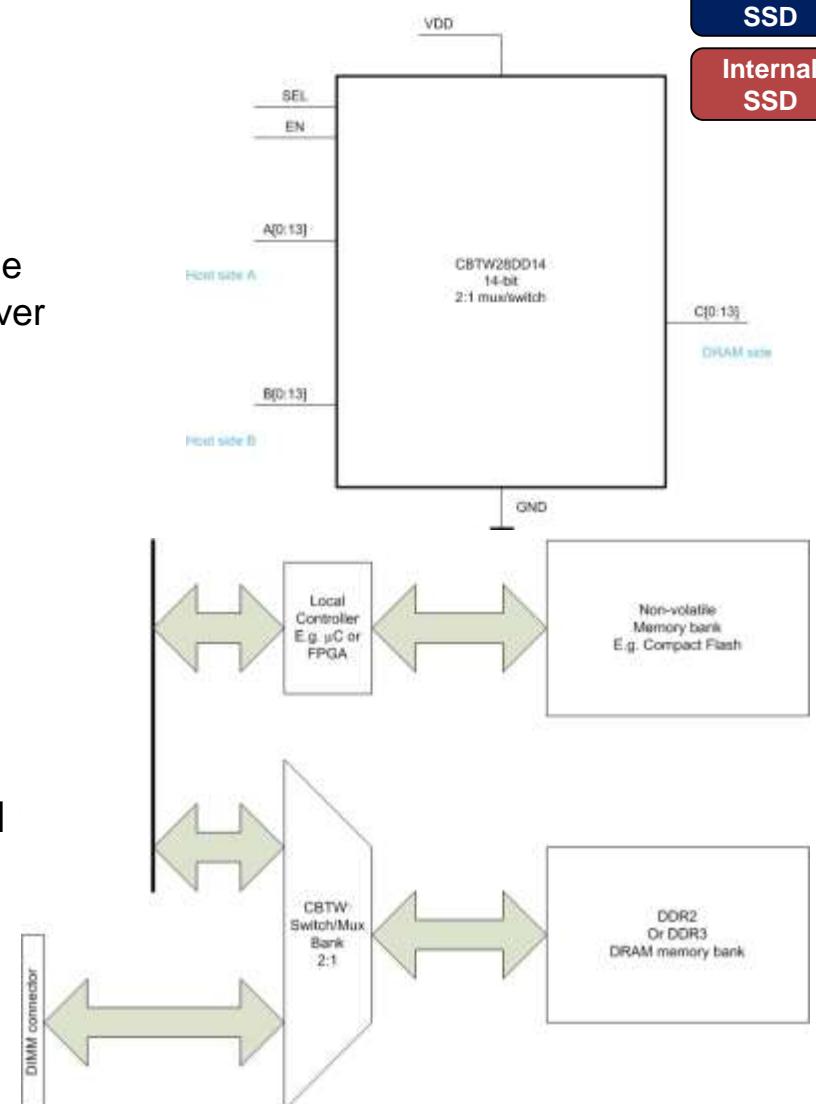


CBTW28DD14

DDR3 Mux

Storage
SSD
Internal
SSD

- ▶ Channel width: 14 bits
 - Optimal to fit one data lane each as well as divide address & command bus and auxiliary signals over remaining muxes
- ▶ SSTL_15 and SSTL_18 signaling
- ▶ 1.5 V or 1.8 V supply voltage
- ▶ Bandwidth > 3 GHz
- ▶ Supports 1.6 Gbps throughput per lane
- ▶ Bidirectional ports
- ▶ CMOS select signals compatible with 1.5 V and 1.8 V signaling
- ▶ Switch/mux topology: 1:2
- ▶ ESD 4kV HBM, 1kV CDM
- ▶ TFBGA48 package, 4.5 x 4.5mm, 0.5 mm pitch



*CBTW denotes a new family of CBT muxes suitable for 1.2 V and higher power supply operation.

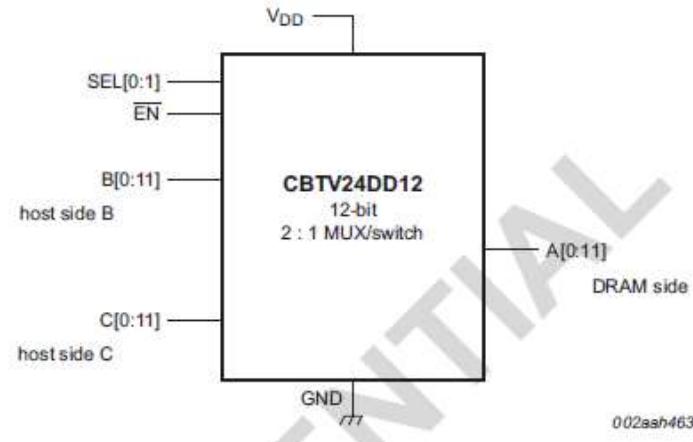
CBTV24DD12

DDR3/DDR4 Mux

Storage
SSD

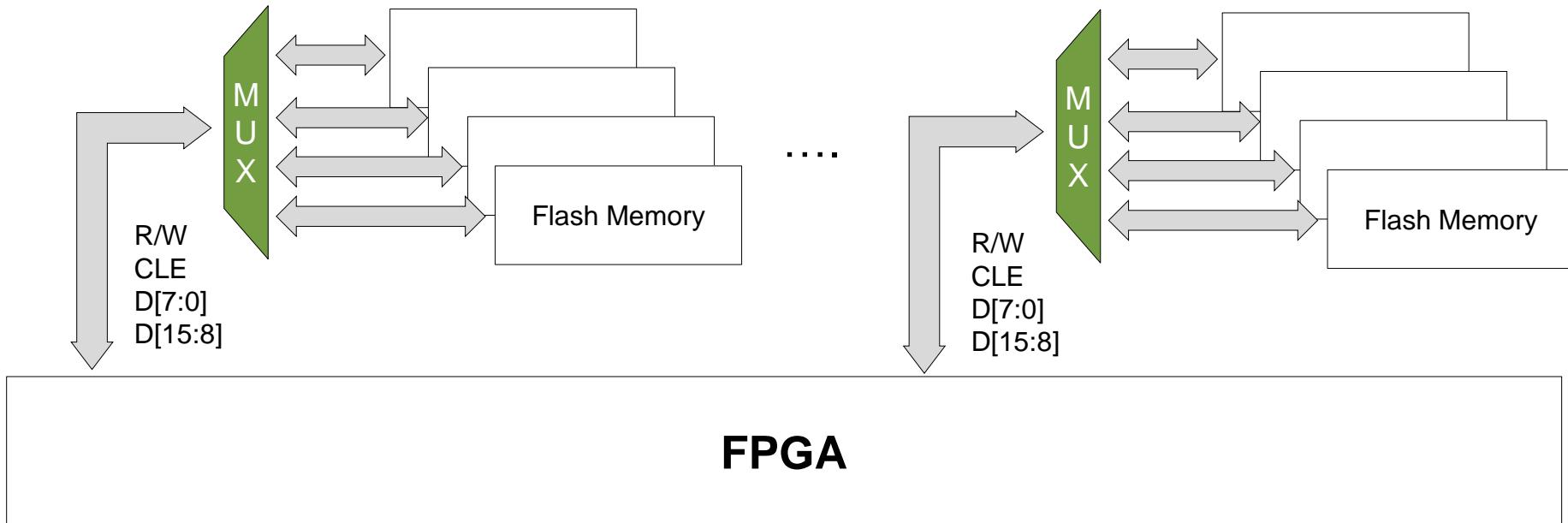
Internal
SSD

- ▶ Channel width: 12 bits
 - Optimal to fit one data lane each as well as divide address & command bus and auxiliary signals over remaining muxes
- ▶ Supply Voltage: 1.8V-3.3V
- ▶ Bandwidth: 8 GHz
- ▶ Input Return Loss: -16dB @ 4GHz
- ▶ Skew < 6ps (3 ps typical)
- ▶ R_{ON} : 8 ohms; $\Delta R_{ON} < 1$ ohm
- ▶ Supports 3.2 GT/s throughput per lane
- ▶ Bidirectional ports
- ▶ CMOS select signals
- ▶ Switch/mux topology: 1:2
- ▶ ESD 2kV HBM, 1kV CDM
- ▶ VFBGA48 package, 3.0 x 8.0 x 1 mm, 0.65 mm pitch



Load distribution application example

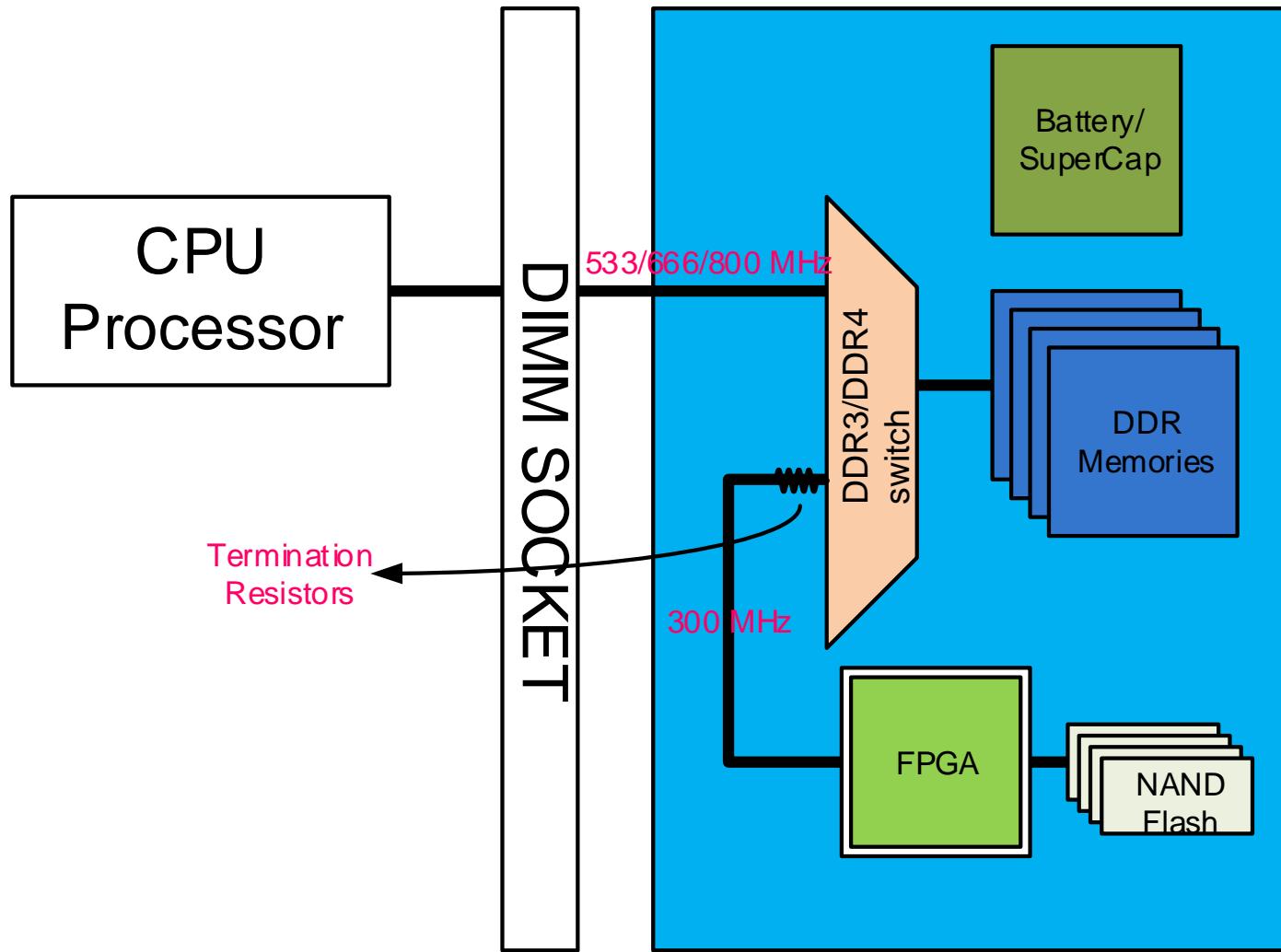
SSD based storage system



4:1 mux – CBTU4411 (DDR2 speeds)
2:1 mux – CBTW28DD14 (DDR3 speeds)
2:1 mux – CBTV24DD12 (DDR4 speeds)

NVDIMM Memory Mux Application example

Storage
SSD
Internal
SSD



USB Type C Solutions

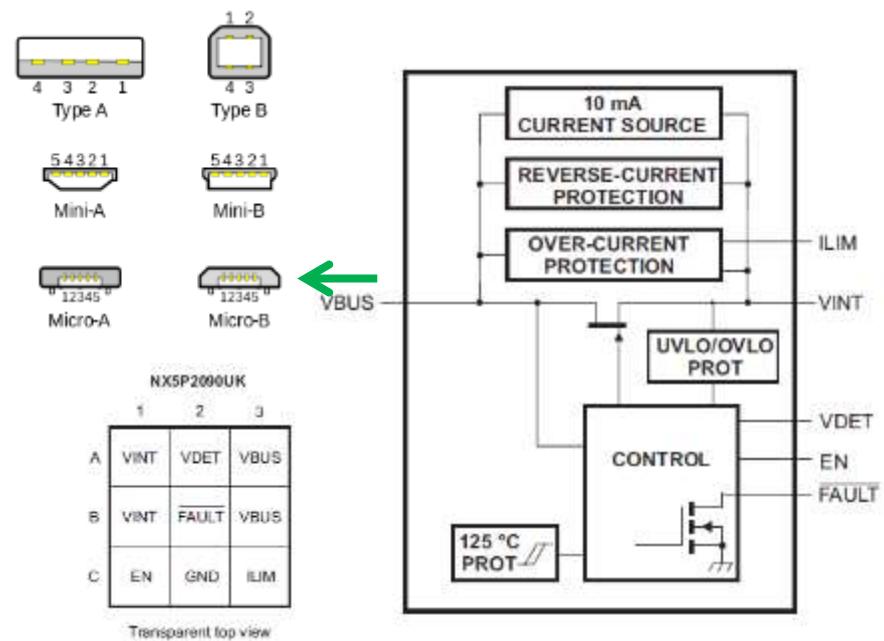
CBTL04GP043

Crossbar Multiplexer

- ▶ 4-channel crossbar multiplexing
 - 2 high-speed, large voltage swing differential channels 2:2 mux
- ▶ -3dB bandwidth: 8.5GHz for Vic=2.2V
- ▶ Low insertion loss
 - -1dB at 100 MHz
 - -1.5dB at 2.5 GHz
- ▶ Low off-state isolation: -16dB at 2.5GHz
- ▶ Low return loss: -20dB at 2.5GHz
- ▶ Low crosstalk: -20dB at 2.5GHz
- ▶ Low intra-pair differential skew (5 ps typical)
- ▶ Low inter-pair skew (70 ps typical)
- ▶ Single 3.3 V supply voltage
- ▶ Package: XFBGA28, 2mm x 4mm, 0.5mm ball pitch
- ▶ Signaling supported:
 - DisplayPort v1.2 @ 5.4Gbps
 - PCIe Gen2 @ 5.0Gbps
 - PCIe-Gen3 @ 8Gbps
 - HDMI 1.4 @ 3.4Gbps
 - USB3 @ 5.0Gbps
 - UART
 - USB2
 - DP AUX
- ▶ Applications:
 - Portable devices, Computing applications
 - Applications where reversible connectors are required
 - Enterprise applications

NX5P2090 Load Switch with OVP/OTP

- ▶ Power switch for USB OTG 3.0 applications
 - NX5P2090 is designed for USB OTG and general USB applications.
 - Isolates VBUS OTG voltage source from interface pin during over-current or over-temperature events
 - Externally adjustable current limit; output voltage detect, OVP, OTP, and fault indicator
 - Used in power domain isolation applications to reduce power dissipation and extend battery life
- ▶ Features
 - Operates from 3.0 to 5.5 V
 - Low ON resistance: R_{ON} typ 60 mΩ
 - VBUS 30V Tolerant
 - Short circuit protection
 - OVLO and UVLO protection
 - Adjustable current: 200 mA to 2000 mA
 - Over-temperature protection at 125 °C
 - Reverse bias current protection
 - Soft start turn-on, slew rate controlled
 - ESD IEC contact 8kV
- ▶ Package: W CSP9, 1.4X1.4, 0.4mm pitch



External
SSD

T-Bolt
SSD

DisplayPort/Thunderbolt switches

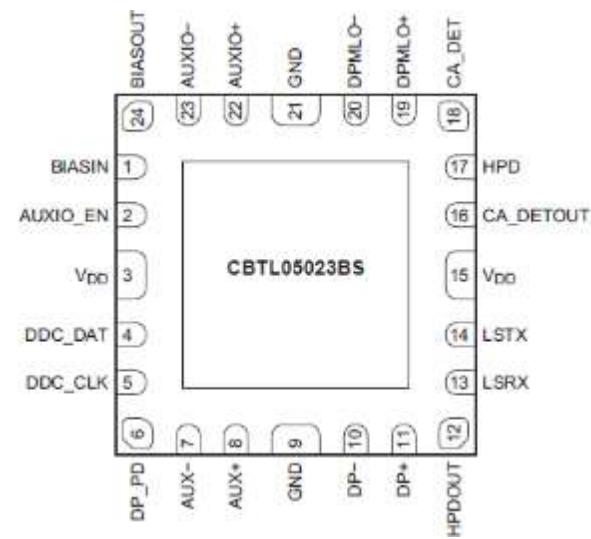
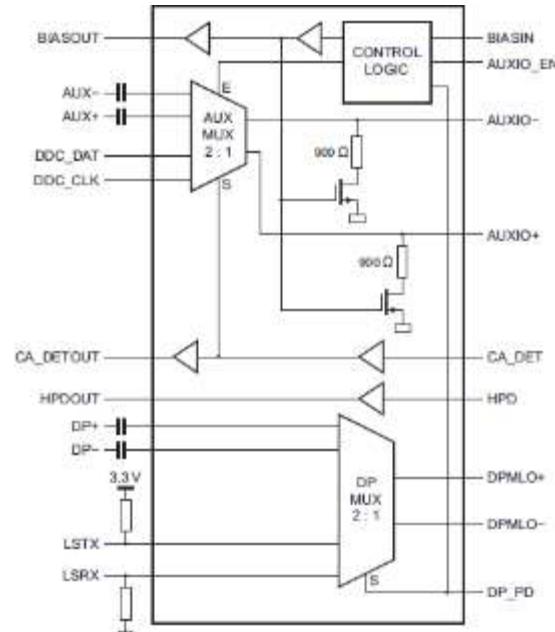


CBTL05023 Thunderbolt Mux

External
SSD

T-Bolt
SSD

- CBTL05023 is optimized to interface TBT/miniDP connector for TBT applications
- Excellent Signal Integrity to support 5.4Gbps DP1.2 HBR2 data rate
 - 15dB DDRL @ 2.5GHz for DP MUX
 - 2dB DDIL @ 2.5GHz for DP MUX
 - 7GHz bandwidth with 3.3V common mode input voltage
 - Pass rail-to-rail LS signal swing without clipping
- Optimized Integration to work with external PIN diodes for 10Gbps+AUX/DDC MUX
 - BIASOUT buffer supports bias current up to 6 PIN diodes
 - Integrated bias R for PIN diode path
- HPD input buffer with 5V tolerant
- Small 3 mm X3 mm HVQFN24 package with 0.4mm pitch

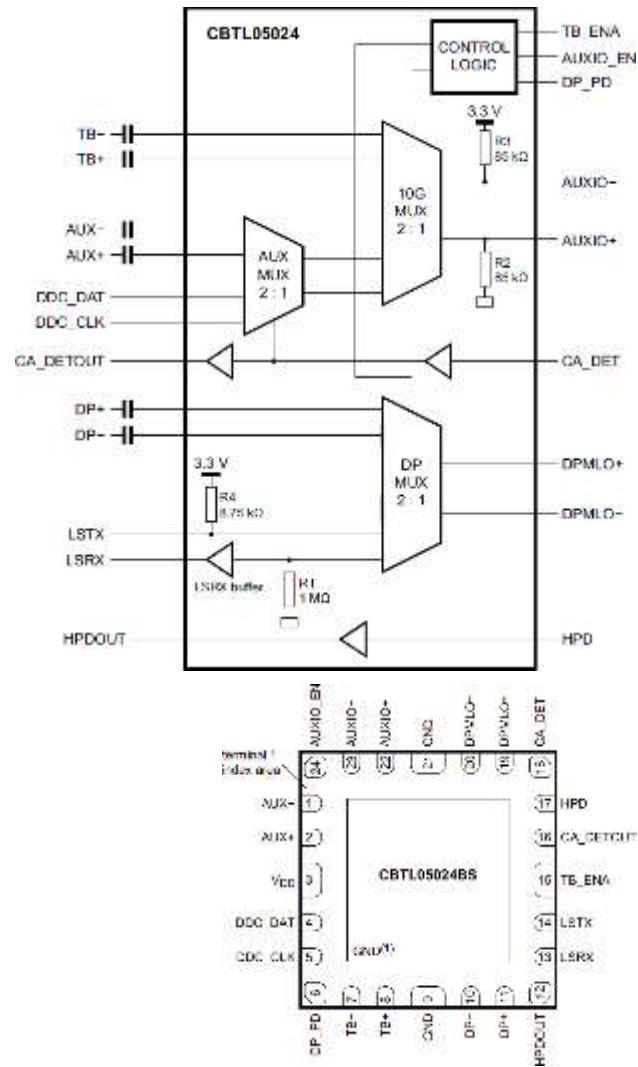


CBTL05024 Thunderbolt Switch

- ▶ Highly integrated MUX for Thunderbolt application
- ▶ 2-channel multiplexing
 - 1 channel 3:1 muxing
 - Thunderbolt RX signal @ 10.3125Gbps
 - DisplayPort AUX
 - Rail-to-rail DDC
 - 1 channel 2:1 muxing
 - DisplayPort main link @ 5.4Gbps
 - Thunderbolt LSTX/LSRX
- ▶ Buffers for HPD, CA_DET, and LSRX
 - HPD input buffer with 5V tolerant
 - LSRX works at VDD=2.3V
- ▶ Thunderbolt channel
 - -3dB bandwidth: 10GHz
 - Low insertion loss: -1.3dB at 5GHz
 - Low return loss: -16dB at 5GHz
 - Ron: 8ohm typical
- ▶ DisplayPort channel
 - -3dB bandwidth: 6GHz
 - Low insertion loss: -2dB at 2.7GHz
 - Low return loss: -15dB at 2.7GHz
 - Ron: 9ohm typical
- ▶ Single 3.3 V supply voltage
- ▶ ESD: 1500V HBM, 500V CDM
- ▶ Package: HVQFN24, 3mm x 3mm, 0.4mm pitch



Thunderbolt



CBTL06DP213

External
SSD

5.4 Gbps DisplayPort 1.2 Switch

T-Bolt
SSD

- Bi-directional switch for DPv1.2 applications

- 2:1 mux/switch of 4 high speed lanes of DP main link
- 4:1 mux/switch of DP AUX channels/DDC signals
- 2:1 mux/switch of DP HPD signal
- 2 selection pins and 1 shutdown pin

- Excellent signal integrity

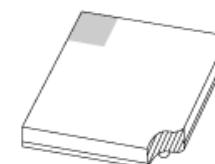
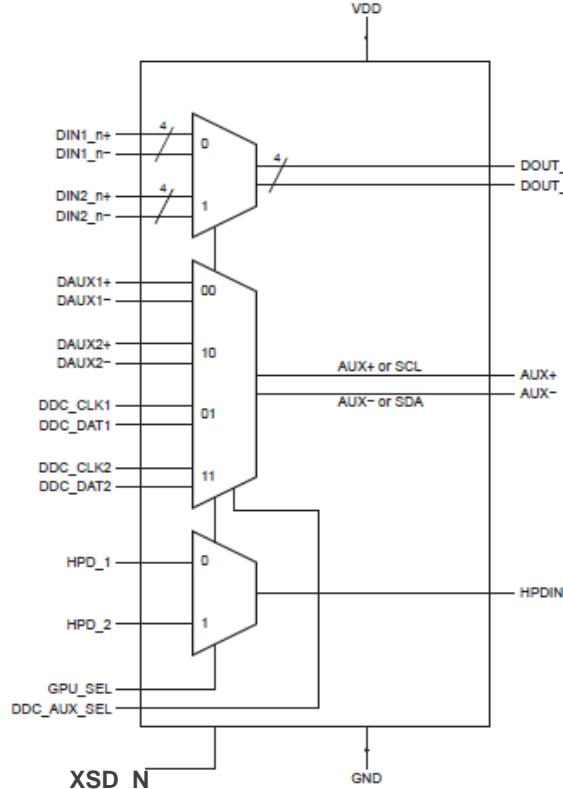
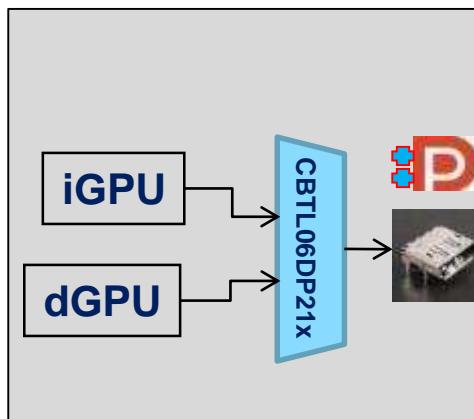
- R_{ON} : 14Ω
- Diff. return loss
 - -20 dB @ 100 MHz
 - -17 dB @ 1.35 GHz
 - -13 dB @ 2.7 GHz
- Diff. insertion loss
 - -0.9 dB @ 100 MHz
 - -1 dB @ 1.35 GHz
 - -1.3 dB @ 2.7 GHz
- -3dB BW: 11 GHz

- Supply voltage 3.3V

- Current: active (2 mA typical), shutdown (10 µA)

- ESD 2kV HBM, 500V CDM

- Package: TFBGA48, 5 x 5 x 1.15 mm, 0.5mm pitch



USB 3.0 Redrivers

USB 3.0 Redrivers

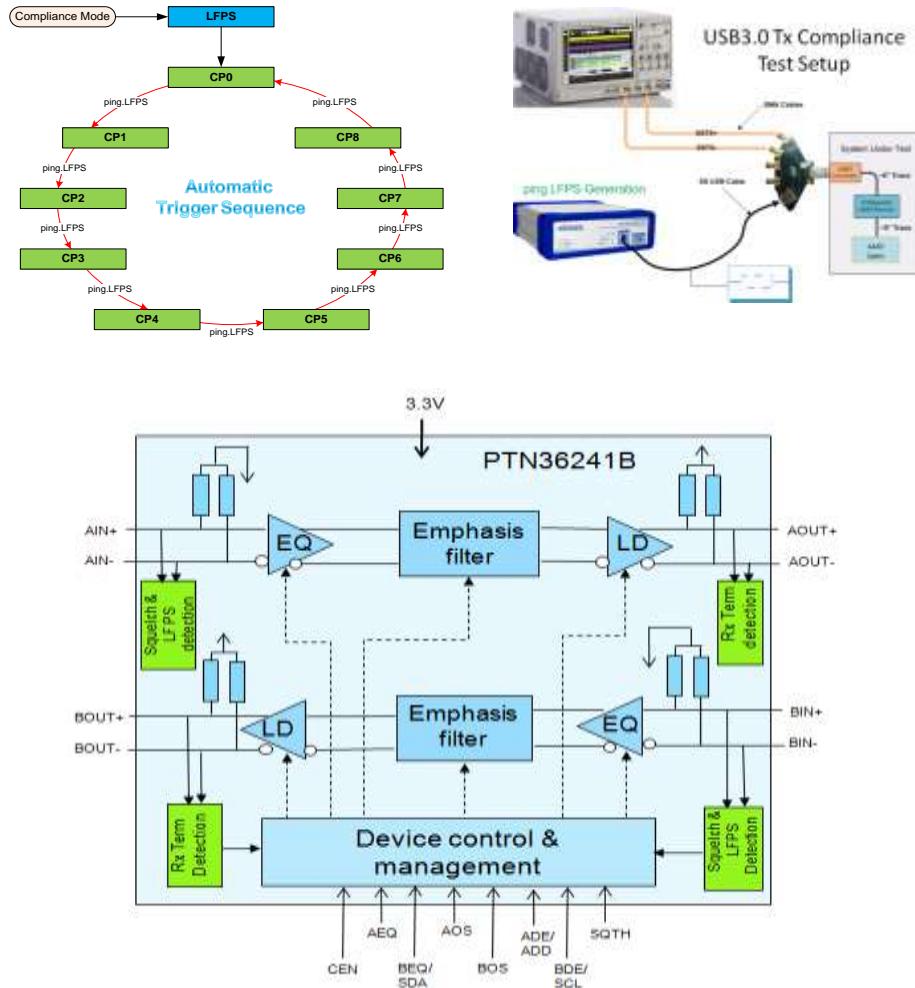
- Provide signal integrity enhancement functions for insertion loss compensation and inter-symbol interference recovering
 - Achieve longer transmission distance
 - Easy to pass USB 3.0 compliance test and solve interoperability issues caused by deteriorated signal integrity

DESCRIPTION	CH	BW	SETTINGS	POWER	PACKAGE	PART#	
Single Port	2 channels	5 Gbps	5-state quinary pins OS, EQ, DE	53 mW @ U2/U3 20 mW @ No Connect 10 mW @ Sleep mode Vdd = 3.3V	HVQFN24	PTN36241B	
Dual Port	4 channels	5 Gbps	binary pins OS, EQ, DE	66 mW @ U2/U3 26 mW @ No Connect 0.5 mW @ Sleep mode Vdd = 3.3V	HVQFN32	PTN36242L	
Half port	1 channel TX or RX	5 Gbps	adjustable RX equalization, TX de-emphasis & output swing	active: 97 mW (54mA) deep power saving: 18 µW (10 µA) Vdd = 1.8V	X2QFN12 1.6 x 1.6 x 0.35 mm, 0.4 mm pitch	PTN36221A	
NEW	Single port	2 channels TX and RX	5 Gbps	adjustable RX equalization both channels, TX de-emphasis & output swing	active: 189 mW (105 mA) U2/U3 state: 1.8 mW (1 mA) no connection: 0.9 mW (0.5 mA) deep power saving: 18 µW (10 µA) Vdd = 1.8V	X2QFN12 1.2 x 2.0 x 0.35 mm, 0.4 mm pitch	PTN36241G

PTN36241B USB 3.0 Redriver

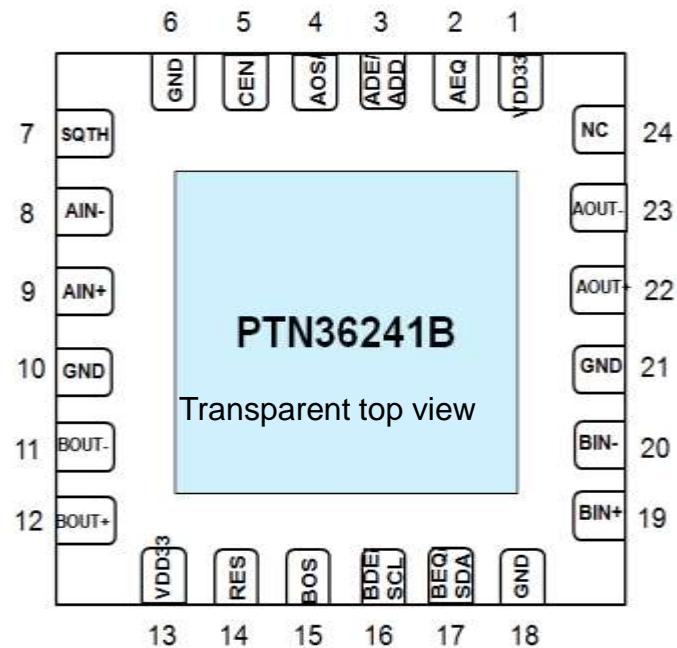
External
SSD

- ▶ Differential signal processing chain delivering high signal integrity performance
- ▶ Ultimate configuration flexibility
 - 5-level programming pins (patent-pending quinary pins)
 - Intelligent I²C muxing on same pins
- ▶ Intelligent power management with multiple power modes
- ▶ Patent-pending auto compliance mode for easy, automatic compliance testing



PTN36241B USB 3.0 Redriver

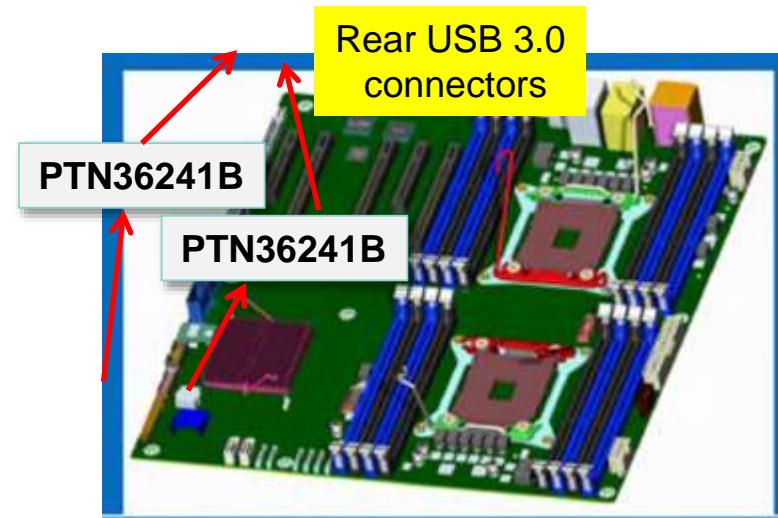
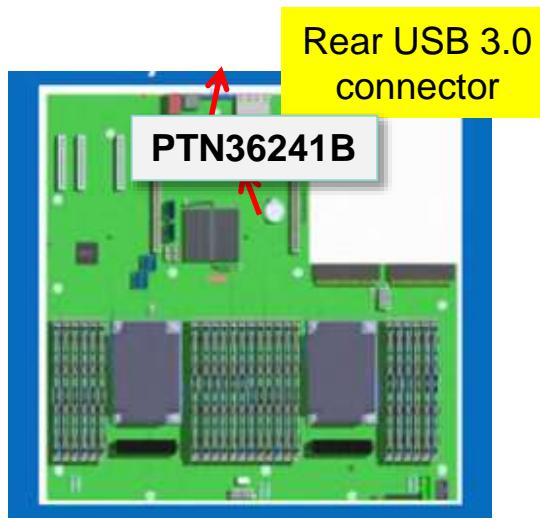
- ▶ Supports USB 3.0 (SuperSpeed) (5 Gbps)
- ▶ Highlights
 - Link budget enhancement compensates for high-frequency losses/inter-symbol interference
 - Programmable equalizer and de-emphasis through pins or I²C bus
 - Selectable output swing, transmit emphasis and receive equalization & input signal threshold
 - Rx termination indication & detection
- ▶ LFPS detection and forwarding
- ▶ Hot plug capable
- ▶ Specifications
 - ESD HBM 6kV, CDM 1.25kV
 - Power supply: 3.3V
 - Package: HVQFN24 (4 mm x 4 mm, 0.5 mm pitch)



PTN36241B USB 3.0 Redriver Use Case

Grantley Server Reference Designs

Note: PTN36241B equivalent part used on reference designs

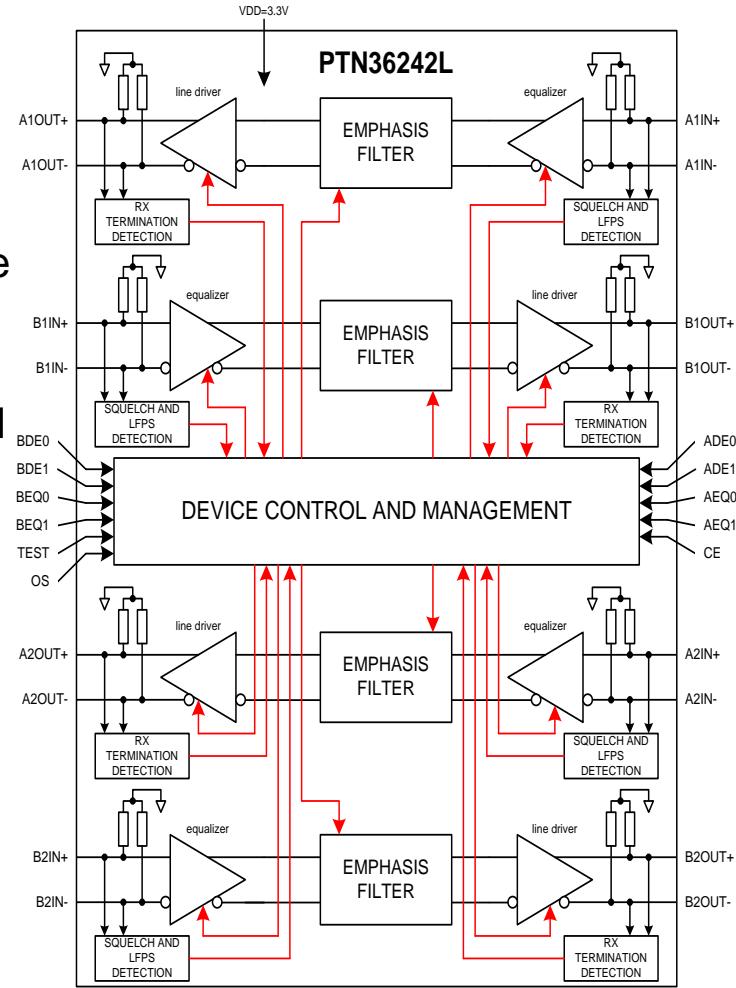


PTN36242L

Dual-Port USB 3.0 Redriver

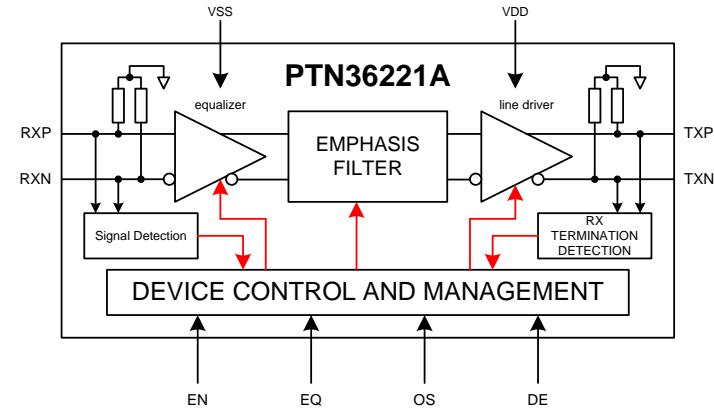
External
SSD

- ▶ Supports USB 3.0 (SuperSpeed) (5 Gbps)
- ▶ Highlights
 - Link budget enhancement compensates for high-frequency losses/inter-symbol interference
 - Programmable equalizer and de-emphasis through pins or I²C-bus
 - Selectable output swing, transmit emphasis and receive equalization & input signal threshold
 - Rx termination indication & detection
- ▶ Low power
 - Low active power: 775 mW
 - Low power-saving mode: 80 mW in U2/U3 states
- ▶ Power supply: 3.3V
- ▶ Package: HVQFN32
 - 3x6x0.85 mm, 0.4 mm pitch



PTN36221A – USB 3.0 Redriver

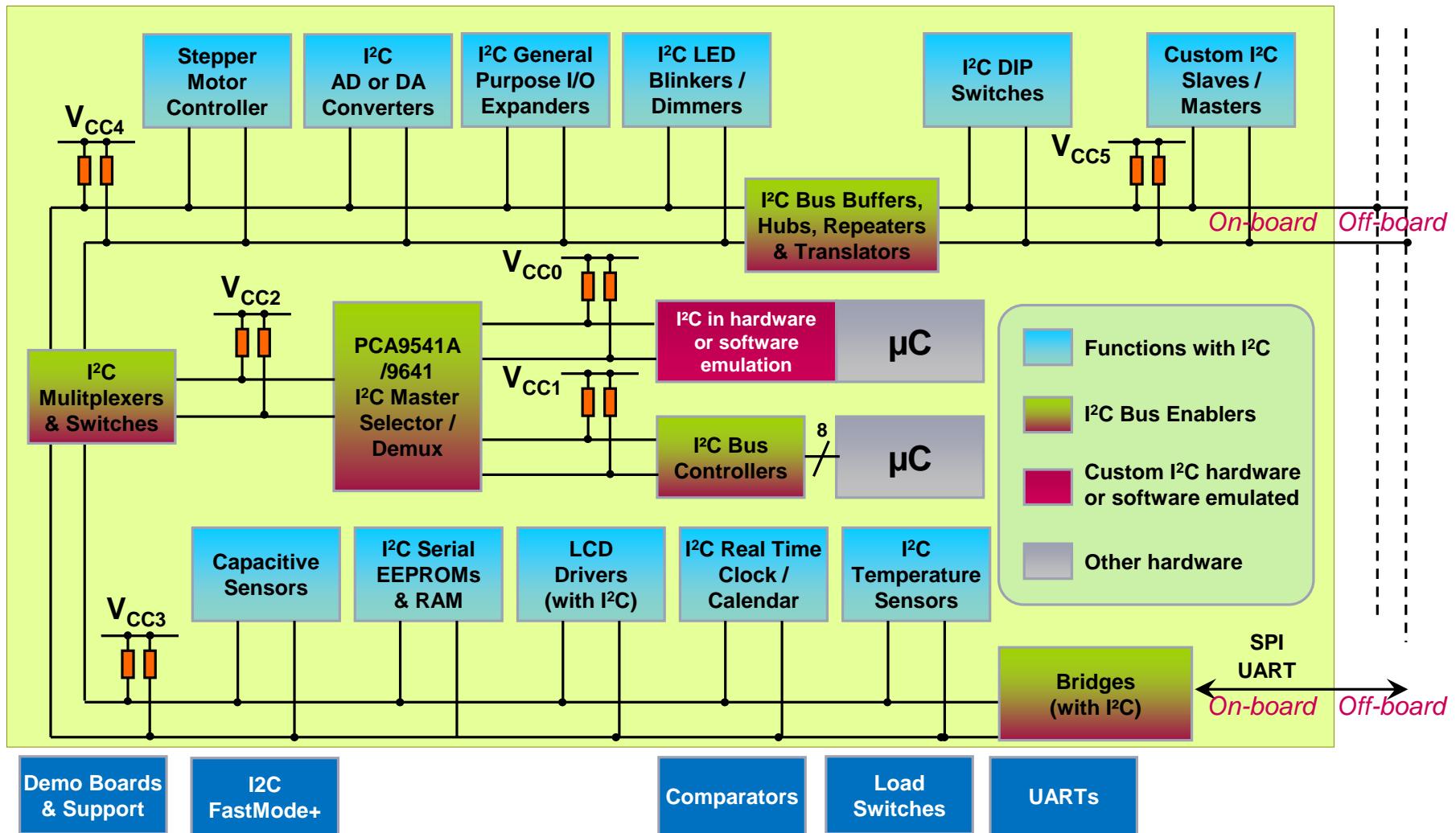
- ▶ SuperSpeed USB 3.0 compliant
- ▶ Adjustable receive equalization, transmit de-emphasis, and output swing functions
- ▶ Low power management scheme ($V_{DD}=1.8V$)
 - Active power: 97 mW (54 mA)
 - U2/U3 state: 5 mW (2.8 mA)
 - No connection: 1 mW (0.55 mA)
 - Deep power saving: 18 μ W (10 μ A)
- ▶ Hot plug capable
- ▶ Supply voltage (V_{DD}): $1.8V \pm 5\%$
- ▶ ESD 8kV HBM; 1kV CDM
- ▶ Operating temperature range: -40 to 85 °C
- ▶ Package: small, thin X2QFN12, 1.6 x 1.6 x 0.35 mm, 0.4 mm pitch



System Management

Standard I²C building blocks

Overview of all standalone peripherals



- ▶ Bus speed DC to 1 MHz fully compatible with existing I²C and SMBus
 - Higher bandwidth allows more devices on the bus and more complicated patterns w/o addition of buffers
- ▶ Bus drive strength 10x normal I²C I/O drive w/o addition of buffers
 - Drive heavier capacitive load or longer cable lengths
 - Low cost alternative to USB, Ethernet, wireless
- ▶ New practical features
 - Software reset of I/O ports (via I²C bus)
 - Hardware reset pin
 - Hardware address pins connecting to V_{CC}, GND, SCL, SDA allow up to 64 addresses vs the normal 8 using only three pins
- ▶ New NXP Cortex™ microcontrollers support Fast-mode plus
- ▶ Target applications: amusement/gaming, lighting, remote user interface applications (e.g. POS, security, kiosk, etc)
- ▶ I²C-bus Specification UM10204 at www.nxp.com/i2c

NXP Fast-mode Plus Product Offerings

I²C

Storage
SSD

Bus Controller	Bus Buffer	LED Controller					GPIO		
		Device	Device	Device	CHAN	TYPE (OD = Open Drain; TP = Totem Pole)	OUTPUT		Device
(mA)	(V)								
PCA9661 PCA9663 PCA9665	PCA9600 PCA9601 PCA9617A PCA9646	PCA9622	16	OD	100	40	PCA9672	8	YES
		PCA9624	8	OD	100	40	PCA9673	16	YES
		PCA9626	24	OD	100	40	PCA9674/74A	8	NO
		PCA9632	4	OD/TP	25/10	5	PCA9670	8	YES
		PCA9633	4	OD/TP	25/10	5	PCA9675	16	NO
		PCA9634	8	OD/TP	25/10	5	PCA9671	16	YES
		PCA9635	16	OD/TP	25/10	5	PCA9698	40	YES
		PCA9685	16	OD/TP	25/10	5			
		PCA9955A	16	Constant current	57	20			
		PCA9956A	24	Constant Current	57	20			



General Purpose I/O Expanders

GPIO Expanders Value Proposition



▶ Why used?

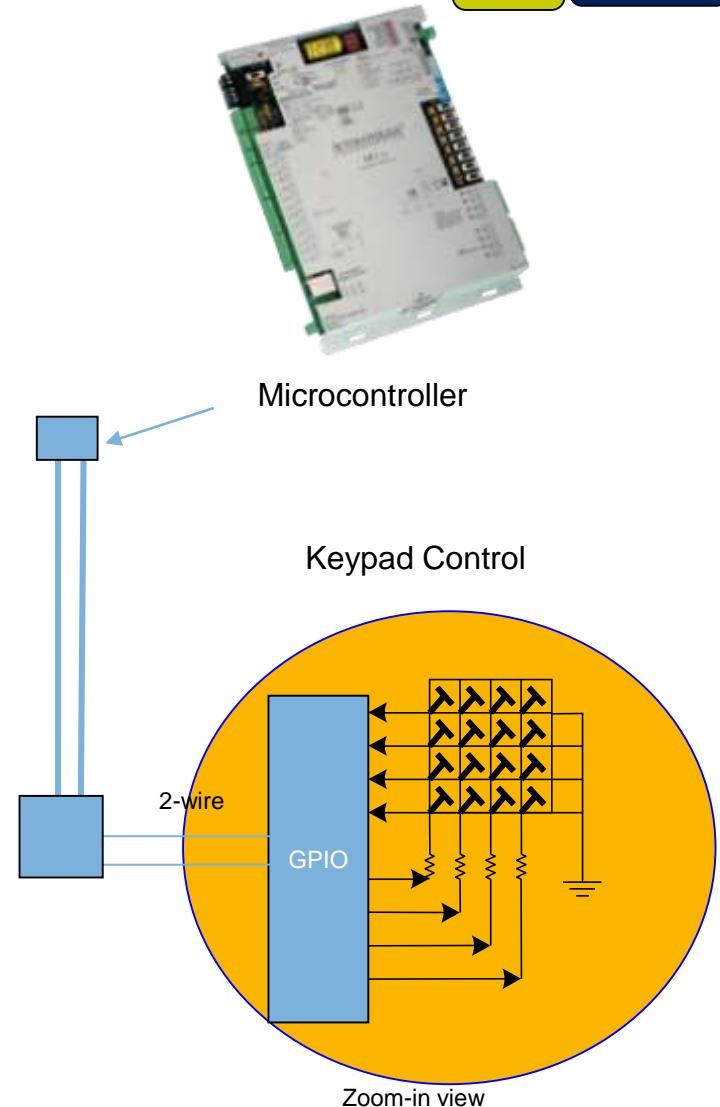
- Easily adds I/O via I²C-bus
- Additional inputs for keypad, switch and fan control
- Additional outputs for LED control, power switch and timers.

▶ Where used?

- Networking platforms, Backplanes

▶ Why NXP GPIOs?

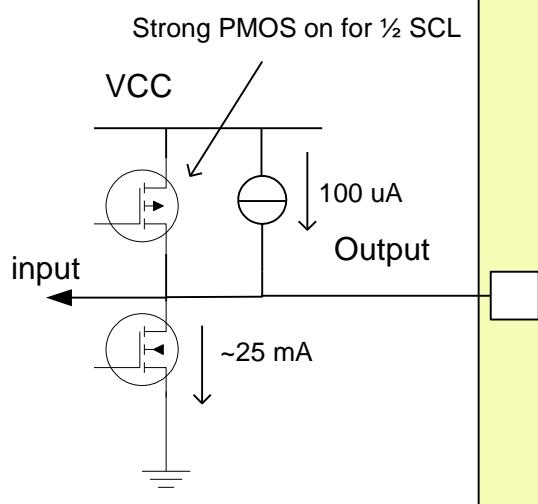
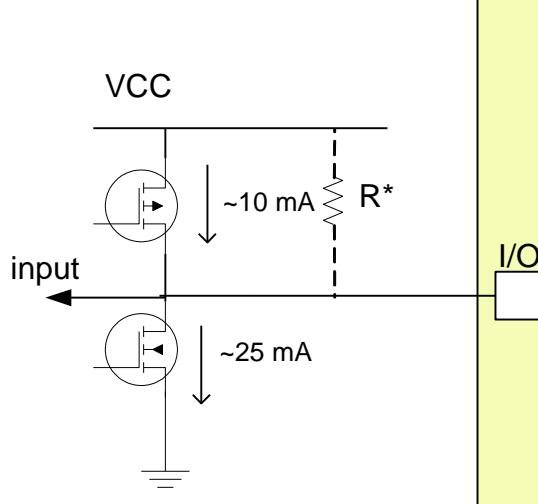
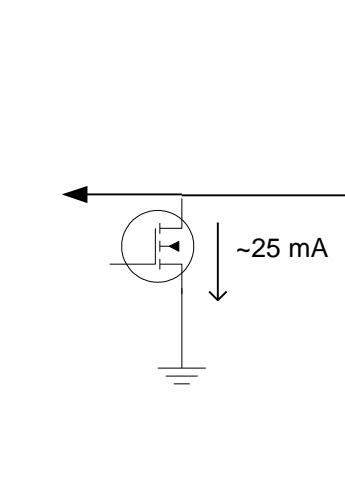
- Largest selection of 4, 8, 16 and 40-bit GPIO in Quasi-bidirectional and Push-pull outputs with Interrupt and/or reset in a wide range of packages
- Wide selection of low power/low voltage (1.8V) GPIO expander portfolio suitable for mobile applications
- Continuous innovation with new features



Flexible I/O (Output) Structures

I²C

Storage
SSD

Quasi Output	Totem-Pole Output	Open-Drain Output
 <p>Strong PMOS on for $\frac{1}{2}$ SCL</p> <p>VCC</p> <p>input</p> <p>~25 mA</p> <p>100 uA</p> <p>Output</p>	 <p>VCC</p> <p>input</p> <p>~10 mA</p> <p>R*</p> <p>~25 mA</p>	 <p>I/O</p> <p>~25 mA</p>
<ul style="list-style-type: none"> Strong PMOS transistor is turned on only during the LH transition PMOS transistor is off during static drive Weak current source at the output 	<ul style="list-style-type: none"> Upper PMOS transistor is turned on during static high drive Some devices have weak pull-ups at the output 	<ul style="list-style-type: none"> No upper PMOS transistor No pull-up resistor No weak current drive

Quasi Output

► Features

- 8- and 16-bit in quasi-bidirectional outputs with interrupt and/or reset
- Wide range of packages

BITS	V RANGE	BANDWIDTH	RESET	INT	I/O PULL-UP [1]	NOTES	PART(S)
8	2.5V to 6.0V	100 kHz	NO	YES	weak PU		PCF8574(A)
	2.2V to 3.6V	400 kHz	NO	NO	weak PU	2 Kb EEPROM	PCA9500
		400 kHz	NO	YES	weak PU	2 Kb EEPROM	PCA9501
	2.3V to 5.5V	1 MHz	YES	NO	weak PU		PCA9670
		1 MHz	YES	YES	weak PU		PCA9672
		1 MHz	NO	YES	weak PU		PCA9674 (A)
16	2.5V to 5.5V	400 kHz	NO	YES	weak PU		PCF8575
	2.3V to 5.5V	400 kHz	NO	YES	weak PU		PCA8575
		1 MHz	YES	NO	weak PU		PCA9671
		1 MHz	YES	YES	weak PU		PCA9673
		1 MHz	NO	YES	weak PU		PCA9675

Note [1]: The Quasi-outputs have a strong pull-up (transistor) to V_{DD} to allow fast rising edges into heavy loaded outputs.
 The devices with weak pull-ups have a 100-µA current source to V_{DD}.

I²C GPIOs

I²C

Storage
SSD

Totem-Pole Output

BITS	V RANGE	BW	RESET	INT	I/O PULL-UP	NOTES	PART#
4	2.3 to 5.5V	400 kHz	NO	NO			PCA9536
			YES	YES			PCA9537
8	2.5 to 3.6V	400 kHz	YES	YES		SPI & I ² C	PCA9502
	2.3 to 5.5V			YES			PCA9534
	2.3 to 5.5V						PCA9538
	1.65 to 5.5V		YES	YES		Low standby current: 1.5 µA typ at 5V supply; 1.0 µA typ at 3.3V supply	PCA9538A
	2.3 to 5.5V			YES	100 KΩ	Use PCA9554A for alternate I ² C address	PCA9554/A
	1.65 to 5.5V					Use PCA9554C for alternate I ² C address	PCA9554B/C
	2.3 to 5.5V		YES				PCA9557
	1.1 to 3.6V		YES	maskable	prog. PU / PD or bus hold	low voltage, 2 supplies for level translation Selectable Open Drain	PCA9574
	1.65 to 5.5V		YES	YES		Standby current: 3 µA max dual V _{CC}	PCA6408A
16	2.3 to 5.5V	400 kHz	NO	YES			PCA9535
	1.65 to 5.5V			YES		Low standby current: 1.5 µA typ at 5V supply; 1.0 µA typ at 3.3V supply	PCA9535A
	2.3 to 5.5V						PCA9539
	2.3 to 5.5V		YES	YES		"R" version resets I ² C-bus state machine	PCA9539R
	1.65 to 5.5V						PCA9539A
	2.3 to 5.5V			YES	100 KΩ		PCA9555
	1.65 to 5.5V						PCA9555A
	1.1 to 3.6V		YES	maskable	prog. PU / PD or bus hold	Active low, low voltage, 3 supplies for level trans, Selectable Open Drain	PCA9575
	1.65 to 5.5V		YES	YES		Dual V _{CC} , low standby current: 1.5 µA typ at 5V supply; 1.0 µA typ at 3.3V supply	PCA6416A
40	2.3 to 5.5V	400 kHz	YES	YES	100 KΩ	OE	PCA9505
			YES	YES		OE	PCA9506
	2.3 to 5.5V	1 MHz	YES	YES		OE, Selectable Open Drain	PCA9698



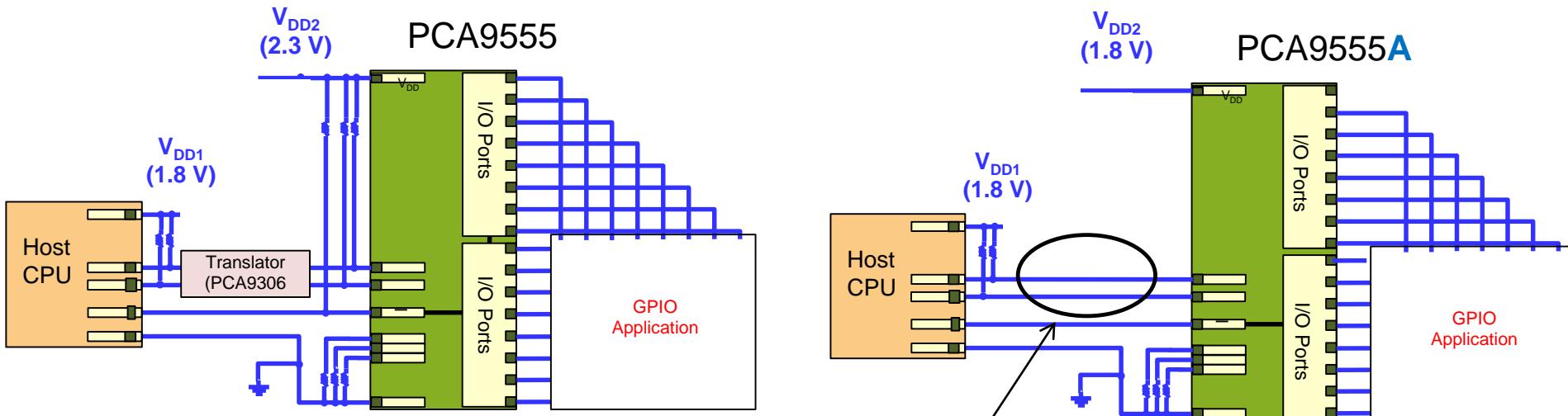
Open Drain Output

- ▶ No upper PMOS transistor
- ▶ Prevent current leakage through protection diode

BITS	V RANGE	BANDWIDTH	RESET	INTERRUPT	I/O Pull-Up	NOTES	PART(S)
8	3.0V to 3.6V	400 kHz	NO	NO	weak PU	2 Kb EEPROM, with 5-bit mux, 1-bit latch dip switch	PCA9558
16	2.3V to 5.5V		NO	YES			PCA9535C
	4.5V to 5.5V		NO	YES			PCF8575C

New PCAxxxxA Low Voltage GPIO Family

Operates Down to 1.65V and Up to 5.5V



- ▶ Benefit
 - Lower V_{CC} to 1.65V on GPIO supply eliminates the need for a voltage translator
- ▶ Easy migration
 - Drop-in replacement for existing PCA95XX GPIO family
 - Alternate source to Texas Instruments TCAxxxx family

PCA6416A

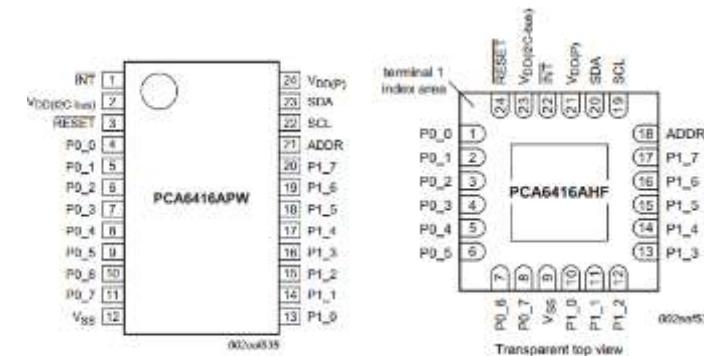
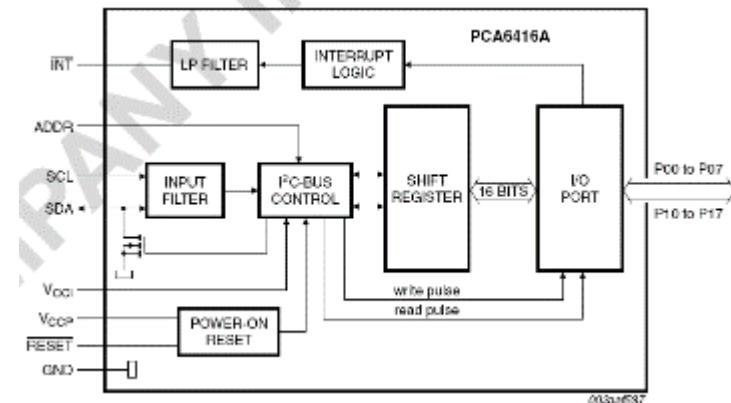
I²C

Storage
SSD

Dual Vcc Low-voltage, 16-bit I²C-bus I/O expander with interrupt output, reset, and configuration registers

Features

- ▶ Operating Power-Supply Voltage Range of 1.65 V to 5.5 V
- ▶ Low Standby Current Consumption of 3 uA Maximum
- ▶ Allows Bidirectional Voltage-Level Translation and GPIO Expansion Between 1.8, 2.5, 3.3 or 5 V SCL/SDA and 1.8, 2.5, 3.3, or 5 V Totem Pole configured I/O Port
- ▶ Schmitt-Trigger Hysteresis of 10% of SCL/SDA Supply Voltage
- ▶ Noise Filter on SCL/SDA Inputs
- ▶ Fast Mode I²C Bus Operating Frequency of up to 400-kHz
- ▶ Active-Low Reset Input
- ▶ Open-Drain Active-Low Interrupt Output
- ▶ 5-V Tolerant I/O Ports
- ▶ High current Drive for Directly Driving LEDs
- ▶ Input/Output Configuration Register
- ▶ Polarity Inversion Register
- ▶ Internal Power-On Reset
- ▶ Power-Up With All Channels Configured as Inputs
- ▶ No Glitch On Power-Up
- ▶ Package – 24 pin TSSOP, HWQFN and BGA
- ▶ Latch-Up Performance Exceeds 100 mA per JESD 78, Class II
- ▶ ESD Protection Exceeds JESD 22
 - 2000-V Human-Body Model (A114-A)
 - 1000-V Charged-Device Model (C101)



PCAL GPIO Family with Agile I/O

I²C

Storage
SSD

Low Voltage / Operates Down to 1.65V and Up to 5.5V

- Operates Down to 1.65V and Up to 5.5V
- Easy migration: drop in replacement for existing PCA95XX GPIOs
- Features input latch, /INT mask and other new Agile IO features

BITS	V RANGE	BW	RESET	INT	I/O PULL-UP	NOTES	PACKAGE	PART#
8	1.65 to 5.5V	400 kHz	YES	YES	programmable	single V _{CC}	HVQFN16, TSSOP16	PCAL9554B
			YES	YES	programmable	single V _{CC}	HVQFN16, TSSOP16	PCAL9554C
			YES	YES	programmable	dual V _{CC}	HVQFN16, TSSOP16, XQFN16, XFBGA16	PCAL9538A
16	1.65 to 5.5V	400 kHz		YES	programmable	single V _{CC} & advanced IO	HWQFN24, TSSOP24	PCAL9555A
				YES	programmable	single V _{CC} & advanced IO	HWQFN24, TSSOP24	PCAL9535A
			YES	YES	programmable	single V _{CC} & advanced IO	HWQFN24, TSSOP24	PCAL9539A
			YES	YES	programmable	Voltage Level Translation	TSSOP24, HWQFN24, 24-pin BGA (XFBGA, VFBGA & UFBGA)	PCAL6416A
NEW	24	0.8 to 3.6V	1 MHz	YES	YES	programmable	Additional Agile I/O features	QFN32, TSSOP32, UFBGA32
								PCAL6524



Features of the PCA^Lxxxx IO Expanders



- ▶ Backwards compatible to existing GPIOs with new superset of registers to control the configurable features. The PCA64xxA and PCA95xxA devices will be drop in replacements while the PCA^L64xxA and PCA^L95xxA will offer these additional features:
- ▶ GPIO input latch (bit by bit – default not latched):
 - ▶ Lock I/O pin changes on input until the register is read.
- ▶ GPIO output drive strength control (bit by bit – default 10 mA push and 25 mA pull):
 - ▶ User can program I/O drive strength 25%, 50%, 75% or 100%
 - ▶ This output can be used to control the brightness of LEDs.
- ▶ GPIO open drain control (24-bit bit by bit and 8 and 16-bit bank by bank – default push pull):
 - ▶ Provide an optional open-drain output for each I/O pin.
 - ▶ This output can also provide an additional wired-OR plane.
- ▶ GPIO pull up or pull down (bit by bit – default no PU/PD):
 - ▶ User can turn on/off an internal pull-up or pull down on each I/O pin.
- ▶ GPIO interrupt mask and interrupt status (bit by bit – default not masked):
 - ▶ User can enable or disable interrupts of each I/O pin.
 - ▶ Identifies the source of interrupts of each I/O pin.

PCAL6416A

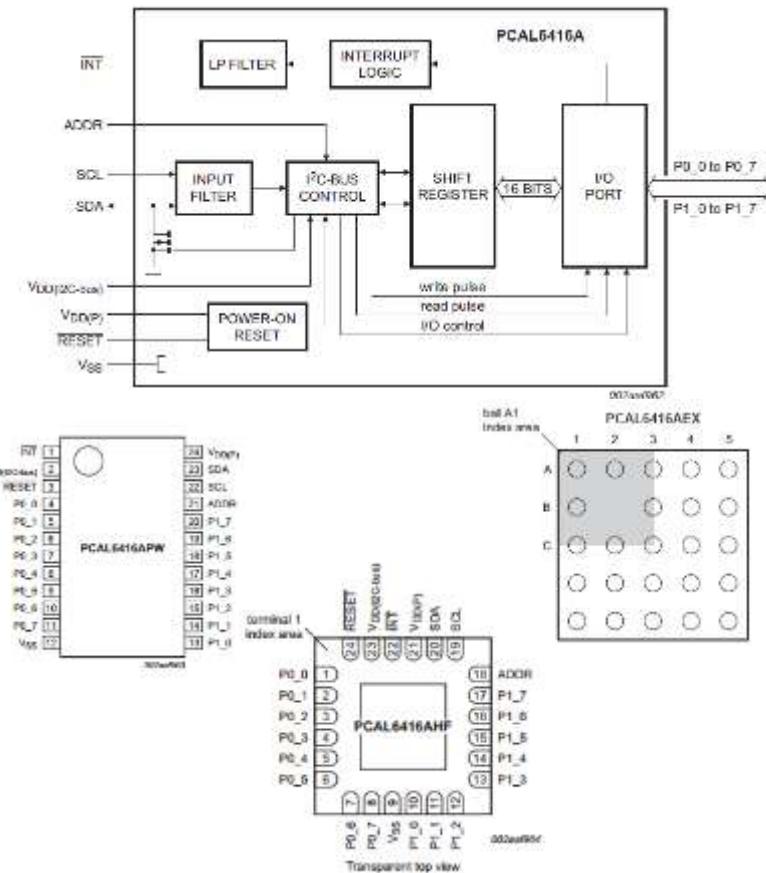
I²C

Storage
SSD

Dual-V_{CC} Low-Voltage, 16-Bit I²C-Bus Expander with latchable inputs, maskable interrupt, and other programmable I/O features

Features:

- Operating Power-Supply Voltage Range of 1.65 V to 5.5 V
- Low Standby Current Consumption of 3 µA (Max)
- Bidirectional Voltage-Level Translation between 1.8V to 5V SCL/SDA and 1.8V to 5V Totem Pole configured I/O Port
- Schmitt-Trigger Hysteresis; 10% of I²C-Bus Supply Voltage
- Fast Mode I²C-Bus Operating Frequency of up to 400-kHz
- Active-Low Reset Input
- Open-Drain Active-Low Interrupt Output
- 5-V Tolerant I/O Ports
- **Output port configuration: bank selectable push-pull or open-drain output stages**
- **Interrupt status (read-only) register identifies interrupt source**
- **Bit-wise I/O programming for output drive strength, input latch, pull-up/pull-down enable, pull-up/pull-down selection, and interrupt mask**
- High current Drive for Directly Driving LEDs
- Internal Power-On Reset
- Power-Up With All Channels Configured as Inputs
- No Glitch On Power-Up
- Package – 24 pin TSSOP, HWQFN, BGA and HLA
- Latch-Up Performance Exceeds 100 mA per JESD 78, Class II



Two Vcc Low-voltage; 24-bit I2C-bus I/O expander with additional Agile I/O features and FM+

- ▶ Features

- 24-bit GPIO
- ~ 0.85 – 3.6V I2C-bus for interface to processor
- 1.65 – 5.5V I/O and core supply
- Fm+ (1MHz) interface
- Additional Agile I/O + features:
 - Enhanced input read & INT status functionality
 - Input hysteresis for noise immunity
 - Clock gating for lower power
 - Auto increment mode for ease of use
 - SMBus ARA, device ID, software reset I2C interface
 - Latched input - register for latched state and also actual current input state
- Logic transition level that will generate interrupt (high or low going)
- Read the interrupt flags to determine which inputs have an interrupt request
- Ability to clear individual interrupt flag
- 5 state per address pin
- Slew control (Port I/O)
- Packages: TSSOP32, QFN32, UFBGA32

I²C Low-Voltage GPOs

I²C

Storage
SSD

- Small, low voltage, low cost
- General purpose, output only

BITS	V RANGE	BW	RESET	INT	I/O PULL-UP	NOTES	PACKAGE	PART#
4	1.1V to 3.6V	1 MHz	SW	NO	YES	4 mA PP outputs	TSSOP8, XQFN8	PCA9570
8	1.1V to 3.6V	1 MHz	SW	NO	YES	4 mA PP outputs	XQFN12, DHVQFN14, TSSOP14	PCA9571

PCA9570 4-bit GPO Expander

I²C

Storage
SSD

- ▶ Small, low-cost, low voltage

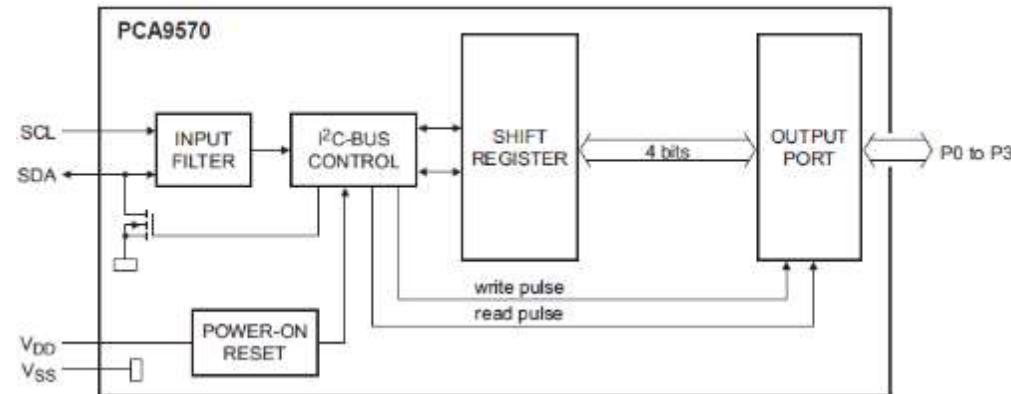
- ▶ Features

- Supply voltage: 1.1 to 3.6V
- 4-bit, 4 mA push-pull outputs
- Supply current : 20 μ A typ. operational, 75 μ A max.
- 1 MHz I²C-bus interface with 6 mA SDA sink capability for lightly loaded buses and improved power consumption
- I²C-bus Fast Mode compliant
- Readable device ID (manufacturer, device type, and revision)
- Software reset and power-on reset

- ▶ Packages:

- TSSOP8
- XQFN8 (1.2 x 1.4 x .5mm or 1.6 x 1.6 x .5 mm)

- ▶ ESD protection exceeds 2000V HBM



PCA9571 8-bit GPO Expander

I²C

Storage
SSD

- ▶ Small, low-cost, low voltage

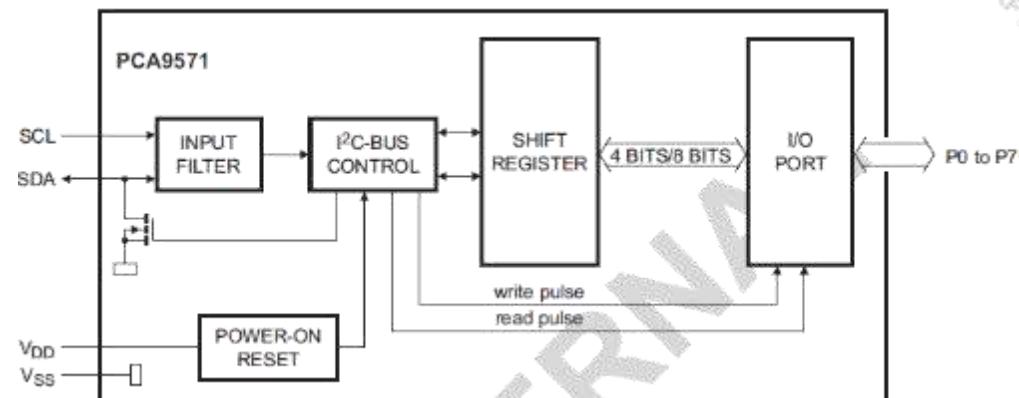
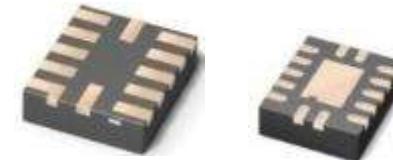
- ▶ Features

- 1.1 to 3.6V operation with 8-bit, 4mA push-pull outputs
- Supply current : 20 μ A typ. operational, 75 μ A max.
- 1 MHz I²C-bus interface with 6 mA SDA sink capability for lightly loaded buses and improved power consumption
- I²C-bus Fast Mode compliant
- Readable device ID (manufacturer, device type, and revision)
- Software reset and power-on reset

- ▶ Packages

- XQFN12, DHVQFN14, TSSOP14

- ▶ ESD protection:
exceeds 2000V HBM



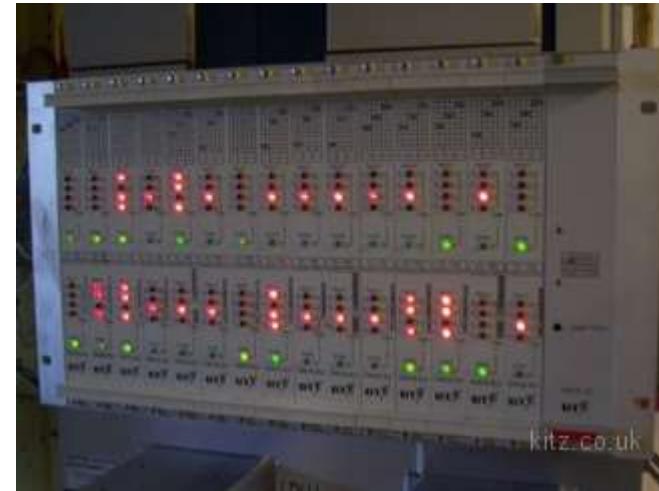
LED Controllers

LED Controllers Value Proposition

I²C

Storage
SSD

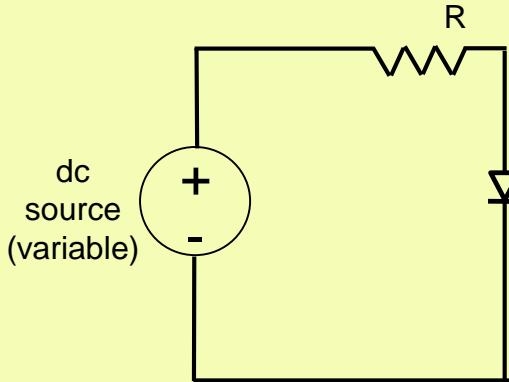
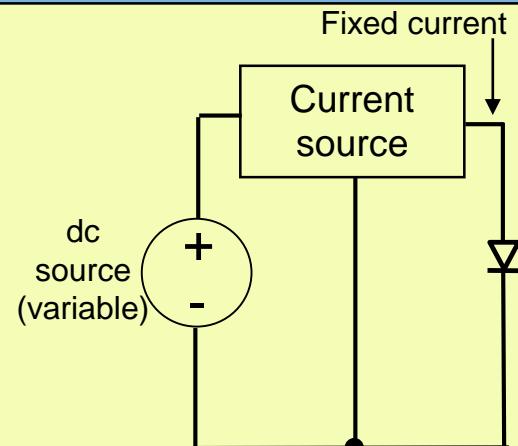
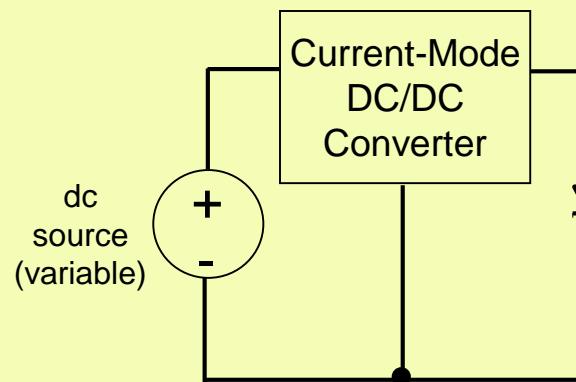
- ▶ **Why used?**
 - Offloads CPU from blinking and status operation
- ▶ **Where used?**
 - Status indicator and control on cards and back panel.
- ▶ **Why NXP LED Controller?**
 - Large selection of LED Controllers in a wide range of packages
 - Minimized supply voltage ripple with programmable LED outputs phase shifting
 - Thermally enhanced HTSSOP package



Methods of Driving LEDs

I²C

Storage
SSD

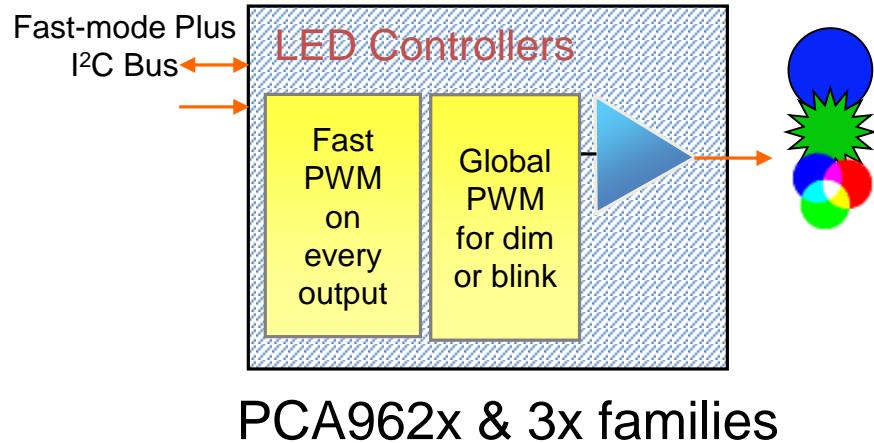
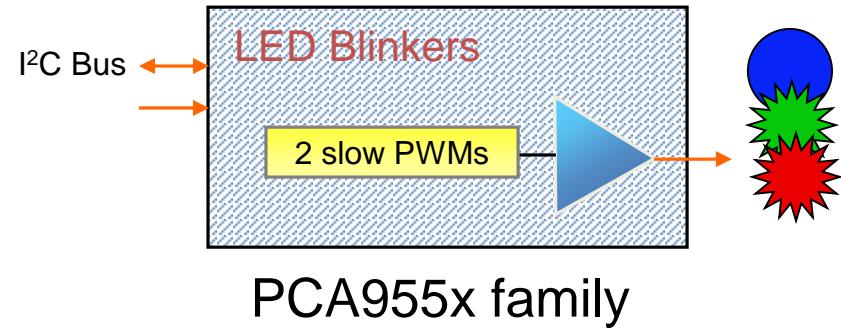
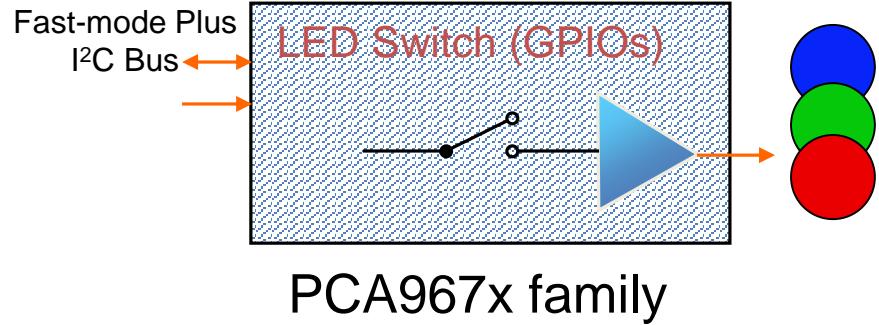
Voltage Source + Resistor	Current Source	Current-Mode DC/DC Converter
 $I_F = \frac{V_{IN} - V_F}{R}$	 $I_F \approx \text{constant}$	 $I_F \approx \text{constant}$
<p>Pros:</p> <ul style="list-style-type: none"> • Heat is dissipated in the resistor • Source is independent of heat dissipated • Good for driving multiple LEDs in series, with different V_F <p>Cons:</p> <ul style="list-style-type: none"> • I_F changes with V_{IN} 	<p>Pros:</p> <ul style="list-style-type: none"> • LED light remains constant with supply voltage fluctuations <p>Cons:</p> <ul style="list-style-type: none"> • Heat is dissipated at the current source • Current source is sensitive to heat dissipation 	<p>Pros:</p> <ul style="list-style-type: none"> • LED light remains constant with supply voltage fluctuations • Ability to step-up or step-down LED supply voltage • Good for directly driving LED when source and supply voltages are different. <p>Cons:</p> <ul style="list-style-type: none"> • More expensive

I²C LED Switch Blinkers, Dimmers and Controllers

I²C

Storage
SSD

Product overview



LED Controller Portfolio

I²C

Storage
SSD

Voltage-Source LED Controllers

Number of Outputs	LED Blinkers (25mA / 5V)	LED Dimmers (25mA / 5V)	Color Mixing LED Controllers (25mA / 5V)	Color Mixing LED Controllers (100mA / 40V)
2	PCA9550	PCA9530		
4	PCA9553	PCA9533	PCA9632 ^[1] PCA9633	
8	PCA9551	PCA9531	PCA9634	PCA9624
16	PCA9552	PCA9532	PCA9635 ^[3] PCA9685 ^{[2] [3]}	PCA9622
24				PCA9626

[1] Low power version of PCA9633

[2] The PCA9685 has 12-bit PWM while the PCA9635 has 8-bit PWM

[3] AEC-Q100 qualified

Current-Source LED Controllers

Device	# of Outputs	F _{osc}	Output Current	Active-Low /OE	Interface	
PCA9922	8	None	15mA ~ 60mA	Yes	25-MHz Serial Shift Interface	
PCA9903 ^[1]	3	1.25MHz	20mA – 50mA	Yes	Fm+ I ² C	
PCA9906 ^[1]	6	1.25MHz	20mA – 50mA	Yes	Fm+ I ² C	
PCA9954A ^[1]	8	8MHz	225µA ~ 57mA	Yes	Fm+ I ² C; 125 Addresses	
PCA9952 ^[2]	16	8MHz	5mA ~ 57mA	Yes	Fm+ I ² C; 8 Addresses	
PCA9955 ^[2]	16	8MHz	5mA ~ 57mA		Fm+ I ² C; 16 Addresses	
PCA9955A ^[2]	16	8MHz	225µA ~ 57mA	Yes	Fm+ I ² C; 125 Addresses	
PCA9745A ^[1]	16	8MHz	225µA ~ 57mA	Yes	Serial-Shift; No Address	
PCA9755A ^[1]	16	8MHz	225µA ~ 57mA	Yes	SPI; 25 Addresses	
PCA9956A	24	8MHz	225µA ~ 57mA	Yes	Fm+ I ² C; 125 Addresses	61

[1] In development

[2] AEC-Q100 Qualified

PCA963x

I²C

Storage
SSD

25-mA / 5V LED Controller

Features:

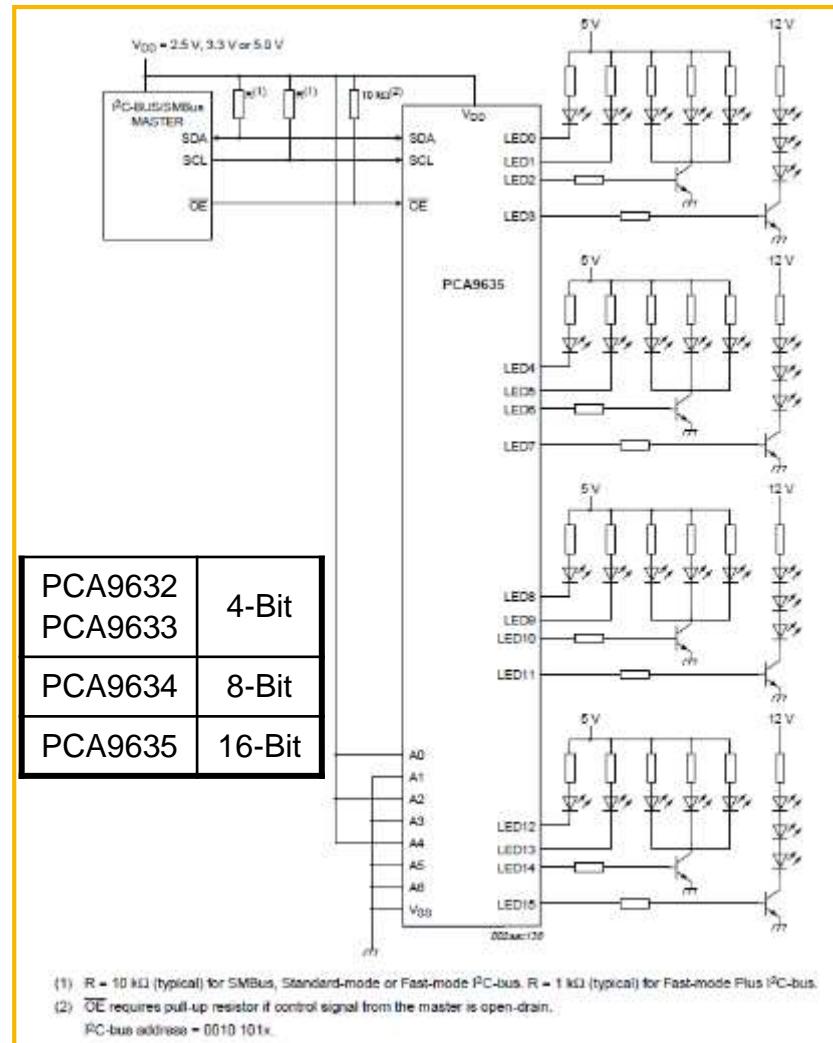
- ▶ LED drivers with totem-pole outputs to sink up to 25mA or source up to 10mA (per output)
- ▶ Individual LED dimming with 8-bit or 256 steps individual PWM
- ▶ Global LED dimming or blinking with 8-bit or 256 steps individual PWM
- ▶ Fast-mode Plus I²C interface (1MHz)
- ▶ 124 individual addresses with 4 programmable sub calls address groups

Benefits:

- ▶ Same software as PCA962x
- ▶ Drive up to 25mA per output

Applications:

- ▶ Status indicators for networking platforms



PCA9955A

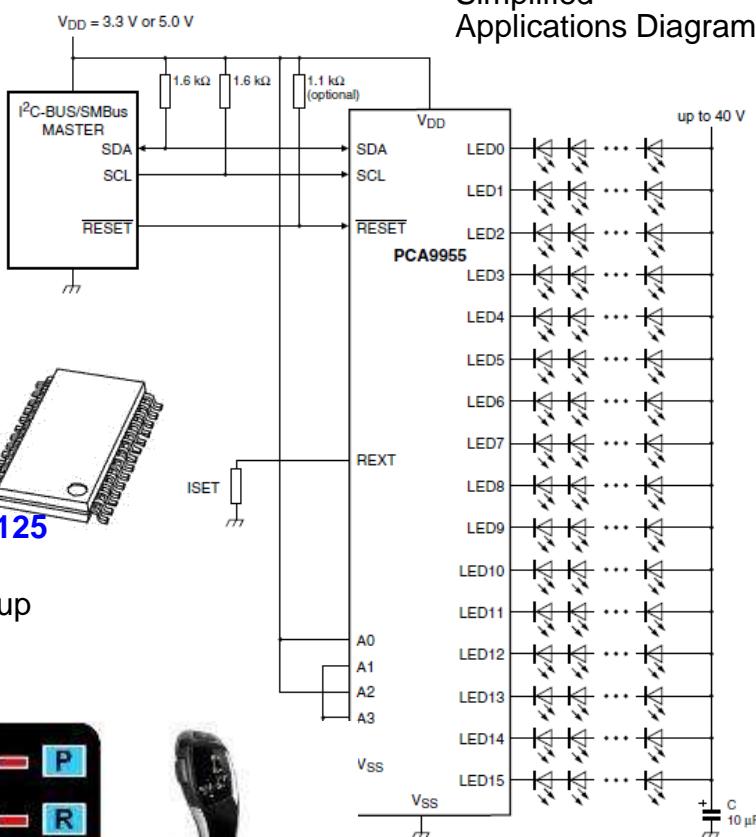
I²C

Storage
SSD

20V / 57mA 16-Channel Constant-Current LED Controller

FEATURES

- ▶ $V_{CC} = 3.0 \text{ V to } 5.5 \text{ V}$
- ▶ Output
 - Constant current; Up to 57mA current drive/channel
 - 20V sustaining voltage
 - R_{EXT} sets I_{LED} for all channels
 - **$\pm 4\%$ channel-to-channel matching**
 - **$\pm 6\%$ IC-to-IC matching**
 - 0.8V (typ) regulation voltage
 - 256:1 LED current peak adjustment
 - **Real-time LED short or open detect**
- ▶ Digital Interface
 - I²C (Fm+), 1 MHz (bi-directional)
 - **Three quinary (five states) input address pins allow up to 125 devices to be connected on the same bus**
 - Four software programmable I²C-bus addresses (one LED group call address and three LED sub call addresses)
- ▶ PWM Generator
 - 256:1 Individual PWM dimming range (31.25kHz)
 - 256:1 Global PWM dimming range (122Hz)
 - 256:1 Global blinking (0.05Hz to 15Hz)
 - Programmable phase shifting (125ns to 1.875us)
- ▶ Over-Temperature Protection (150 °C typ)
- ▶ -40 °C to +85 °C Operating Temperature
- ▶ HTSSOP28 Package with Thermal Relief Pad
- ▶ **Compliant to ESD Standards (3kV HBM, 300V MM)**

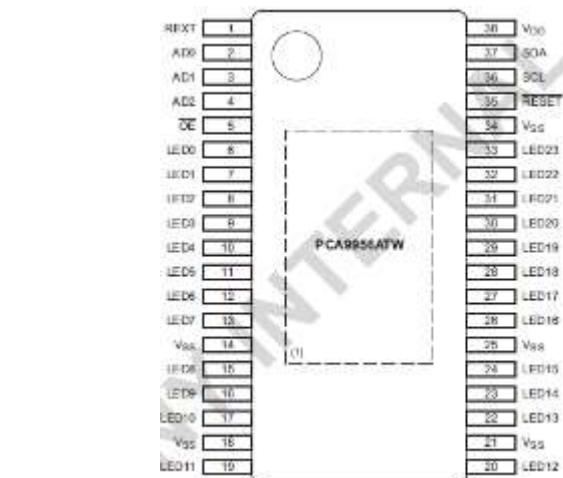
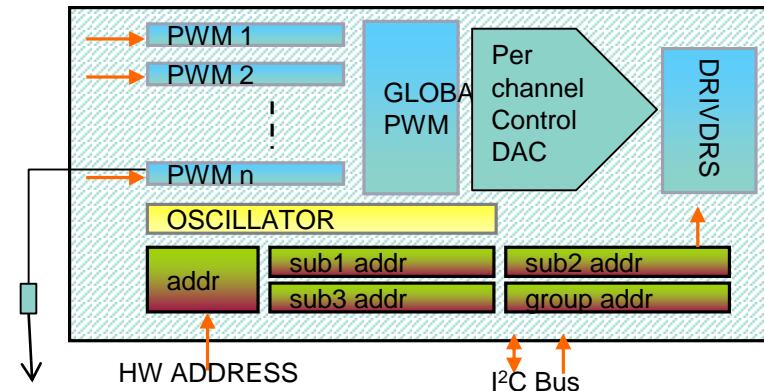


24-channel I²C-bus Constant-Current LED Controller

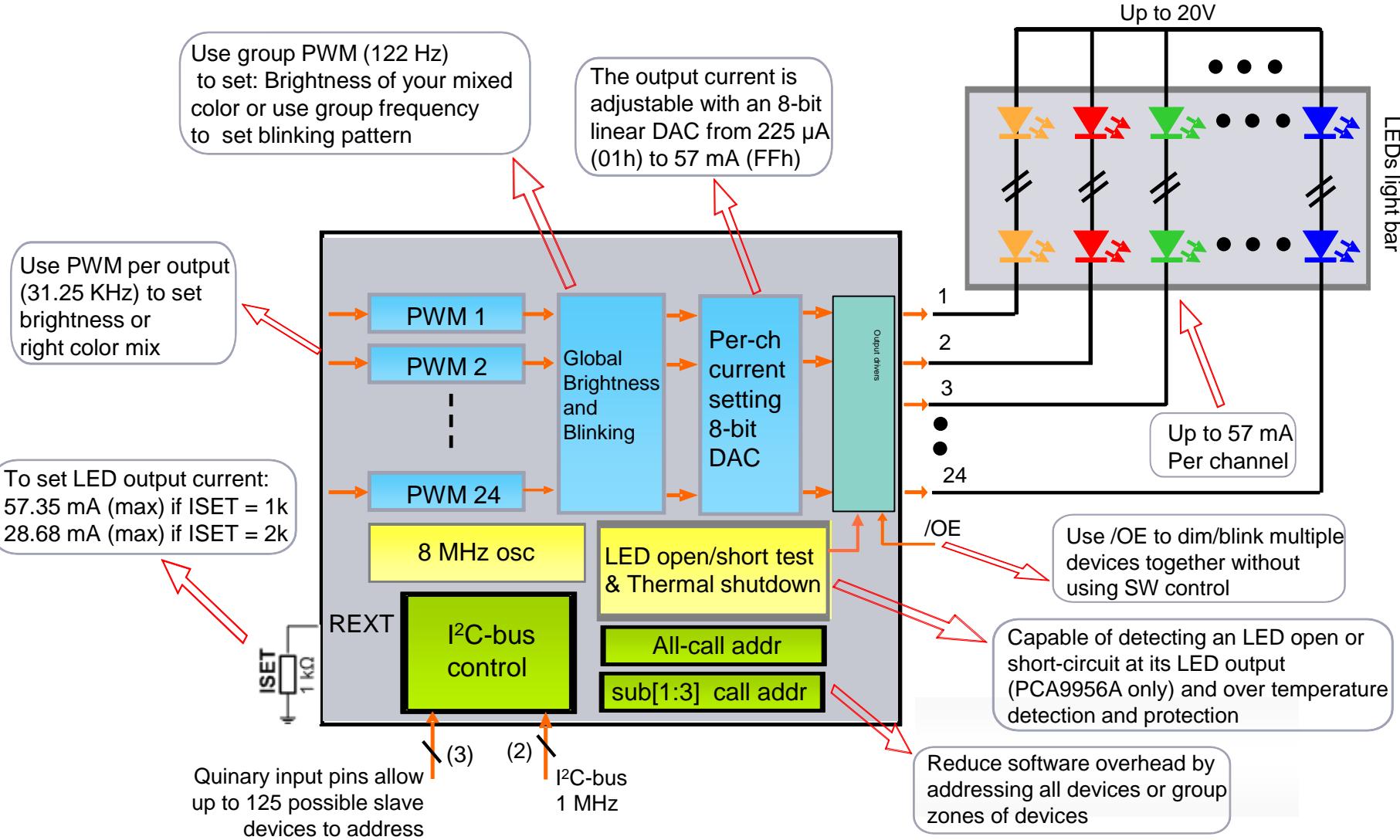
Features:

- 57-mA Constant current LED drivers @ 20 V
- External resistor to set the overall output current
- Output to output accuracy $\pm 4\%$
- Chip to chip output accuracy $\pm 6\%$
- 8-bit programmable output to output delay
- Per channel 8-bit DAC to set individual output current^{REXT}
- Per channel 8-bit PWM to dim LED in 256 steps
- Global 8-bit PWM to dim or blink in 256 steps
- 3 HW ADDR pins to allow up to 125 devices per bus
- 4 programmable sub calls address groups for cluster control
- LED open/short and over-temp detection
- Fast-mode Plus (1 MHz) I²C-bus interface
- Thermally enhanced package HTSSOP38

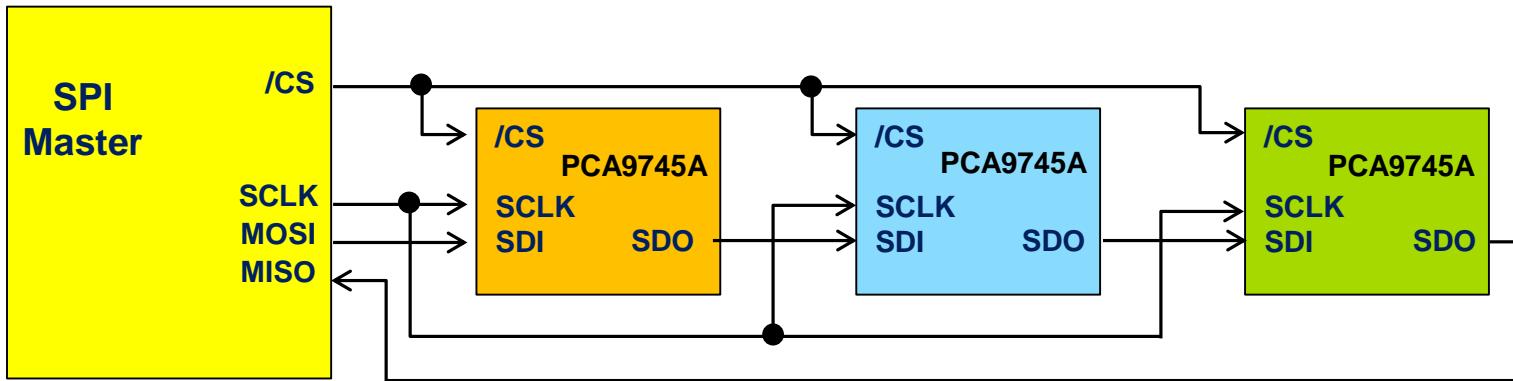
Block Diagram:



PCA9956A LED controller block diagram



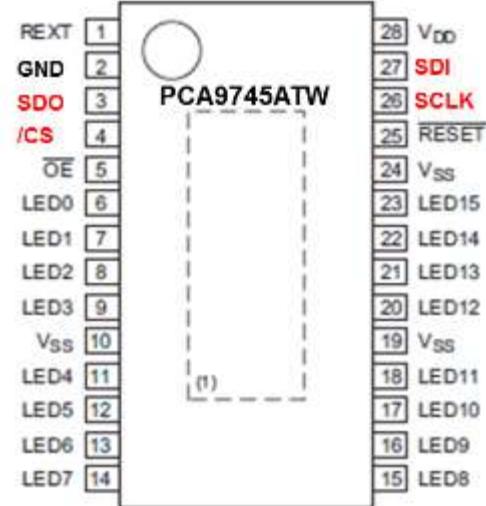
PCA9745A SPI Daisy Chain Connection



SPI Data Format

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
MSB	Register Address				LSB	R / W	MSB	Data				LSB			

- SPI Master send 16-bit (clocks with address and data) x 3 (number of slaves) to access all slave devices at the same time
- Only one byte data can be read/write from/to all slave devices
- No slave address required



Bus Buffers & Level Shifters

I²C Bus Buffer Portfolio

I²C

Storage
SSD

Repeaters

PCA9527
PCA9507 + ½ PCA9517

SO

PCA9515/15A

SO

PCA9509
Processor to SMBus

SO

PCA9509A
Processor to SMBus

SO

PCA9509P
Processor to SMBus

SO

PCA9517A
0.9 – to 5.5V

SO

PCA9507
RTA for HDMI

SO

PCA9519
4 x PCA9509

SO

PCA9617A
0.8 to 5.5V

SO

Hot-Swap Buffers

PCA9508
Active Level Shifter

SO

PCA9512A/12B
Active Level Shifter

IO

PCA9511A
0.6-V Threshold, 2 Vcc

IO

PCA9514A
0.8-V Threshold

IO

PCA9513A
92-µA Current Source

IO

PCA9510A
No Accelerator

IO

Extenders (Long Cable) (Long Cable Drivers)

P82B96 [1]

SO

P82B715
No Static Offset

AM

PCA9600/9601
1-MHz Speed

SO

PCA9614
2-CH dl2C

SO

PCA9616
3-CH hot swap dl2C

SO

PCA9615
2-CH hot swap dl2C

SO

NO = No Offset

SO = Static Offset

IO = Incremental Offset

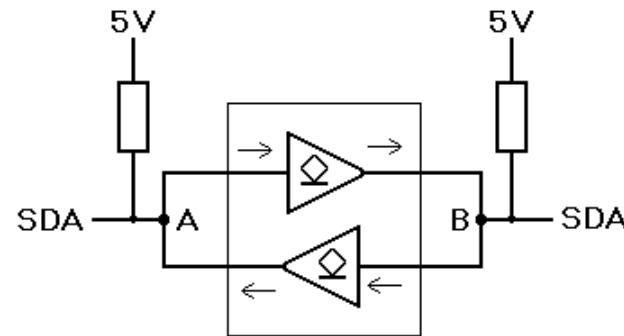
AM = Amplifier

[1] P82B96 is widely used for opto-isolation applications
Red device = 1 MHz system



Why Special Buffers on I²C-Bus ?

- ▶ The I²C-bus assumes the possibility of simultaneous bi-directional signal flows.
 - Without any buffers, the bus wires are clearly bi-directional.
- ▶ Conventional buffers only handle signals traveling in one direction at any one time.
 - There are logic buffers with a direction control pin, but at any one time they are uni-directional.
- ▶ Buffers for use on an I²C-bus must not have any pull-up capability. They must have open-collector or open drain outputs.
- ▶ If two conventional logic buffers are connected as shown then they will simply latch to the LOW state the first time either side goes LOW.
 - The logic symbol represents a non-inverting, open drain, buffer.



If side A is externally pulled LOW, then the upper open drain buffer pulls the bus at side B to the LOW level.

With this LOW now on side B, the lower buffer will pull side A LOW and even if the external drive at A is removed the buses at A and B will simply remain latched LOW.

A **special** type of buffer is required for I²C-bus.

Types of I²C-Bus Buffers

I²C

Storage
SSD

No Offset	Static Offset	Incremental Offset	Amplifier
		<p>Symmetrical buffer using offsets applied to the input levels.</p>	<p>Asymmetrical device, amp only sinks current in one direction</p> <p>Rheostat-like a passive resistor what higher current side is called low</p>
<p>Characteristics:</p> <ul style="list-style-type: none"> • Buffer automatically changes direction in response to the applied drive signal • For use on SDA line <u>ONLY</u> • Buffer output has “no offset” and pulls its output down very close to 0V 	<p>Characteristics:</p> <ul style="list-style-type: none"> • A fixed third logic level is introduced on the special I/O side • The third logic level is higher (static offset) than 0.4V, but low enough to still be a low to the other devices on the bus 	<p>Characteristics:</p> <ul style="list-style-type: none"> • A dynamic third logic level is introduced by adding an incremental offset voltage to the input • Either bus will be driven (down), by a voltage follower, to a level 100mV higher than the voltage level of the other bus 	<p>Characteristics:</p> <ul style="list-style-type: none"> • The bus current is amplified, but in only one signal direction • Current gain enables a 3-mA driver on the input side to drive a bus with 30-mA pull-up on the other side

Pros & Cons of Different Types of Buffers



NO OFFSET

<ul style="list-style-type: none"> Both I/Os pull-down to zero volts for full level swing and best noise margin on output side Both inputs interface with any slave and with most buffers 	<ul style="list-style-type: none"> Only used on SDA due to glitch during auto reversing Only class that doesn't support clock stretch or multi-master because SCL buffer is unidirectional User required to design Master's timing to accommodate buffer and any system delays
---	---



INCREMENTAL OFFSET

<ul style="list-style-type: none"> Good V_{OL} as long as V_{IL} is low enough Can be used in series or parallel Supports logic level shifting Only type where both I/Os can be fully I²C compliant 	<ul style="list-style-type: none"> Offsets add up as parts are placed in series
--	--

HYBRID INCREMENTAL OFFSET

<ul style="list-style-type: none"> Good V_{OL} as long as V_{IL} is low enough Variety of parts available including parts with special features such as rising edge accelerators, precharge, and current source pull-up 	<ul style="list-style-type: none"> Offsets add up as parts are placed in series Can only be used for level shifting when part uses dual power supplies V_{IL} requirement restricts the bus low voltage
---	---

STATIC OFFSET

<ul style="list-style-type: none"> Strong drive down to V_{OL} (~0.6 V) Wide range of single and hub parts with special features and options - offset voltage, drive strength, over-voltage tolerance, offset on only one side or all sides Work with any slave when bus low voltage is acceptable 	<ul style="list-style-type: none"> Forces a restrictive low bus voltage requirement on the static offset side Side using offset generally cannot interface with other buffers
--	---

AMPLIFIER

<ul style="list-style-type: none"> Allows driving high capacitance (~4000 pF) with low value pull-up resistors Strong drive (30mA) No input level switch points 	<ul style="list-style-type: none"> No enable Not over-voltage tolerant Input not isolated from output
--	--

Hot-Swappable Buffer Value Proposition

I²C

Storage
SSD

Why used?

- During hot-swapping, glitches on the SCL and SDA lines may cause data corruption on the I²C-bus. The NXP hot-swappable buffers will prevent any data corruption in these applications.

Where used?

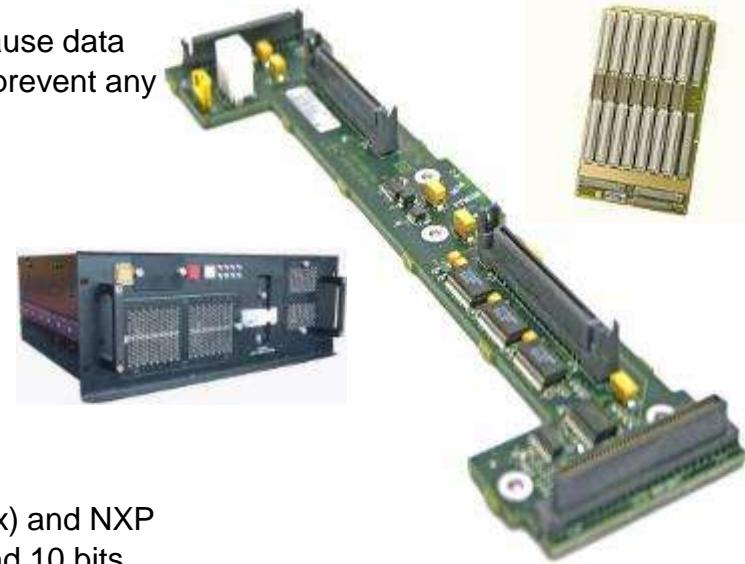
- Applications requiring I/O card insertion into a live system
- Multipoint Backplanes Cards
- VME
- cPCI
- AdvancedTCA Cards

Why NXP Hot-Swappable Buffer?

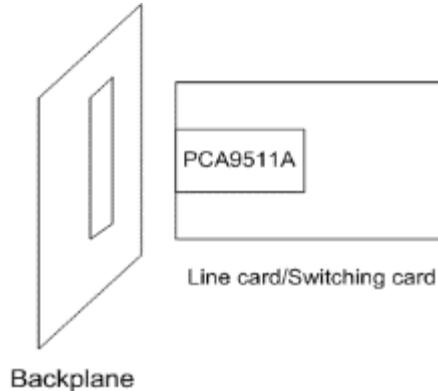
- Large selection of buffers
- Continuous innovation with new differential I²C buffers (P82B48x) and NXP Voltage Translation family (NVT20xx) in widths of 1, 2, 4, 6, 8 and 10 bits

NXP Hot-Swappable Buffer Portfolio

Device	Accelerator	1-V Precharge	Ready OD Output and Low I _{CC} Disable	Dual-V _{CC} for Level Translation	92-mA Current Source	ESD (HBM)
PCA9508				×		6KV
PCA9510A		x (Input Side Only)	×			2KV
PCA9511A	0.6V	×	×			2KV
PCA9512A	0.6V (with Disable Pin)	×		×		2KV
PCA9513A	0.8V		×		x (Input Side Only)	2KV
PCA9514A	0.8V		×			2KV
PCA9615/16						4KV



PCA9511A – Hot swap buffer I2C buffer



▶ Why used?

- To prevent SDA and SCL line corruption during live board insertion and removal from multipoint backplane systems

▶ Features

- Compatible with I2C-bus Standard-mode, I2C-bus Fast-mode, and SMBus standards
- Built-in $\Delta V/\Delta t$ rise time accelerators on all SDA and SCL lines (0.6 V threshold) requires the bus pull-up voltage and supply voltage (VCC) to be the same
- High-impedance SDA and SCL pins for VCC = 0 V

▶ Application

- Used on Line cards, Switching cards interface to support live insertion and removal
- Widely used on FRUs (Field replaceable units)

Long-Distance Bus Buffers Value Proposition

▶ Why used?

- Drives the I²C-bus signals over a long-distance cable and through inter-connects
- Re-drive the SCL and SDA signals into loads exceeding the maximum specified 400-pF bus capacitance

▶ Where used?

- Between card interconnects (does not support voltage level translation)
- In noisy environment with compressors, pumps, relays, EMI, etc.
- To eliminate the need for multiple costly bus controllers
- AdvancedTCA
- Opto-Couplers Interface

▶ Why NXP Long-Distance Buffers?

- Large selection of buffers
- Continuous innovation with new differential I²C buffers (PCA9614/15/16) for very rugged environments
- Invented the I²C-bus

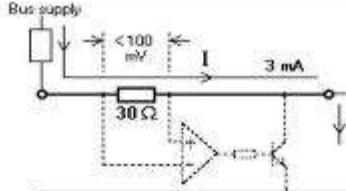
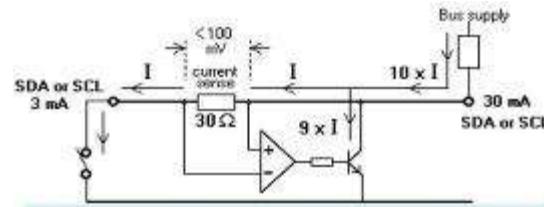
▶ NXP Long-Distance I²C-Bus Buffer Portfolio

Device	V _{CC}	F _{MAX}	Max Cable-Side Load	Cable Length	Capacitance Isolation	Interrupt	Signal Levels	ESD (HBM)
P82B715	3.0V – 12.5V	100kHz	3,000pF	50m			Single-ended	2.5KV
P82B96	2.0V – 15.0V	400kHz	4,000pF	20m	×		Single-ended	3.5KV
PCA9600/01	2.5V – 15.0V	1MHz	4,000pF	20m	×		Single-ended	4.5KV
PCA9614	3.0V – 5.5V	1MHz		100ft	×		Differential	4.0KV
PCA9615	3.0V – 5.5V	1MHz		100ft	×		Differential	4.0KV
PCA9616	3.0V – 5.5V	1MHz		100ft	×	×	Differential	4.0KV

P82B715 I²C-Bus Extender

Features

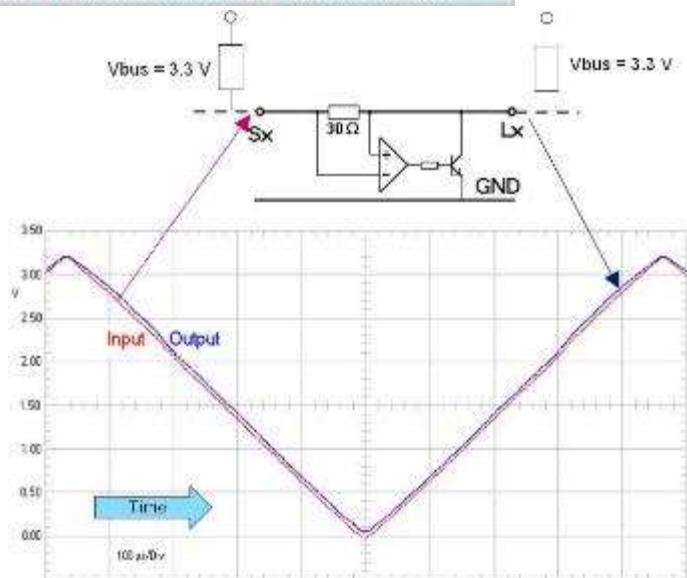
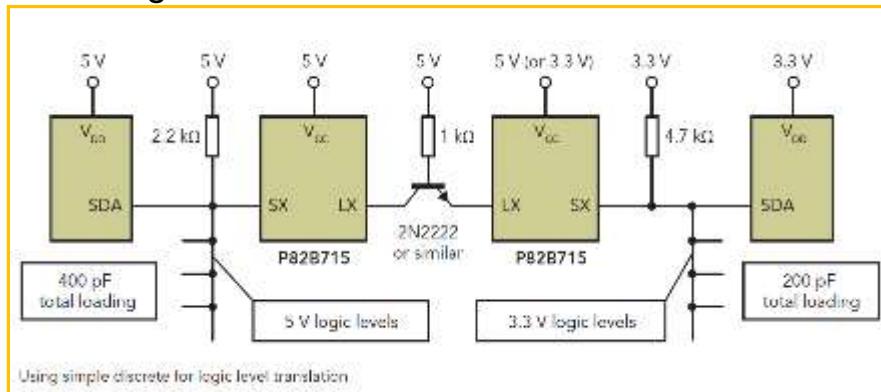
- ▶ Wide supply voltage range from 3V to 12V
- ▶ Amplifies the bus drive current in one direction
- ▶ Scales the current drive by 10x, but does not isolate the bus
- ▶ Scales the capacitive loading and is capable of driving 4000pF load
- ▶ Inputs have no switching level thresholds
- ▶ Compatible with I²C-bus, SMBus, and PMBus
- ▶ Does not do voltage level shifting



Note how the two I/Os are internally connected by a 30 ohm resistor. For all input voltages, the voltage difference between I/Os never exceeds 100 mV.

Applications

- ▶ Driving a bus with low pull-up resistors
- ▶ Extending the communication distance of the I²C-bus over wire



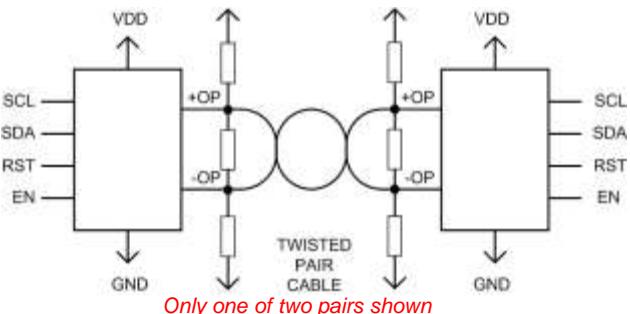
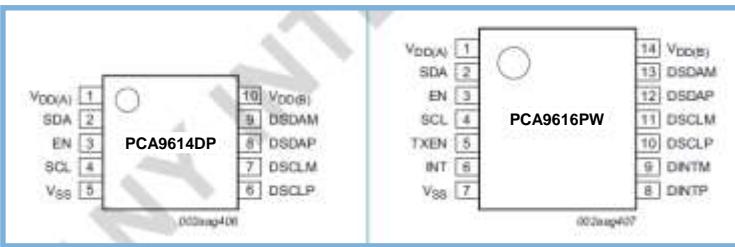
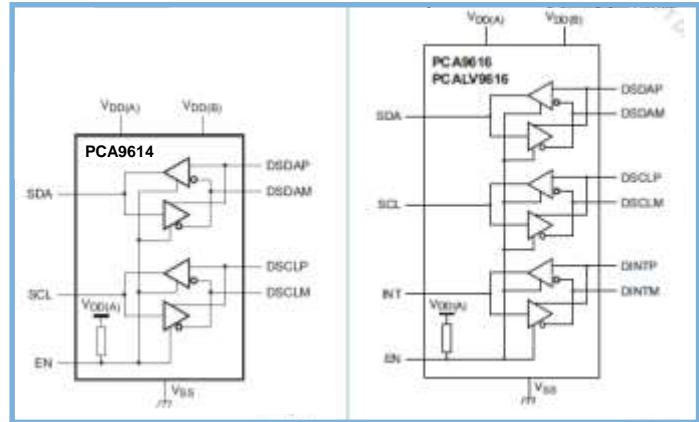
PCA9614/15/16 Differential I²C-Bus Drivers

Features

- ▶ Multi-point differential I²C-bus buffers
- ▶ Communicate over long distances
- ▶ Supports normal I²C mode (100kHz), and fast mode (400kHz)
- ▶ Drive cable lengths up to 100 ft
- ▶ Differential signaling to reduce noise and ground offset
- ▶ Twisted pair cable (or PCB traces) must be terminated at both ends in the characteristic impedance of the cable (or PCB format)
- ▶ For the correct I²C-bus “idle” condition the terminations are biased to supply and ground

Applications

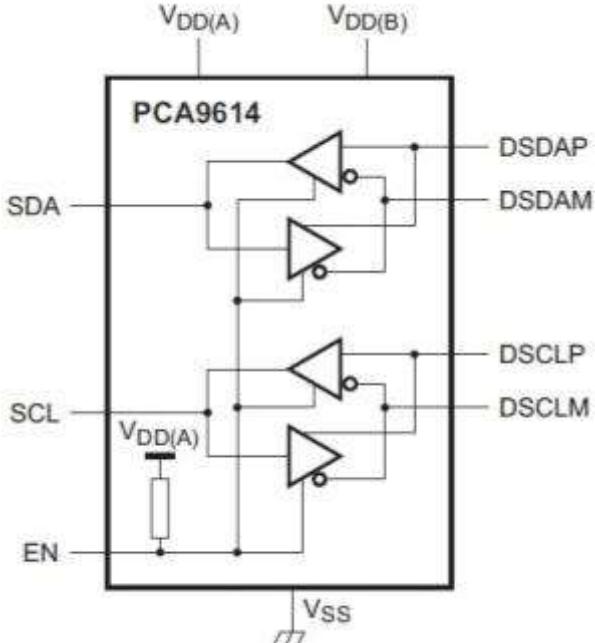
- ▶ Ideally suited for rugged high-noise or long-cable applications:
 - Temperature monitors and leak detectors on remote-board environment with interrupt back to master
 - LED control
 - Open or short detection
 - Power supply control in high-noise environment
 - Heating and cooling control



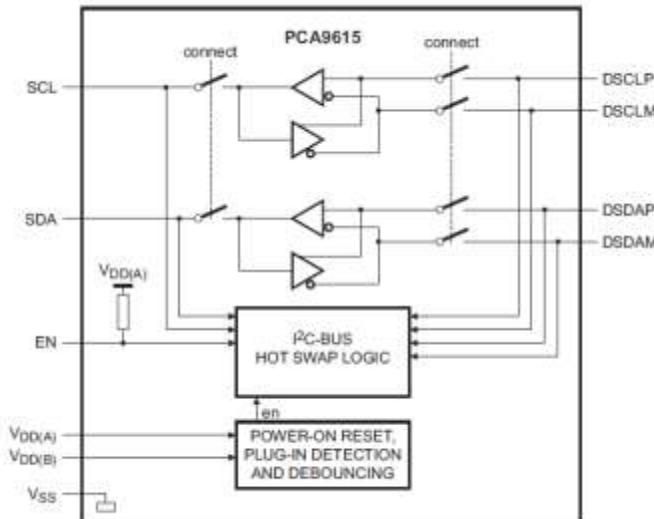
PCA9614/15/16 Differential I²C-Bus Drivers

Block Diagrams

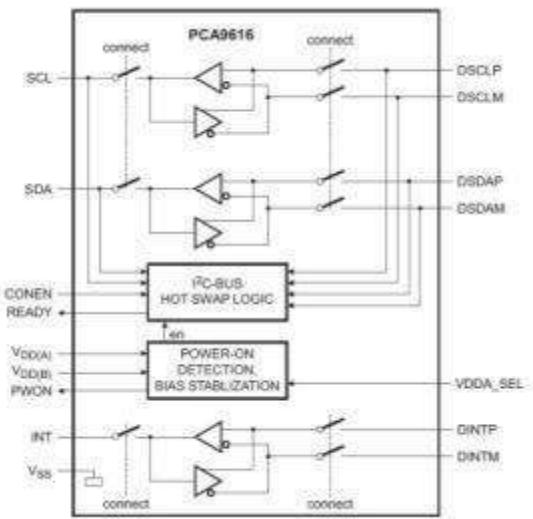
PCA9614



PCA9615



PCA9616



- Simple
- Physical layer translation

- With hot-swap capability
- Connects bus only when voltages on differential side are idle

- With additional channel for interrupt or any other control signal

Voltage Level Translation

Low Power / Passive

- Devices: NVT2xxx (some GTL), PCA9306
- Function: I²C, I²S, SPI, digital RGB Bidirectional Level Shift
- Application: Computing, Mobile & Consumer
- Advantage: Lowest Standby Power

Capacitance Isolation

- Devices: PCA95xx and PCA96xx
- Function: I²C & SMBus Bidirectional Level Shift
- Application: Computing, Networking, Mobile & Consumer
- Advantage: Best Noise Margin

Active GTL

- Devices: GTL2xxx, GTL16xx
- Function: GTL to LVTTL Bidirectional Level Shift
- Application: Computing, Consumer & Telecom
- Advantage: De facto standard for Intel processors

Voltage level Translator Overview



PCA Family

- Features:**
- Single and Dual supply
 - Capacitive isolation
 - High noise margin

- Applications**
- I2C buffering
 - Long cable
 - Hot-swap

NVT Family

- Features:**
- Dual supply
 - Bidirectional
 - Auto-sensing
 - Passive
 - External pull-ups required
 - 1-10 bits wide

- Applications**
- Control interfaces

NTB Family

- Features:**
- Dual supply
 - Auto-sensing
 - Isolates capacitance
 - Push-pull outputs
 - Low output drive

- Applications**
- Control interfaces with active drive

GTL Family

- Features:**
- Supports 'GTL' logic
 - Dual supply
 - Auto sensing
 - GTL to LVTTL level translation

- Applications**
- Supports GTL levels on micro-processors

NTS/NTSX Family

- Features:**
- Dual supply
 - Bidirectional
 - Passive
 - Integrated Pull up resistors
 - NTSX family has high sink current capability

- Applications**
- Control Interfaces

AUP/LVC/AVC Family

- Features:**
- AUP – 1.1 to 3.6V
 - AVC – 0.8 to 3.6V
 - LVC – 1.2-5.5V
 - Live bus insertion and bus hold option
 - TTL compatible inputs
 - Logic functions available

- Applications**
- High capacitance
 - Data interface (high speeds)

Level Translators Portfolio

I²C

Storage
SSD

Active Level Shifter

- Dual supply
- Capacitance Isolation
- High Noise Margins

Active level Shifter

- Single Supply
- Capacitance Isolation

Passive Level Shifter

- No capacitance Isolation
- Low Power & Low Cost

PCA9527
PCA9507 + ½ PCA9517

SO

PCA9614
2.3V – 5.5V

SO

P82B96
2.2 – 15V

SO

PCA9509/A/P
Processor to SMBus

SO

PCA9616
0.8 – 5.5V

SO

PCA9518A
2.3 – 5.5V

AM

PCA9517A
0.9 – to 5.5V

SO

PCA9615
2.3V – 5.5V

SO

PCA9600/9601
2.2 – 15V

SO

PCA9507
RTA for HDMI

SO

PCA9516A
2.3 – 5.5V

SO

PCA9519
4 x PCA9509

SO

PCA9508
Active Level Shifter

SO

PCA9512A
Active Level Shifter

IO

PCA9617A
0.8 to 5.5V

SO

PCA9306
1 – 5.5V

NO

GTL2002/03/10/00
1 – 5.5V

NO

NVT20xx
1 – 5.5V w low Ron

NO

NO = No Offset

SO = Static Offset

IO = Incremental Offset

AM = Amplifier

Red text = 1 MHz system

Active Level-Shifter Value Proposition

I²C

Storage
SSD

Why used?

- Voltage level shifting between host processor's I²C-bus and peripheral devices when there is a mismatch of supply voltages
- Used when additional drive is needed or to isolate two sections of the bus loading

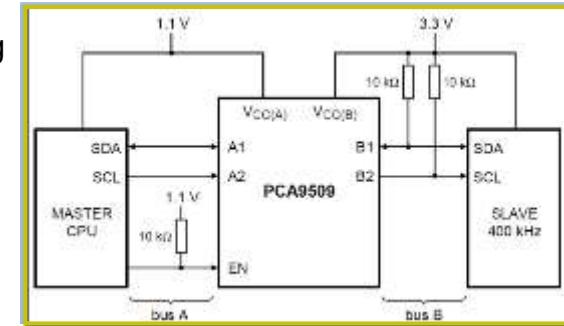
Where used?

- Digital logic level translation between host processor and slave device where **capacitance isolation is required**

Why NXP Level-Shifter?

- Largest selection of active and passive level shifters
- Continuous innovation with new NXP voltage follower and zero-offset active buffers

NXP Level Shifter Portfolio



Device	Description	A side	B-side	Accelerator	Idle Stop Detect for Hotswap	Interrupt	ESD (HBM)
PCA9507	2.7V-to-5.5V Level Shifter	Normal	Static offset	✗ (A-Side)			5KV
PCA9508	0.9V-to-5.5V Level Shifter with Offset Free Hot-Swap	Normal	Static offset		✗		6KV
PCA9509	1.0V-to-5.5V Level Shifter	Static offset	Normal				2KV
PCA9517A	0.9V-to-5.5V Level Shifter	Normal	Static offset				5KV
PCA9519	1.1V-to-5.5V Quad Level Shifter	Static offset	Normal				2KV
PCA9527	3.0V-to-5.5V Level Shifter	Normal	Static offset	✗ (A-Side)		✗	8KV
PCA9617A	0.8V-to-5.5V Level Shifter	Normal	Static offset				5KV



PCA9509A - 0.8 V to 3.3/5 V translator

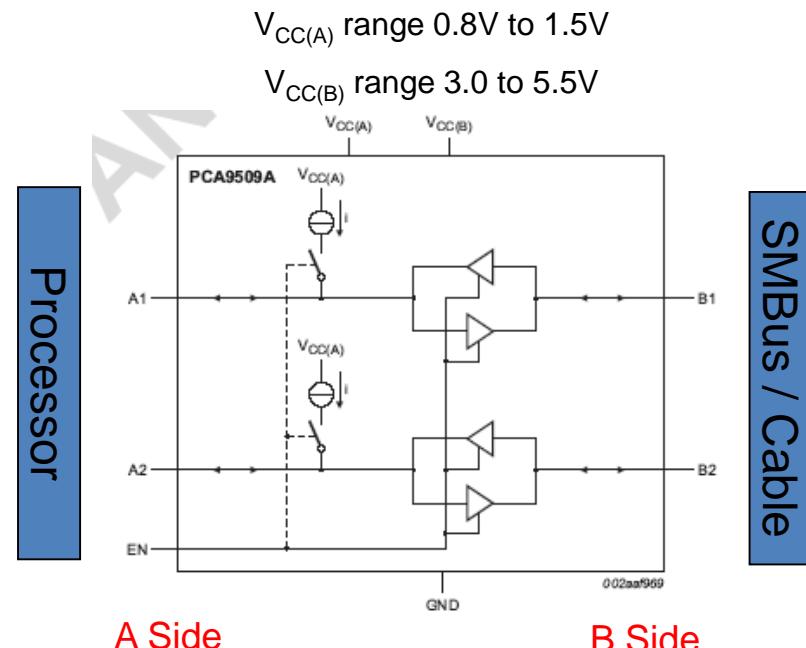
I²C

Storage
SSD

- Bidirectional Voltage translation between 0.8V -1.5V and 3.0 V – 5.5 V without directional pin
- Isolates bus capacitance
- ENABLE signal threshold controlled from 0.8 V side but is 5 V tolerant
- Ideal for 0.8 V master controlling 3.3/5 V slave or vice-versa
- No external pull-up required on the 0.8 V side due to internal current source. No additional components required.
- Lower current consumption
- MSOP8 and XSON8 packages

Target Application:

- Interfacing with very low voltage processors to support existing peripherals



A Side

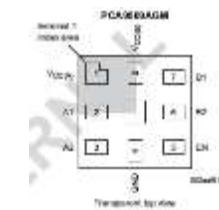
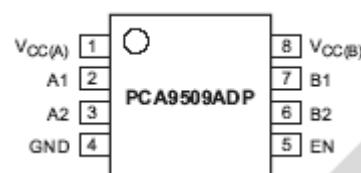
Static Offset

Low Voltage Side

B Side

Normal I²C Levels

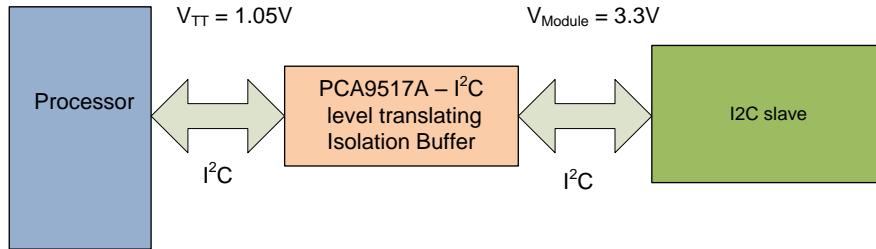
SMBus/5V



PCA9517A – Level translating buffer

I²C

Storage
SSD



▶ Why used?

- Dual V_{CC} for level translation:
 - V_{CCA} : 0.9 V to 5.5 V (Low Side)
 - V_{CCB} : 2.7 V to 5.5 V
- Isolates capacitance and noise for cable application

▶ Features

- 2 channel, bidirectional buffer isolates capacitance and allows 400 pF on either side of the device
- Voltage level translation from 0.9 V to 5.5 V and from 2.7 V to 5.5 V
- I²C-bus and SMBus compatible
- Lock-up free operation
- Supports arbitration and clock stretching across the repeater

▶ Application

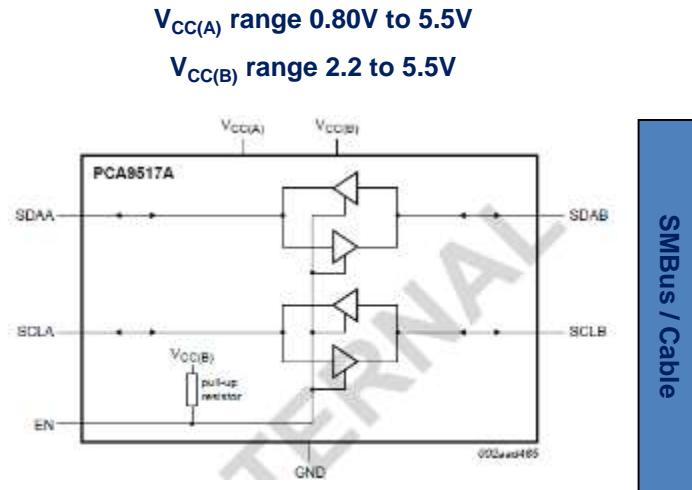
- Used on Line cards, Switching cards around the core controller/processor
- Ethernet switches and power supply interface

PCA9517A 0.80 V to 2.5/3.3/5V translator

I²C

Storage
SSD

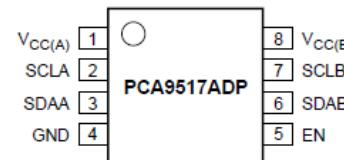
- Bidirectional Voltage translation between 0.80V – 5.5V and 2.2 – 5.5V without directional pin
- Isolate bus capacitance/level shift
- Static offset 2.5/3.3/5V side
- Support **1 MHz system** operation for Grantley platforms
- ENABLE signal threshold controlled from 0.8 V side but is 5.5V tolerant
- Ideal for 0.8 V master controlling 2.5/3.3/5V slave or vice-versa
- External pull-up required on both sides.



A Side

Normal I²C
Levels

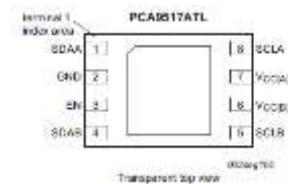
Low Voltage



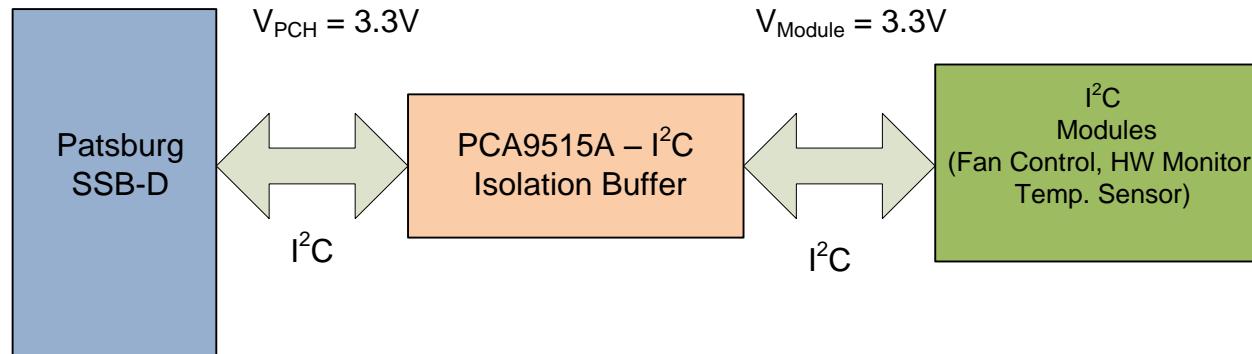
B Side

Static Offset

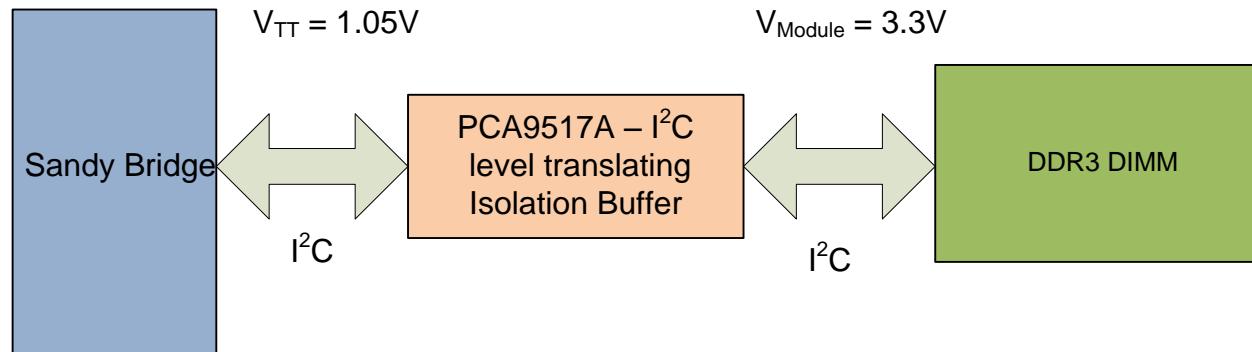
2.5/3.3V SMBus



NXP Buffers on Intel Server Platforms



PCA9515A – Used between the Chipset and I²C modules when the bus capacitance exceeds the max. spec limit of 400pF.



PCA9517A – Used between the processor and DIMM modules on the I²C bus to provide isolation and level translation

Passive Level-Shifter Value Proposition

I²C

Storage
SSD

▶ Why used?

- Voltage level shifting between host processor's I²C-bus peripheral devices when there is a mismatch of supply voltages
- Used when additional drive is not needed and capacitive loading is not an issue

▶ Where used?

- Digital logic level translation between host processor and slave device; **no direction control and no capacitance isolation are required**
- Applications requiring open-drain bidirectional or unidirectional voltage translation (down to 1V) without a direction pin

▶ Why NXP Passive Level-Shifter?

- Largest selection of active and passive level shifters
- Continuous innovation with new NXP Voltage Translation family (NVT20xx) in widths of **1, 2, 3, 6, 8 and 10 bits**

▶ NXP Passive Level-Shifter Portfolio

Device	Description	R _{ON}	Process	ESD (HBM)
PCA9306	2-Bit Bidirectional Voltage-Level Translator	3.5 Ω	CMOS	2kV
GTL2002	2-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
GTL2003	8-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
GTL2010	10-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
GTL2000	22-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
NVT2001/02/03/06/ 08/10	x-Bit Bidirectional Voltage-Level Translator	3.5 Ω	BiCMOS	>4kV



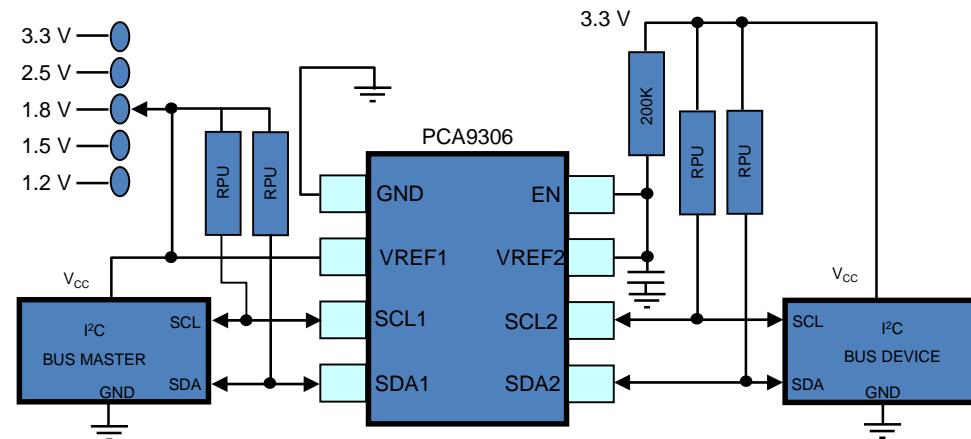
Bidirectional I²C-Bus & SMBus Level Translator

Features

- ▶ Bi-directional without need for direction pin
- ▶ Voltage translation between any voltage from 1.0 V to 5.5 V
- ▶ Lock-up free operation for isolation when EN = LOW
- ▶ Mixed-mode I²C-bus application: run two buses, one at 400 kHz other at 100 kHz operating frequency
- ▶ Excellent ESD performance

Applications

- ▶ Voltage Level Translation
 - Mixed-mode I²C-Bus Applications



NVT20xx: Level Translator Family

I²C

Storage
SSD

Where used?

- Digital Logic level translation
- TI's PCA9306 is drop-in replacement for NXP GTL2002 and PCA9306

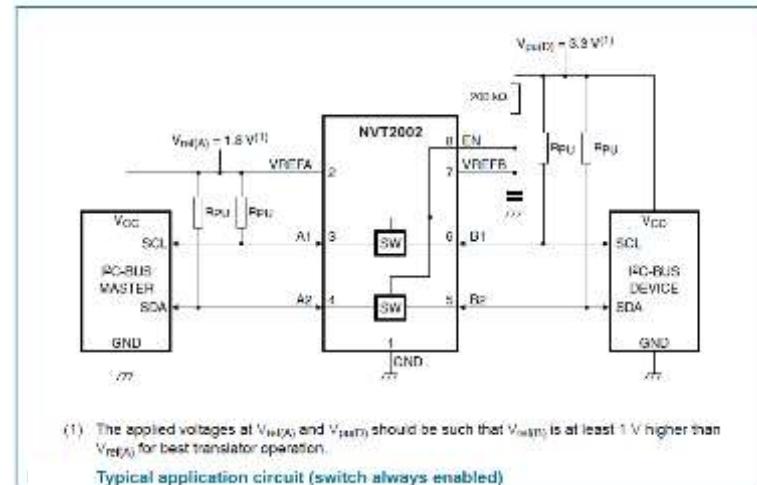
Why used?

- Voltage level shifting in range of 1V and 5V
- Bi-directional without direction pin

Why NXP NVT 20xx Level Shifter?

- More consistent device naming - NVT means “NXP Voltage Translator”
 - NVT2001 – 1-bit
 - NVT2002 – 2-bit (alt source GTL2002)
 - NVT2003 - 3-bit
 - NVT2006 – 6-bit
 - NVT2008 – 8-bit (alt source GTL2003)
 - NVT2010 – 10-bit (alt source GTL2010)
- In TSSOP and smaller packages
- Can be used as FET replacement
- Continuous innovation from NXP

# CH	New	OLD	Usage
1	NVT2001	--	Clock
2	NVT2002 PCA9306	GTL2002	I ² C
3	NVT2003	--	I ² C, server
6	NVT2006	--	
8	NVT2008	GTL2003	Digital RGB
10	NVT2010	GTL2010	Data Bus
22	--	GTL2000	



NVT2003 Level Translator

I²C

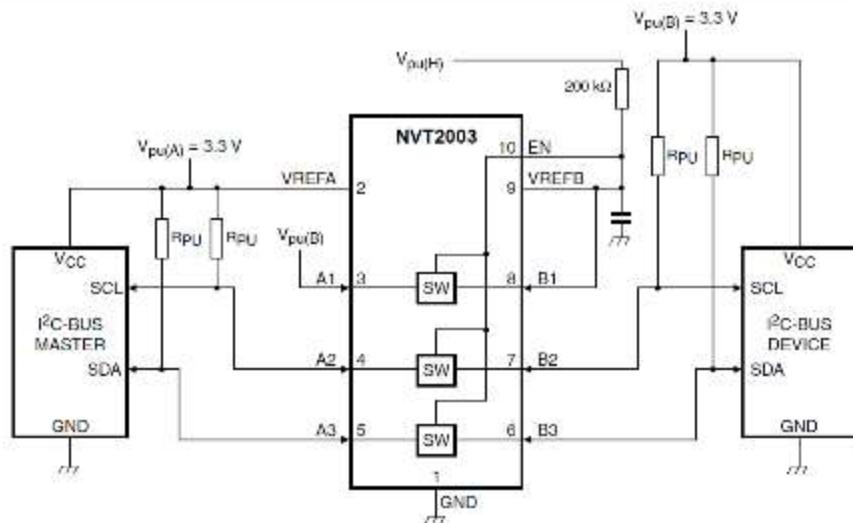
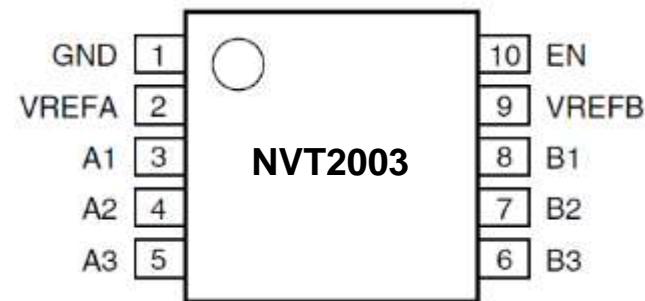
Storage
SSD

Where used?

- Small Level Translations
- Two power supplies for same line

Why used?

- Prevent “fighting” between redundant power supplies
- Bi-directional without direction pin



The applied enable voltage $V_{pu(H)}$ and the applied voltage at $V_{ref(A)}$ and $V_{ref(B)}$ should be such that $V_{ref(H)}$ is at least 1 V higher than $V_{ref(A)}$ and $V_{ref(B)}$ for best translator operation.

Bidirectional level shifting between two different power domains

Level Translators – NTB Family

I²C

Storage
SSD

3-State and Auto-Direction Sensing

- ▶ Auto-direction sensing
- ▶ Wide operating voltage range
- ▶ Dual-supply, translating transceiver
- ▶ Suitable for 3-state and push-pull applications
- ▶ Capacitance isolation
- ▶ Not recommended for open-drain applications (use NTS family instead)

CH	V RANGE	OUTPUT DRIVE	BW	DESCRIPTION	PACKAGE	PART#
1					SC-88, TSOP6, XSON6	NTB0101
2					TSSOP8, XSON8, XSON8U, XQFN10	NTB0102
4	1.65 - 3.6V to 2.3 - 5.5V	-20 µA/1 mA	25 MHz	3-state or push pull	XQFN12, DHVQFN14, WCSP12	NTB0104

NTB0102 Level Translator

I²C

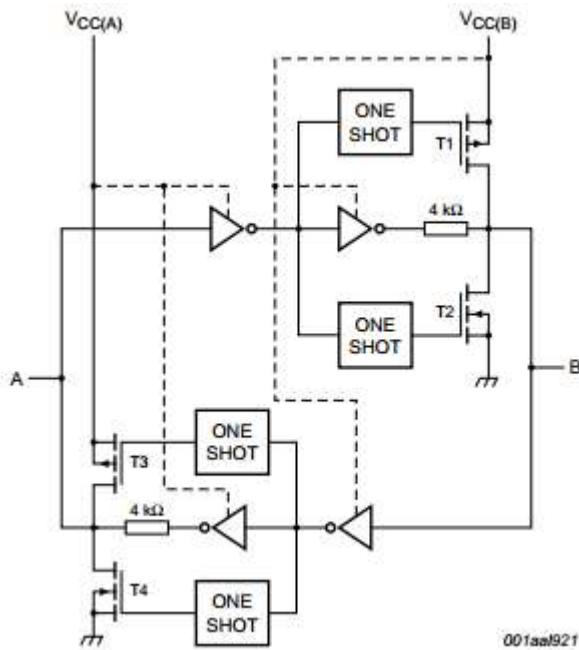
Storage
SSD

Auto-Direction Sensing, 3-state

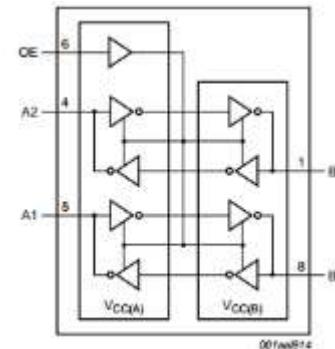
Features

- 2-bit, dual supply, bi-directional
- Auto direction sensing
- Two 2-bit data I/O ports, 1 output enable, 2 supply pins
- Translation: any voltage from 1.2 to 5.5V
- Supply voltage
 - VccA: 1.2 to 3.6V
 - VccB: 1.65 to 5.5V
- Partial power-down mode
- High impedance OFF-state
- ESD
 - 2.5kV / 15 kV HBM (JESD22-A114)
 - 200V MM (JESD22-A115)
 - 1.5kV CDM (JESD22-C101)

Replaces: NLSX5012, FXLA102, TXB0102



NTB0102 3 States



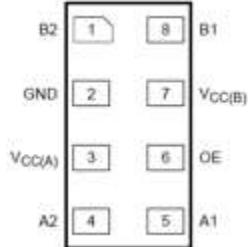
NTB0102 Level Translator

Auto-Direction Sensing, 3-state

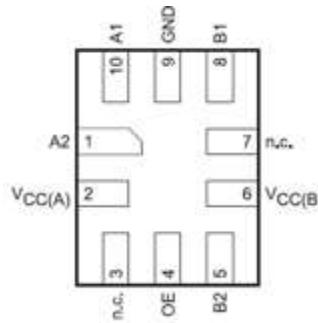
I²C

Storage
SSD

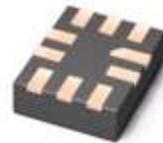
- Packaging: TSSOP8, XSON8, XSON8U, XQFN10



SOT833-1 (XSON8)
1.0 x 1.95, 0.5 mm pitch
SOT1089 (XSON8)
1.35 x 1.0, 0.35 mm pitch



SOT1160 (XQFN10)
1.4 x 1.8, 0.4 mm pitch



Suffix	GD	GM	GT
	SOT996	SOT902	SOT833
Width (mm)	8-pin	8-pin	8-pin
Length (mm)	3.00	1.60	1.00
Pitch (mm)	2.00	1.60	1.95
	0.50	0.50	0.50

NTB0104 Level Translator

Auto-Direction Sensing, 3-state

I²C

Storage
SSD

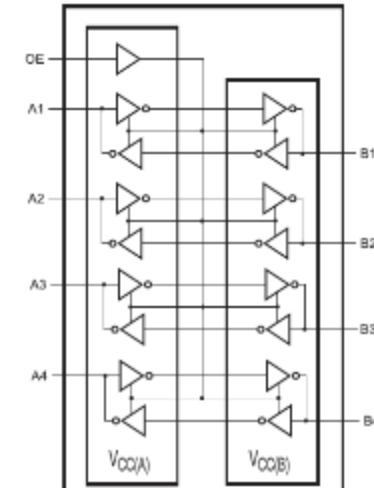
Features

- 4-bit, dual-supply bidirectional translating transceiver
- Auto-direction sensing
- Two 4-bit data I/O ports, 1 output enable, 2 supply pins
- Translates between any low voltage nodes: 1.2V, 1.5V, 1.8V, 2.5V, 3.3V and 5.0V
- Supply voltage
 - VccA: 1.2 to 3.6V
 - VccB: 1.65 to 5.5V
- Partial power-down mode
- High impedance OFF-state
- ESD: 2.5 kV / 15 kV HBM

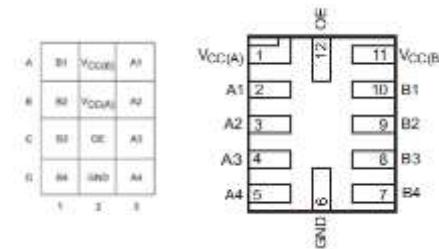
Packages

- XQFN12: 1.7 x 2.0 x 0.5, 0.4 mm pitch
- DHVQFN14: 2.5 x 3.0 x 0.85, 0.4 mm pitch
- WCSP12: 1.2 x 1.6 x 0.56, 0.4 mm pitch

Replaces: NLSX4014, FXLA104, TXB0104



NTB0104 3 States

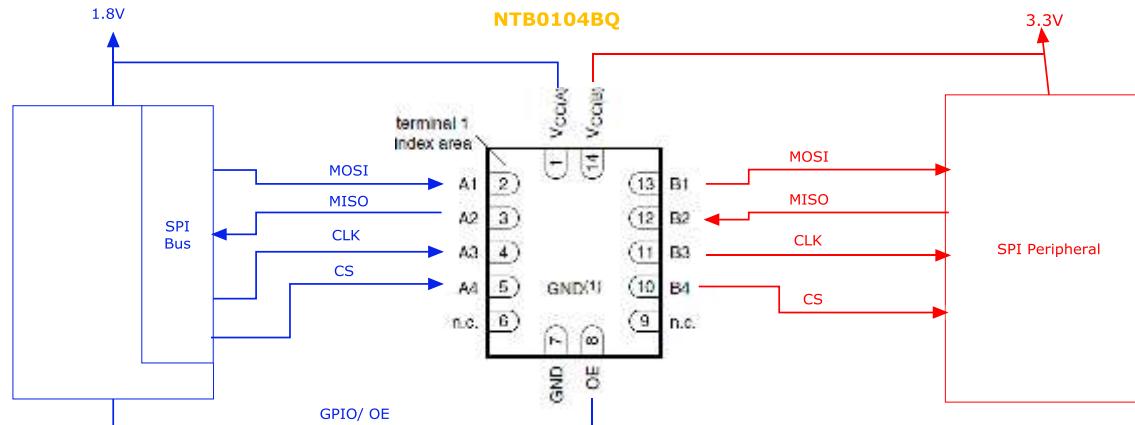


NTB0104 & 74AVC4TD245

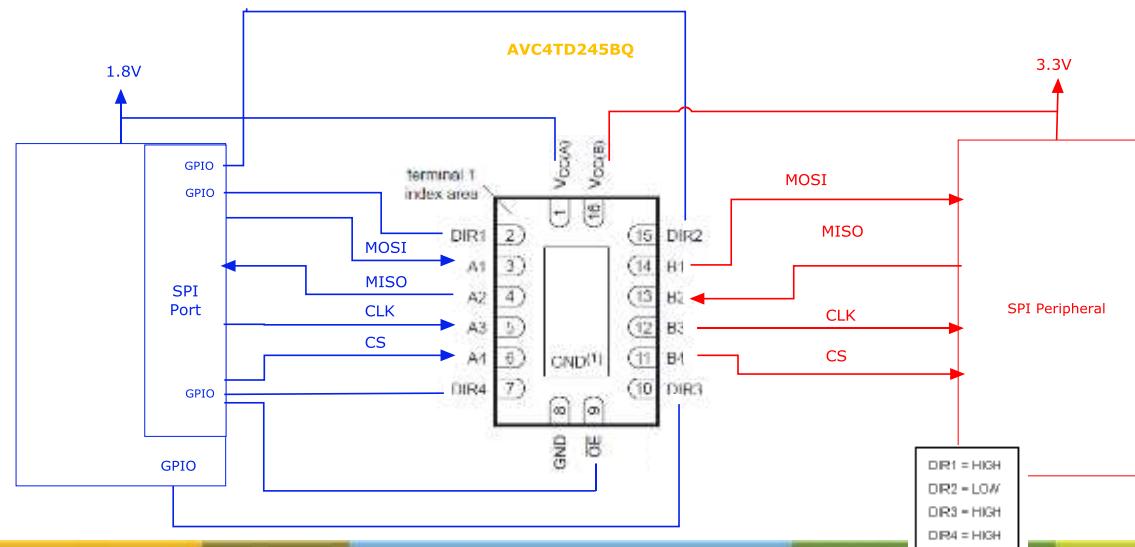
I²C

Storage
SSD

SPI-bus Application Example



* No external pull up resistors are required for SPI signal lines



Level Translators – NTS Family

I²C

Storage
SSD

Open Drain and Auto Direction Sensing

► Features

- Operating voltage range: 1.65 - 3.6V to 2.3 - 5.5V
- Low power consumption: 30 μ A max I_{CC}
- Uni or bi-directional, auto-sensing
- 1-, 2- and 4-bit in multiple small packages
- Push pull and open drain drivers: UART, GPIO, I²C, SMBus, etc.
- No external components required
- Suspend mode; partial power down with IOFF
- Standby mode
- Operating temp range: -40 to 125°C

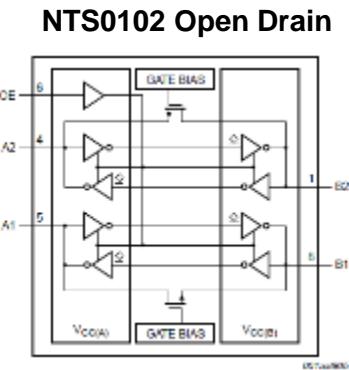
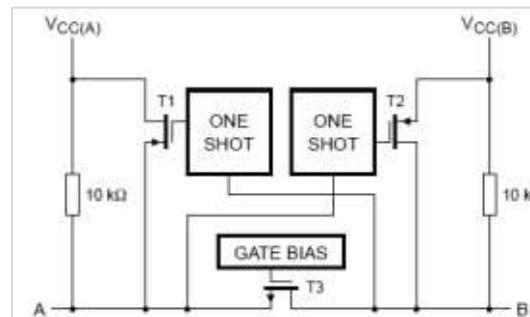
BITS	V RANGE	OUTPUT DRIVE	BW	DESCRIPTION	PACKAGE	PART#
1	1.65 - 3.6V to 2.3 - 5.5V	-20 μ A/1 mA	25 MHz	open drain	TSSOP8, XSON8, XQFN8, XQFN10	NTS0101
2						NTS0102
4					TSSOP14, XQFN12, WLCSP12	NTS0104
2	1.65 - 5.5V	-20 μ A/6 mA	25 MHz	open drain	XQFN8	NTSX2102

NTS0102 Level Translator



Auto-Direction Sensing, Open Drain

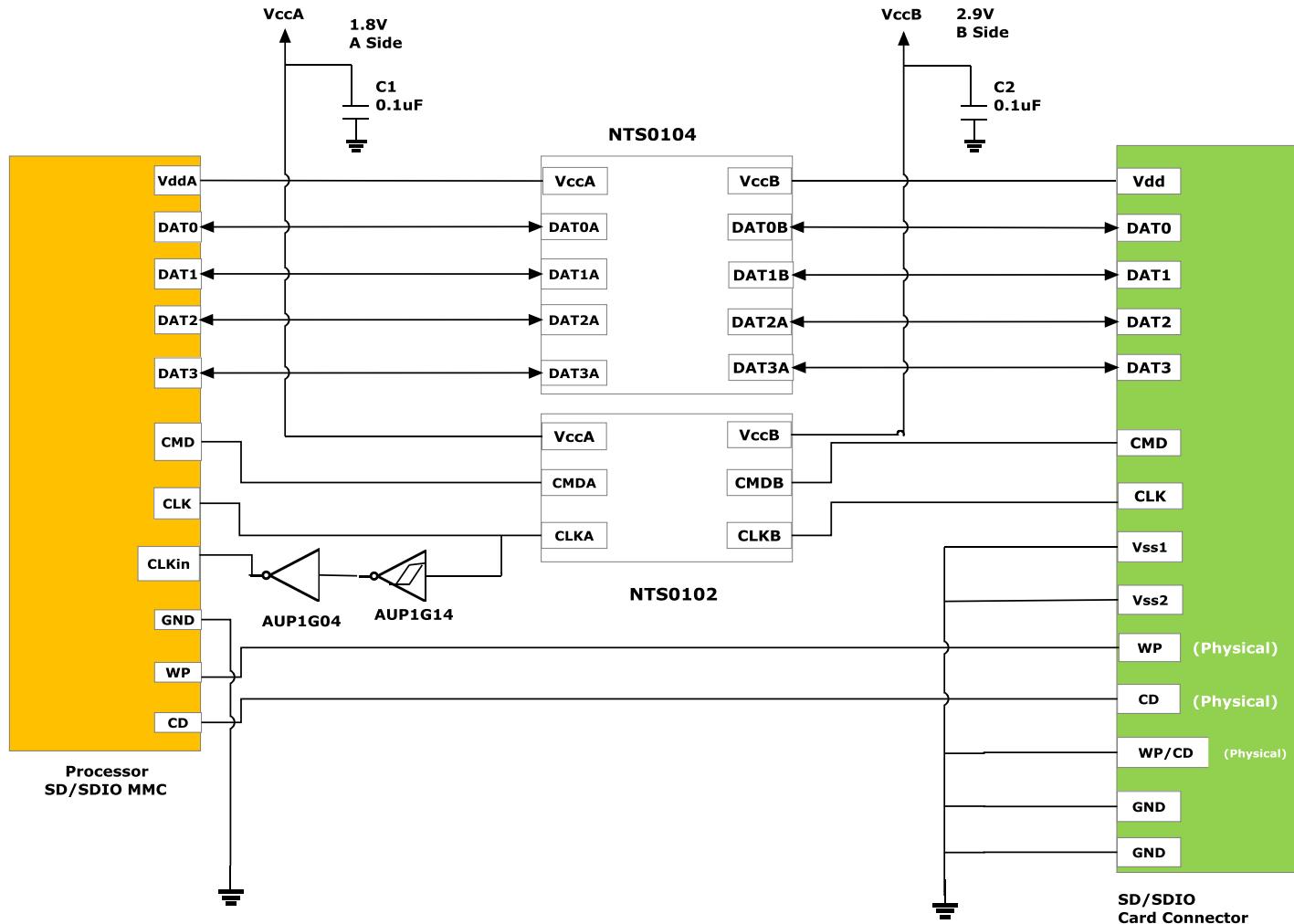
- ▶ 2-bit, dual supply, bi-directional
 - ▶ Features
 - Auto direction sensing
 - Two 2-bit data I/O ports, 1 output enable, 2 supply pins
 - Translation: any voltage from 1.65 to 5.5V
 - Maximum data rates:
 - Push-pull: 50 Mbps
 - Supply voltage
 - VccA: 1.65 to 3.6V
 - VccB: 2.3 to 5.5V
 - Partial power-down mode
 - High impedance OFF-state
 - ESD
 - 2.5kV / 8 kV HBM (JESD22-A114)
 - 200V MM (JESD22-A115)
 - 1.5kV CDM (JESD22-C101)
 - ▶ Replaces: NLSX4373, TXS0102
 - ▶ No external components required
 - One shot used to short (remove) the pull-up resistor during rising edges
 - Edge acceleration eliminates external pull-up resistors, lowering total power dissipation in open-drain applications such as I²C and SMBus



NTS0102/0104 Level Translators Application

SD Card Reference Design

I²C
Storage
SSD



NTS0104 Level Translator

I²C

Storage
SSD

Auto-Direction Sensing, Open Drain

Features

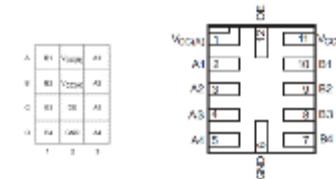
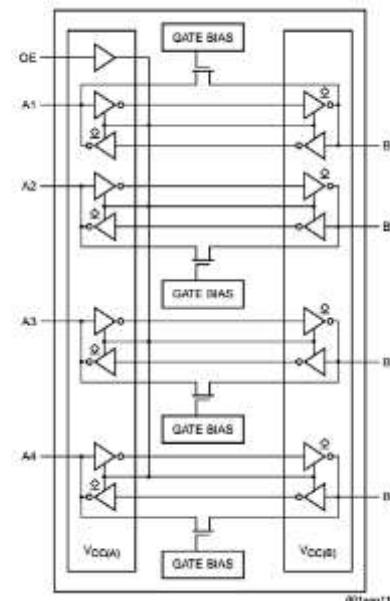
- 4-bit, dual-supply bidirectional translating transceiver
- Auto-direction sensing
- Two 4-bit data I/O ports, 1 output enable, 2 supply pins
- Translation: any voltage from 1.65 to 5.5V
- Supply voltage
 - VccA: 1.65 to 3.6V
 - VccB: 2.3 to 5.5V
- Partial power-down mode
- High impedance OFF-state
- ESD: 2.5 kV / 8 kV HBM

Packages

- TSSOP14
- XQFN12: 1.7 x 2.0 x 0.5, 0.4 mm pitch
- DHVQFN14: 2.5 x 3.0 x 0.85, 0.4 mm pitch
- WCSP12: 1.2 x 1.6 x 0.56, 0.4 mm pitch

Replaces: TXS0104

NTS0104 Open Drain



NTSX2102 Level Translator

I²C

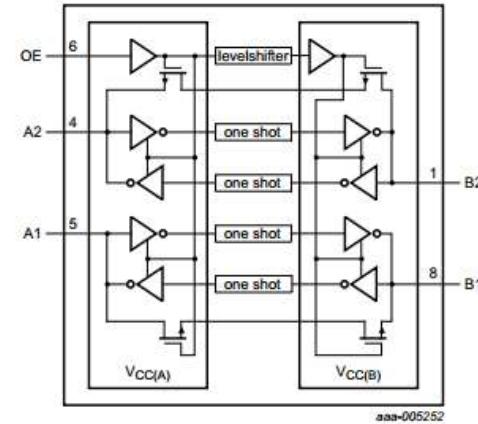
Storage
SSD

Auto-Direction Sensing, Open Drain

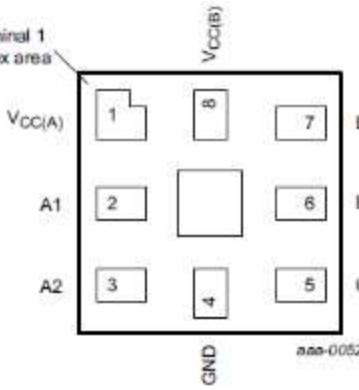
Features

- 2-bit, dual supply translating transceiver
- Auto-direction sensing
- Bidirectional voltage level translation
- Two 2-bit data I/O ports, one output enable, two supply pins
- Output edge-rate accelerator that detects and accelerates rising and falling edges on the I/O pins
- Translates between any low voltage nodes: 1.2V, 1.5V, 1.8V, 2.5V, 3.3V and 5.0V
- Operates at
 - V_{ccA} = 1.65 to 5.5V supply
 - V_{ccB} = 1.65 to 5.5V supply
- Inputs up to 5.5V
- Partial power-down mode
- High impedance OFF-state

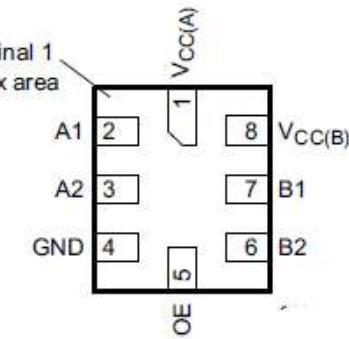
NTSX2102 Open Drain



aaa-005252



SOT902 (XQFN8)
1.6 x 1.6, 0.4 mm pitch



SOT1309 (XQFN8)
1.4 x 1.2, 0.4 mm pitch

Level Translators

AUP, AVC, and LVC Families

I²C

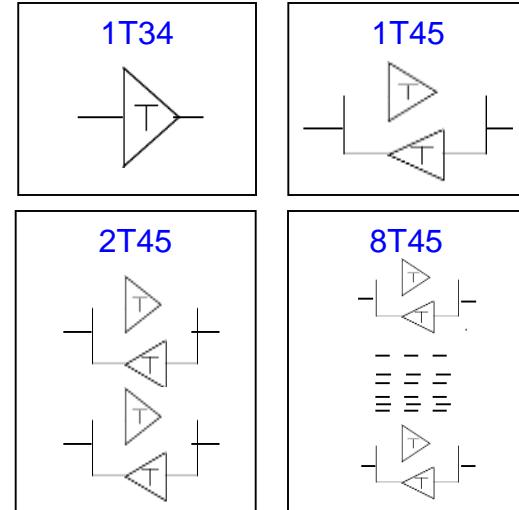
Storage
SSD

- ▶ Three families address most non-I²C-bus requirements

- **AUP**: 1.1 to 3.6V operating range
- **AVC**: 0.8 to 3.6V operating range
- **LVC**: 1.2 to 5.5V operating range

- ▶ Features

- Wide operating voltage (0.8 to 5.5V)
- Bi-directional
- High speed (2ns typical)
- High current capability (up to 50mA)
- Overvoltage (>Vcc) tolerant I/O
- Level translation
- Lowest power consumption
- Live Insertion and Bus hold support insertion and removal of adapter cards without power down
- Stand by/Suspend mode
- TTL compatible inputs
- Configurable logic functions
- Lead-free, RoHS and Dark Green compliant
- Wide variety of leadless packages: TSSOP, PicoGate, MicroPak™, DQFN



AUP Family

I²C

Storage
SSD

Advanced, Ultra-low Power, Bidirectional

► Features

- Operating range: 1.1 to 3.6V
- Low power consumption: .9 µA max ICC
- Level translation
- Extremely low static & dynamic power consumption
- Small footprint packages: TSSOP, XSON
- High noise immunity
- Suspend mode; partial power down with IOFF
- Operating temp range: -40 to 125°C

	CH	SUPPLY V	OUTPUT DRIVE	BW	DIRECTION CONTROL	PACKAGE	PART(S)
AUP FAMILY	1	1.1 - 3.6V	+/- 4mA	250 MHz	Yes	SC-88, XSON6	74AUP1T45
	1	1.1 - 3.6V	+/- 4mA	250 MHz	No	TSSOP5, XSON6, X2SON5	74AUP1T34

Bus Buffers for SPI and Other Buses

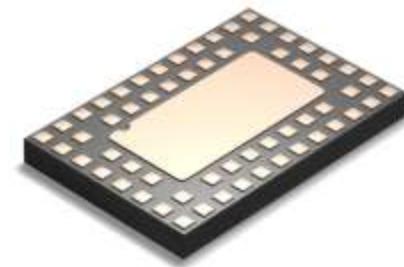
I²C

Storage
SSD

AVC Family: .8 to 3.6V, Bidirectional

► Features

- Operating range: .8 to 3.6V
- Low power consumption: 23 μ A max I_{CC}
- Level translation
- Small footprint packages: TSSOP, XSON, DQFN, and DR-QFN
- High noise immunity
- Suspend mode; partial power down with I_{OFF}
- Operating temp range: -40°C to 125°C



AVC "H" parts have bus hold at inputs

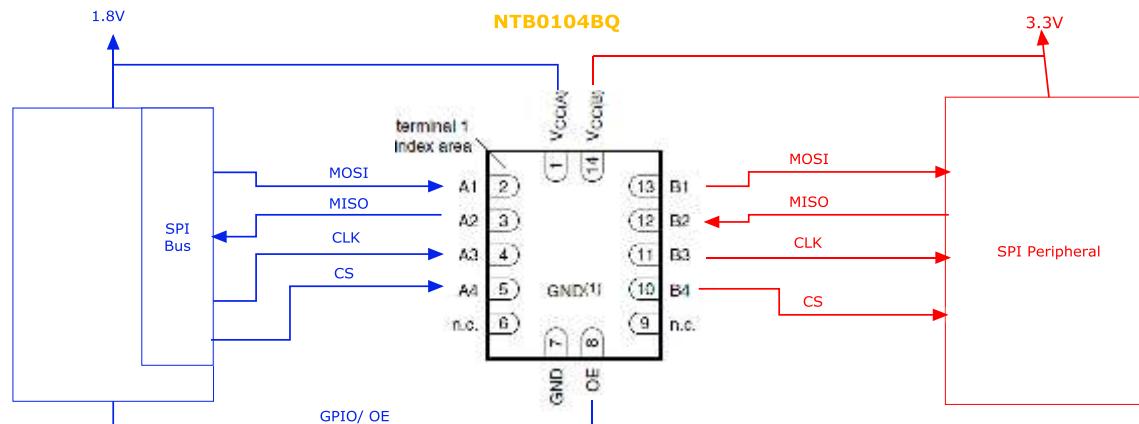
CH	SUPPLY V	OUTPUT DRIVE	BW	OE CONTROL	PACKAGE	PART#
1	0.8 to 3.6V	± 12 mA	250 MHz	no	SC-88, XSON6	74AVC(H)1T45
2				no	TSSOP8, VSSOP8, XSON8	74AVC2T45
4					VSSOP8, XSON8	74AVCH2T45
8				yes	SO16, TSSOP16, DHVQFN16, XQFN16	74AVC(H)4T245
16					TSSOP24, DHVQFN24	74AVC(H)8T245
20				yes	TSSOP48, VFBGA56, HXQFN60	74AVC(H)16T245
					TSSOP56, HXQFN60U	74AVC(H)20T245
					TSSOP56, HXQFN60	74AVC(H)20T245

AVC4TD245 Example Application

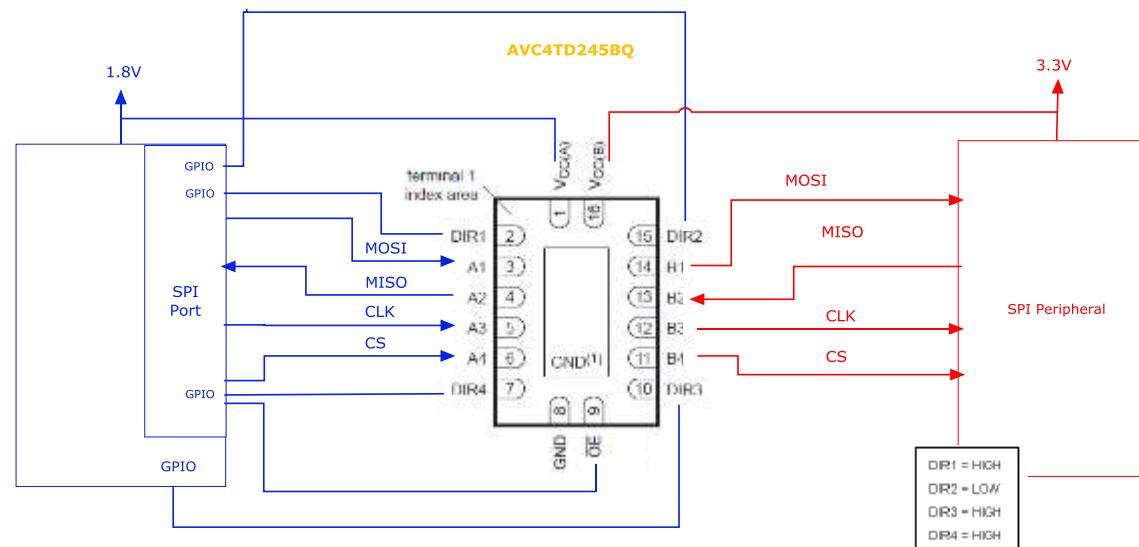
I²C

Storage
SSD

SPI-bus



* No external pull up resistors are required for SPI signal lines



LVC Family

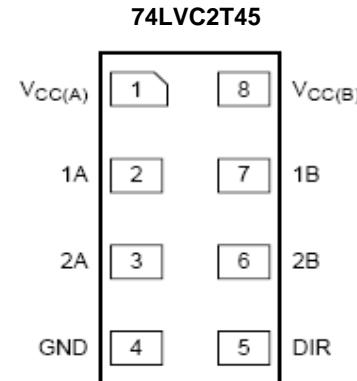
I²C

Storage
SSD

1.2 to 5.5V, Bi-directional

► Features

- Operating range: 1.2 to 5.5V
- Low power consumption: 30 μ A max I_{CC}
- Level translation
- Small footprint packages: TSSOP, XSON
- High noise immunity
- Suspend mode; partial power down with I_{OFF}
- Operating temp range: -40 to 125°C



CH	SUPPLY V	OUTPUT DRIVE	BW	OE CONTROL	PACKAGE	PART#
1	1.2 to 5.5V	+/- 24 mA	210 MHz	no	SC-88, XSON6	74LVC(H)1T45
2	1.2 to 5.5V			no	VSSOP8, XSON8	74LVC(H)2T45
8	1.2 to 5.5V			yes	TSSOP24, DHVQFN24	74LVC(H)8T245
8	1.5 to 5.5V - 1.5 to 3.6V			yes	SO24, SSOP24, TSSOP24, DHVQFN24	74LVC4245A
16	1.5 to 5.5V - 1.5 to 3.6V			yes	SSOP48, TSSOP48, HXQFN60	74ALVC164245

GTL Value Proposition

► Where used?

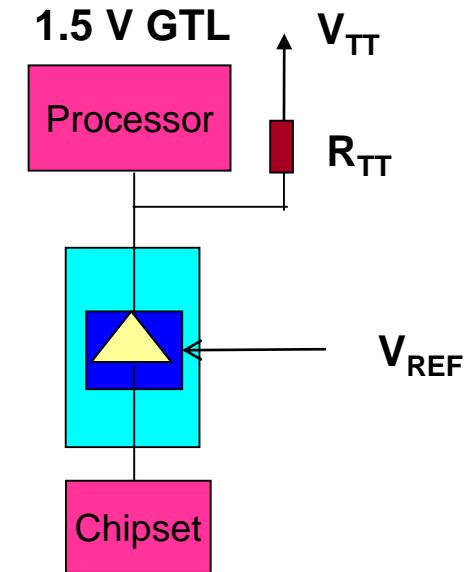
- Signal voltage conversion between low voltage processor and LVTTL device

► Why Gunning Transceiver Logic (GTL)?

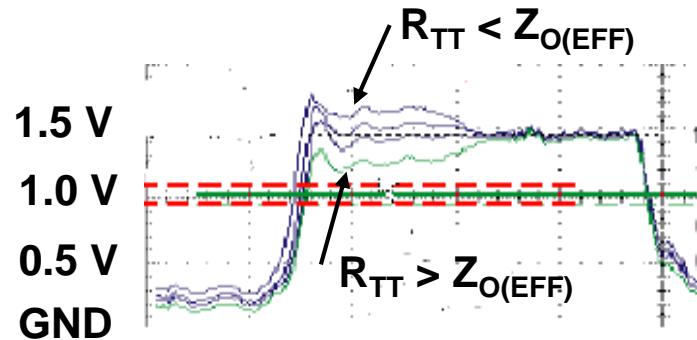
- Largest selection of GTL devices available
- Provide level transition between GTL I/O and LVTTL I/O
- Low voltage open drain interface with externally supplied V_{REF} threshold voltage with $\pm 0.05V$ V_{IL} & V_{IL} range and R_{TT} sized to match trace impedance to minimize reflections.

► Why Dedicated GTL Processor to Chipset Interface?

- Work with Intel on new device functionality that is required with their processors
- Integrated control logic using GTL and LVTTL input line levels
- Enable pin to disable signals
- Saves board space and component count



3.3 VLTTL



$$Z_o = 50 \text{ Ohm}$$

4 bit GTL to LVTTL Bus Transceiver

Application

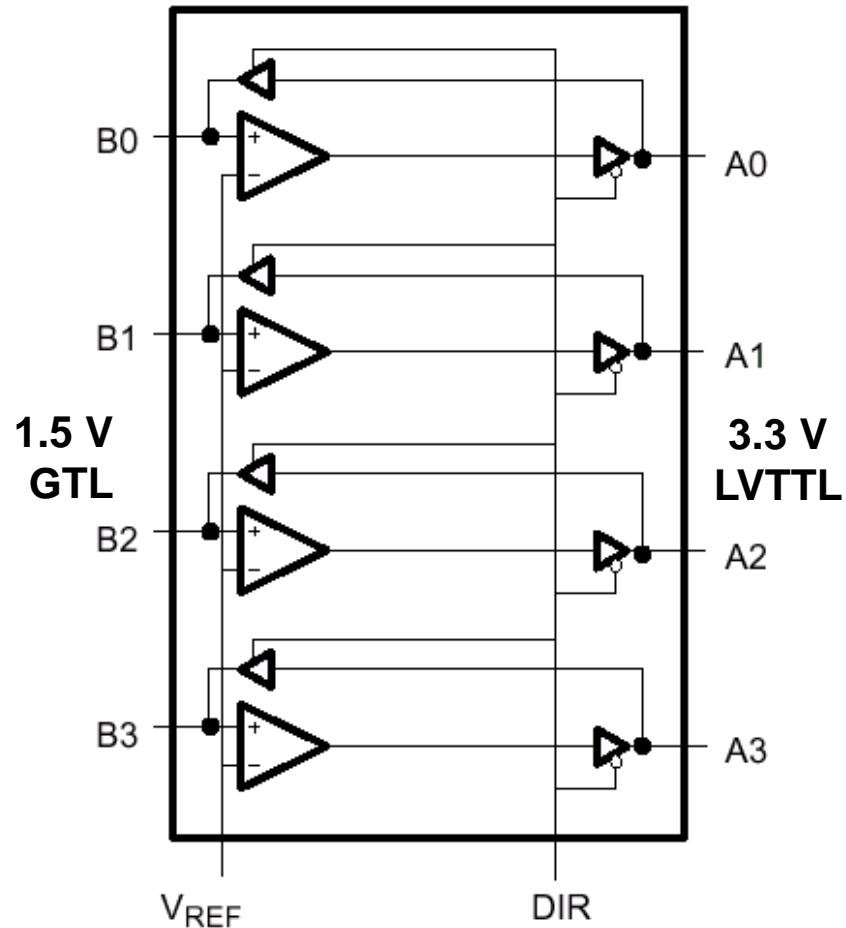
- Intel Server Architecture

Features

- 4-bit LVTTL to GTL translation
- 3.3V V_{CC} with 5 V tolerance
- ± 12 mA A-Port
- Medium Drive (40 mA) B-Port
- Supports Hot Insertion
- 175 MHz Operation
- 14 pin TSSOP package

Similar Devices

- 2-bit GTL2012
- 4-bit GTL2014 - Alt source GTL2005
- 8-bit GTL2018
- 4-bit GTL2034 - GTL to GTL buffer



GTL Active Translation Device Status



Device	Function
GTL2005	4-bit GTL to LVTTL
GTL2006	13-bit Xeon translator
GTL2007	12-bit Xeon translator with power good
GTL2008	12-bit Xeon translator with power good & Hi Z outputs
GTL2009	3-bit Xeon FSB comparator
GTL2012	2-bit GTL to LVTTL
GTL2014	4-bit GTL to LVTTL
GTL2018	8-bit GTL to LVTTL
GTL2034	4-bit GTL to GTL
GTL2107	12-bit Xeon translator with power good & Hi Z outputs

Multiplexers, Demultiplexers & Switches

Multiplexers & Switches Value Proposition



▶ Why used?

- Address conflict resolution if two devices with same address need to be on the same bus
- Voltage level translation to allow devices with different voltage supplies to operate on the same I²C-bus
- Broadcast communication to identically addressed slaves

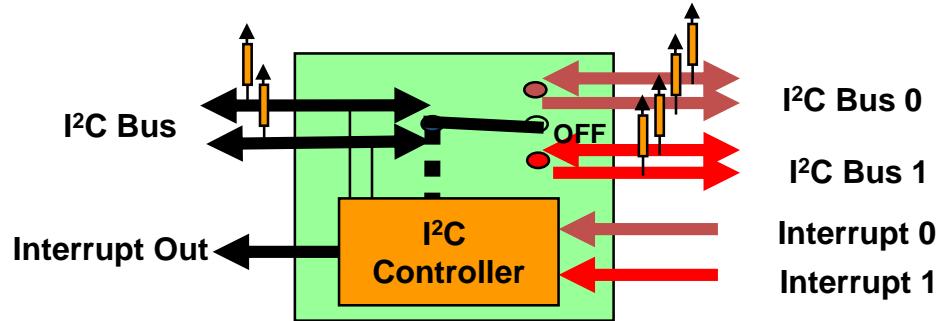
▶ Where used?

- Networking, Telecom, Base-station, Backplane and anywhere that requires the I²C-bus to be split

▶ Differences between Multiplexers & Switches?

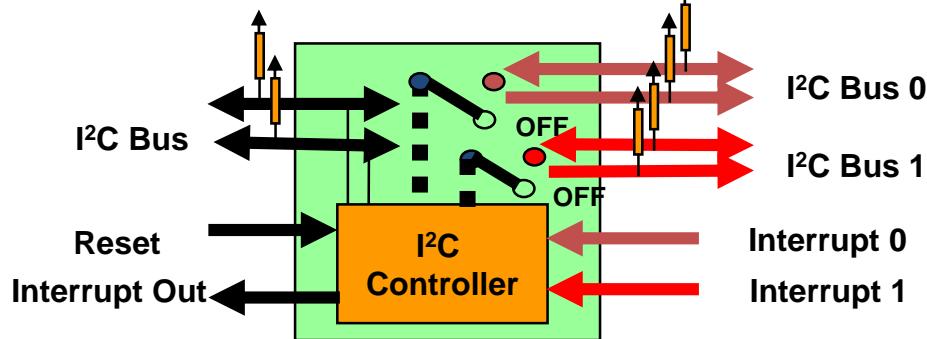
- A mux can select only one channel at a time, while a switch can select one or more channels at a time.

Application Note AN262



Multiplexer

Can only select one downstream channel at a time



Switch

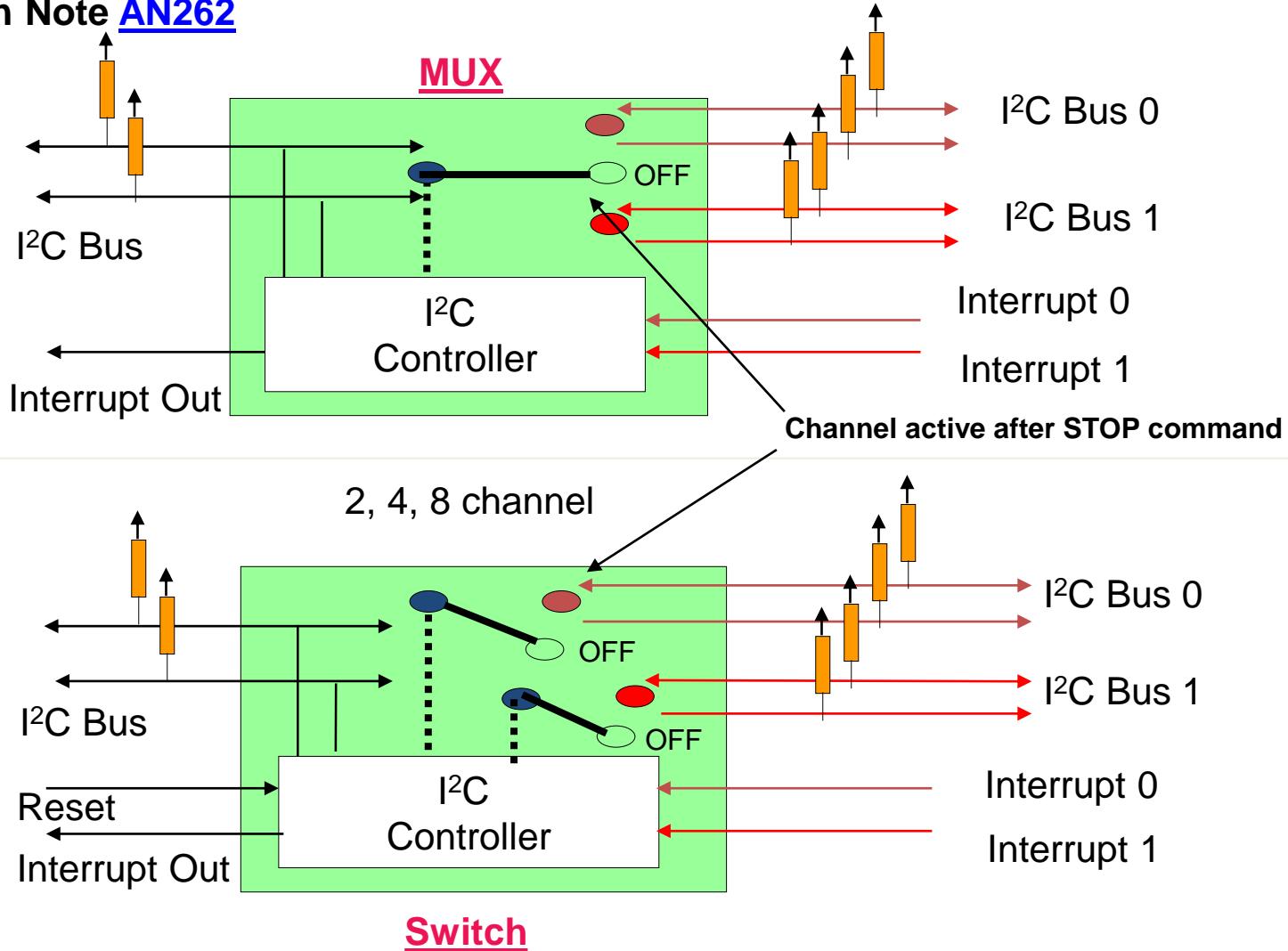
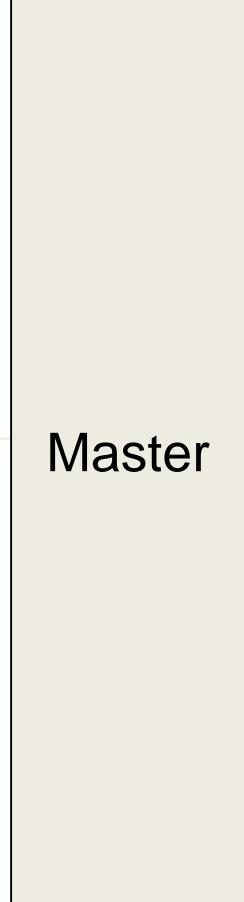
Can select one or more downstream channels at a time.
Multiple channels are selected in broadcast mode.

What are Multiplexers and Switches

I²C

Storage
SSD

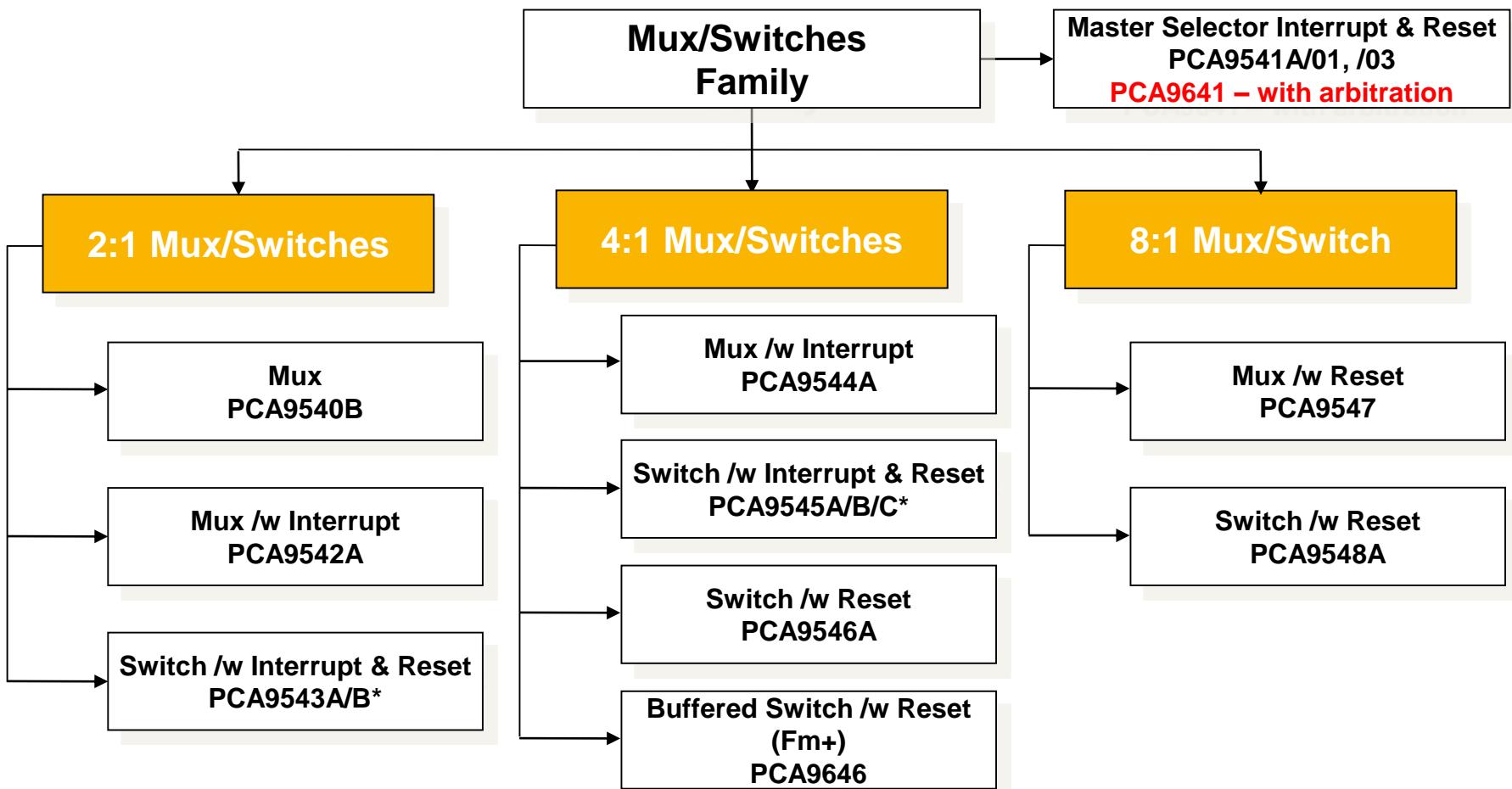
- Application Note [AN262](#)



Multiplexer / Switch Family

I²C

Storage
SSD

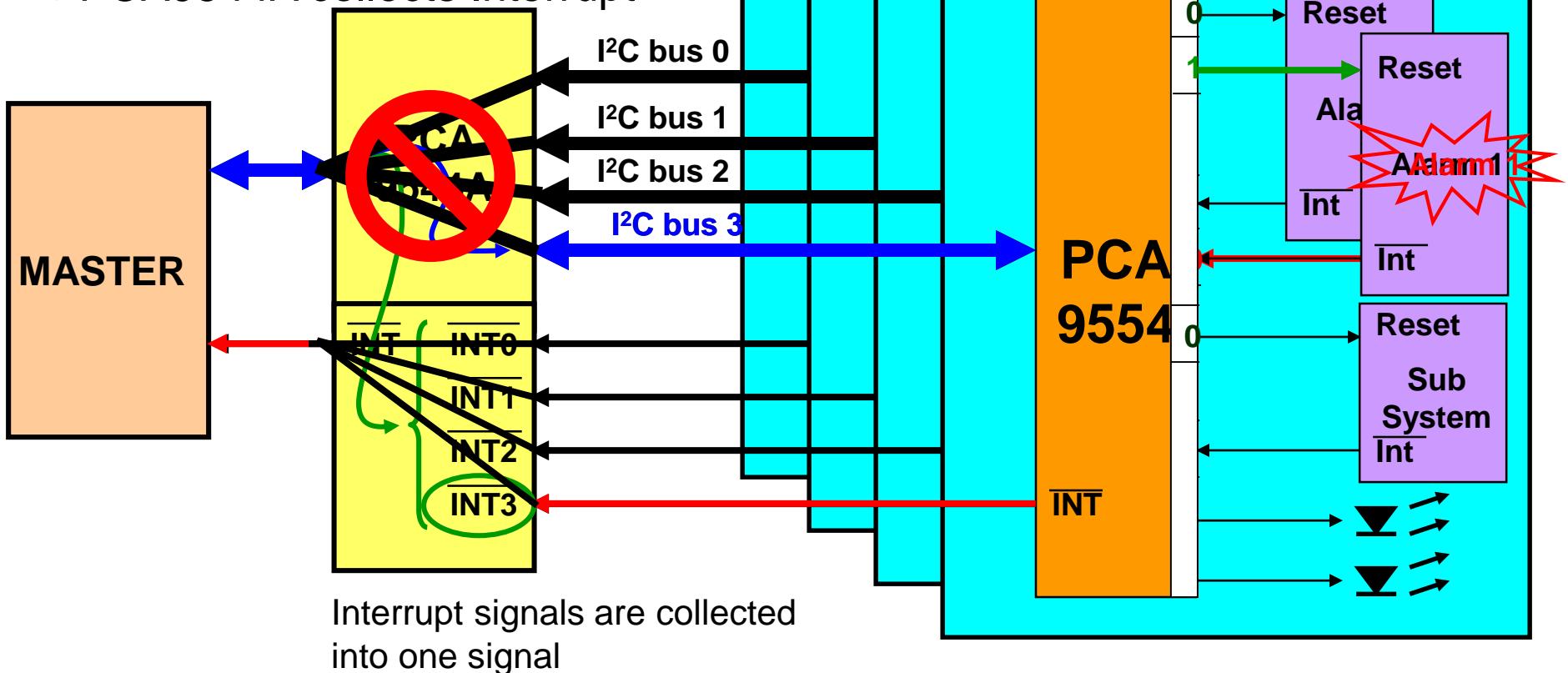


* Note: A and B have different I²C fixed address

I²C Multiplexers: Multi-card Application

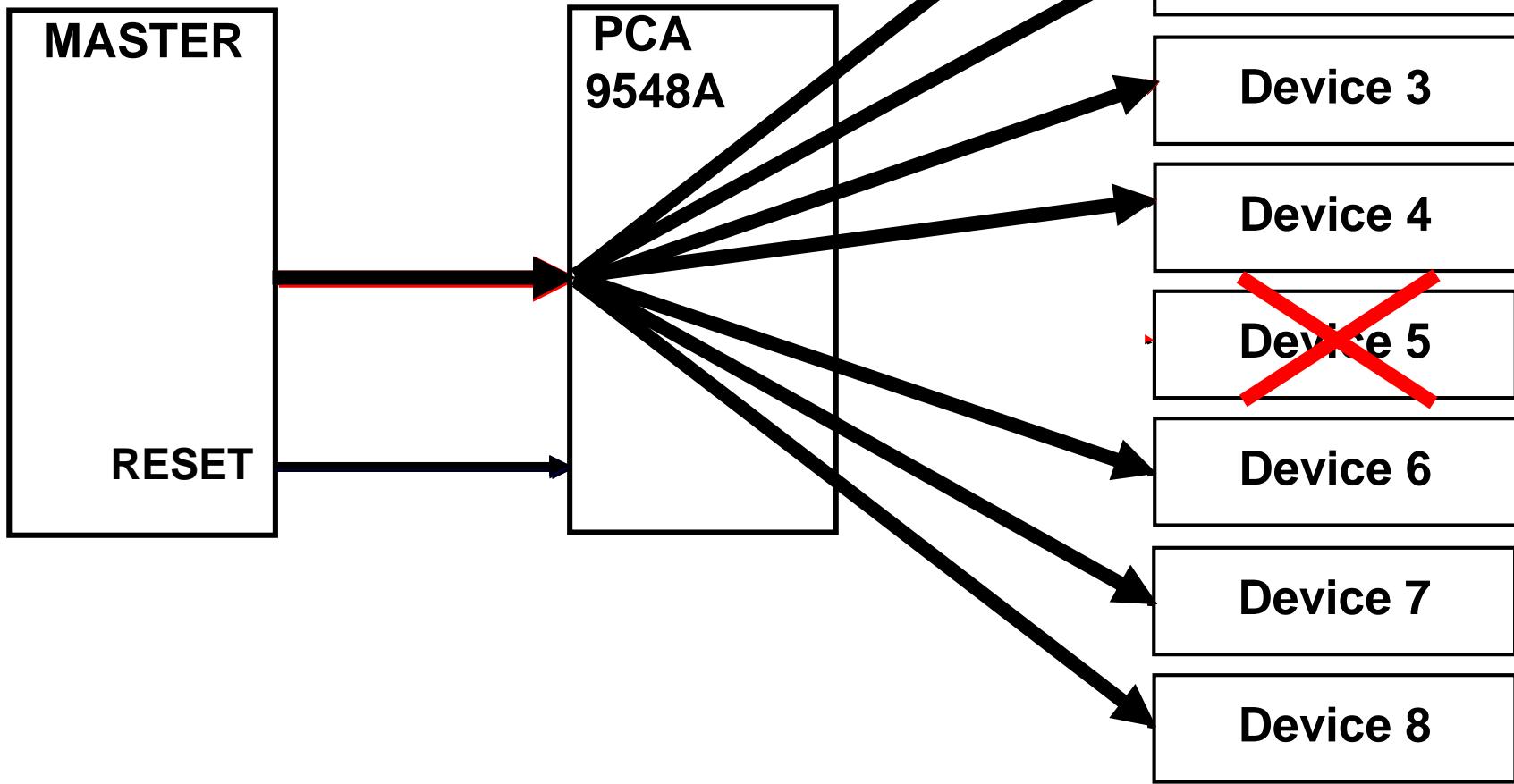


- ▶ Cards are identical
- ▶ One card is selected / controlled at a time
- ▶ PCA9544A collects Interrupt



Isolate An I²C Hanging Segment

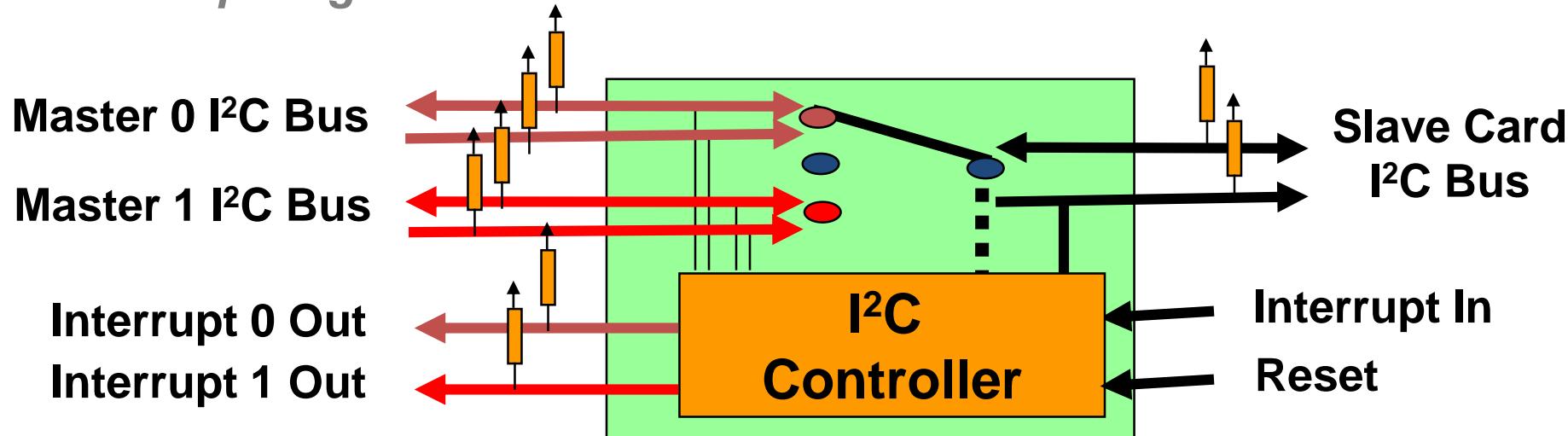
- Isolating individual device becomes very easy for troubleshooting and maintenance.



Two to One I²C Master Selector



w/Interrupt Logic and Reset



FEATURES

- Select one of two I²C masters to a single channel
- I²C/SMBus commands used to select channel
- Reset or Power On Reset (POR) resets state machine
- Interrupt outputs also report demultiplexer status
- Sends 9 clock pulses and stop condition to clear slave card prior to transferring master

KEY POINTS

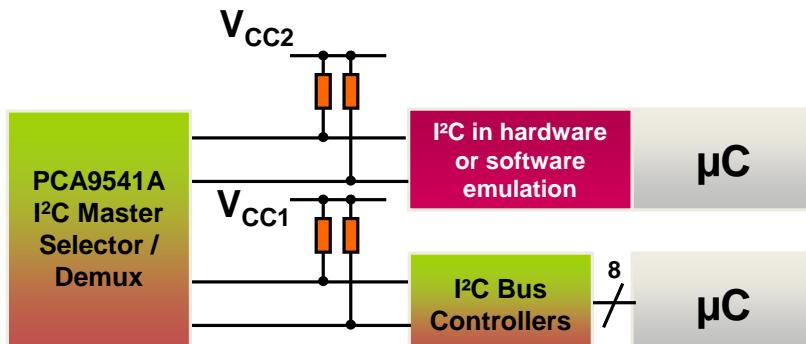
- Allows primary and backup master to communicate to one downstream slave card.
- Arbitration circuit between bus masters
- Doesn't isolate bus capacitance
- Allows voltage translation between 1.8 V, 2.5 V, 3.3 V and 5 V
- Idle detect for live insertion protection

- PCA9541A/01 - defaults to channel 0 on start-up/reset
- PCA9541A/03 – defaults to off on start-up/reset, master commands channel

PCA9541A – Master Selector Switch

I²C

Storage
SSD



► Features

- 4 address pins allowing up to 16 devices on the I2C-bus
- Channel selection via I2C-bus
- Supports hot insertion
- Sends 9 clock pulses and stop condition to clear slave card prior to transferring master
- Packages offered: SO16, TSSOP16, HVQFN16

► Why used?

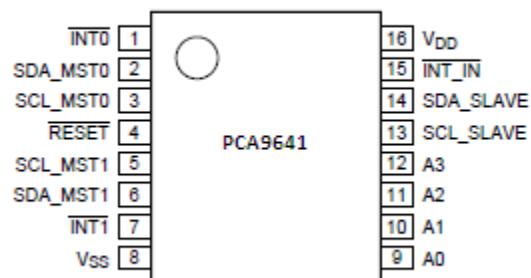
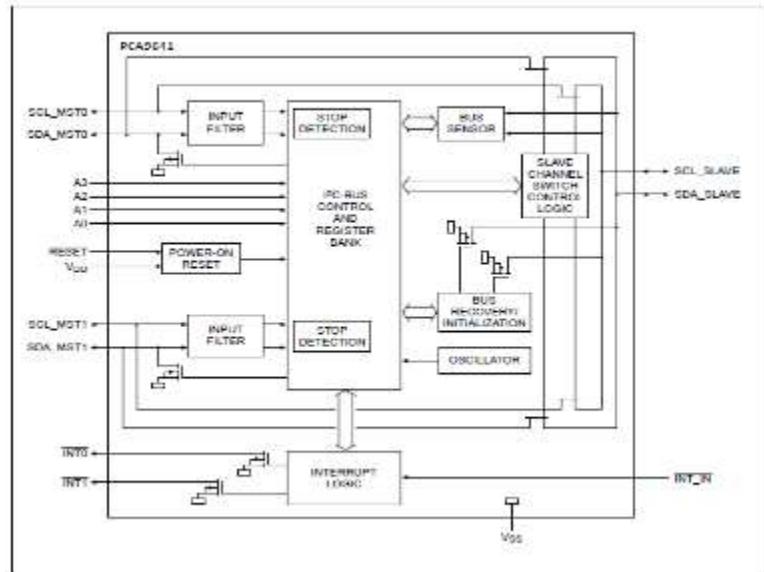
- Add multi-master capability to a system
- Add Isolation in multi-master system
- Allows primary and backup master to communicate to one downstream slave card.
- Arbitration circuit between bus masters
- Allows voltage translation between 1.8 V, 2.5 V, 3.3 V and 5 V
- Idle detect for live insertion protection

► Application

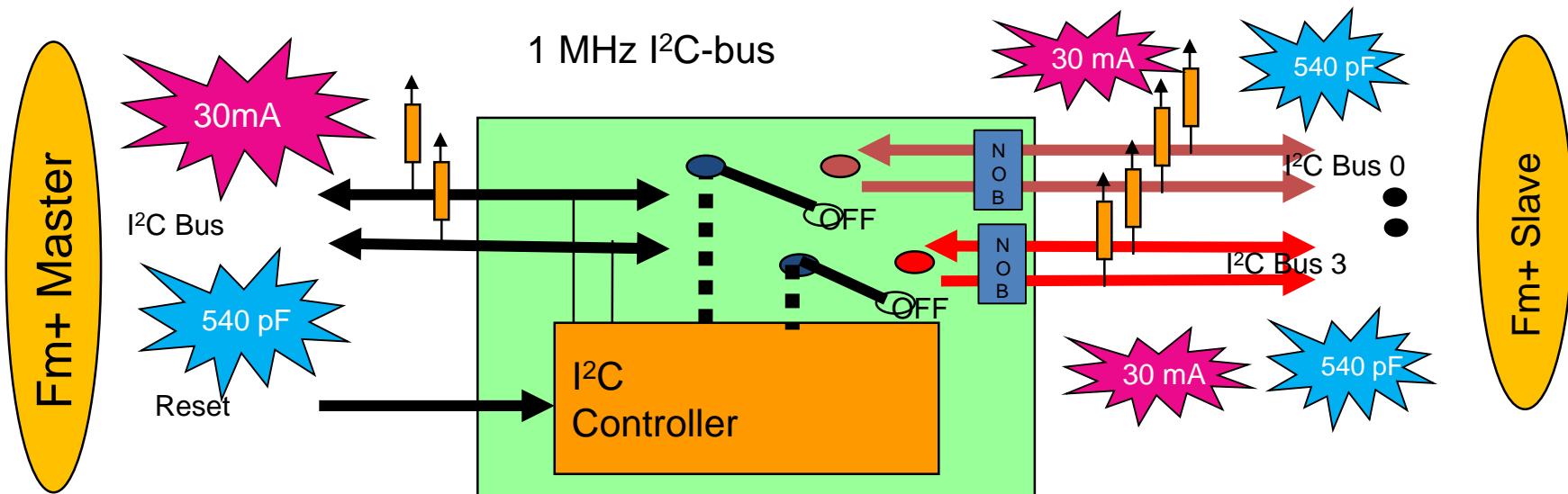
- Fan control unit
- Power supply unit
- Field replaceable unit
- Line cards, Switching cards

PCA9641 Two-to-One Demux with Arbitration

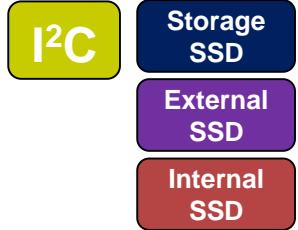
- Drop in version of PCA9541A that supports arbitration between the two master to select control of the slave.
- Solves concern with PCA9541A that both masters could select the slave around the same time, and the last one to perform the write would be the one that gets control of the bus without the other master knowing it didn't have control.
- Neither channel 0 or 1 selected at start up and is deselected after stop condition.
- Master 0 and Master 1 arbitration.
- Arbitration will be performed with a fixed priority to Master 0.
- When a Master is done with the transmission, the PCA9641 will return to neutral
- Once a Master has taken control of the bus, the other master is locked out until the PCA9641 is returned to neutral.
- A bus time-out function will release the masters from the bus, generate a stub bus recovery sequence (9 SCL clocks to slaves), and return the PCA9641 to idle.
- Software reset will return the PCA9641 to start-up condition. This can also be used to kick-off another master from the slave bus if needed.
- BUSINIT function will generate 9 clocks downstream before connecting bus.



PCA9646 Fm+ 4 channel I²C Switch

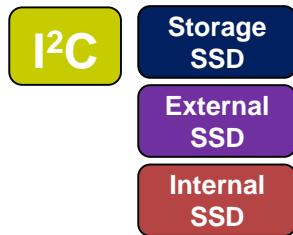


- Fast-mode Plus (Fm+) rated PCA9546A (1 MHz I²C core and 30 mA SDA drive) that works in the Fm+ system to allow Fm+ masters to fan out to four Fm+ bus segments.
- Maximum speed and capacitance loading (1 MHz with 550 pF) is available on each channel due to no offset buffer integrated for each of the bus segments.
- **No Offset bus buffers** require no masters or clock stretching on the downstream bus segments and voltage level translation is not available.



Temperature Sensors

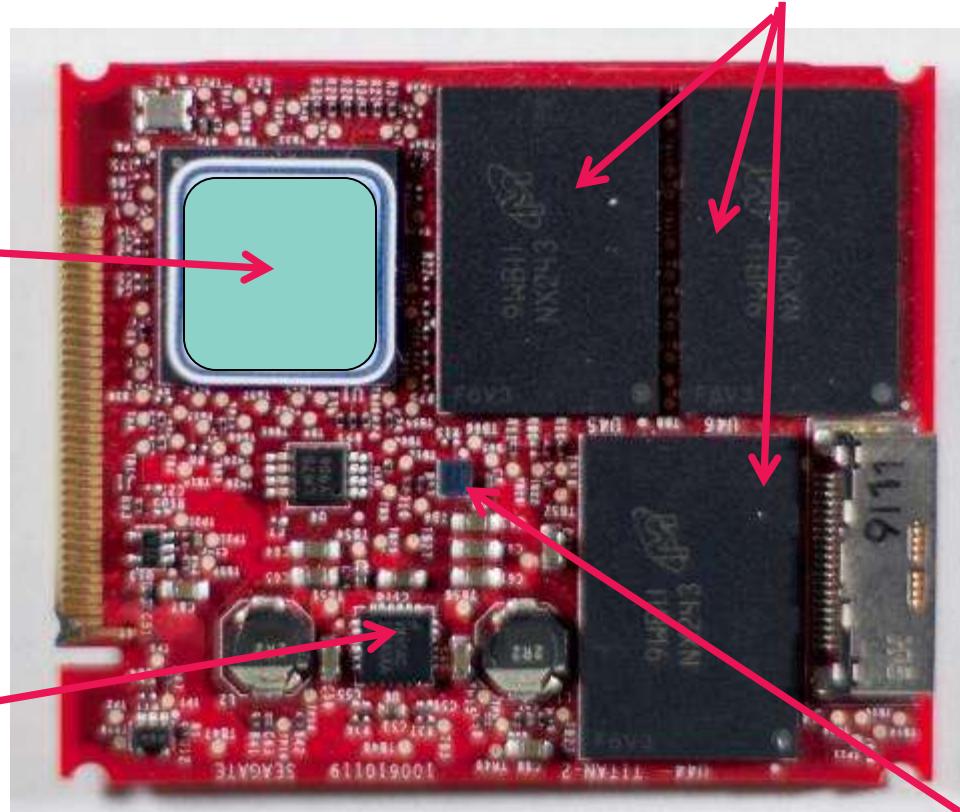
Temp Sensor in SSD Applications



High Density
Memory Array (Flash)

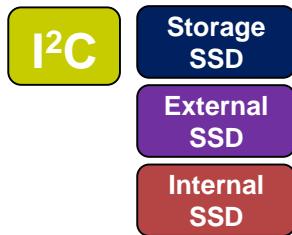
Power-hungry
Controller

High current
Switched-mode
Power Supply

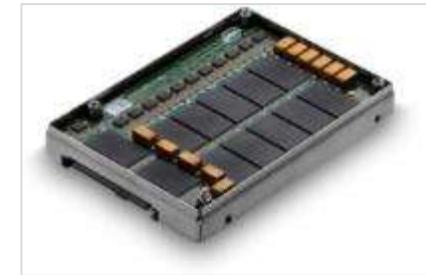
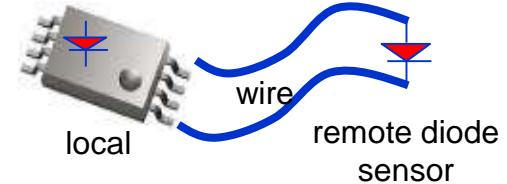


**Temp Sensor
for thermal
management**

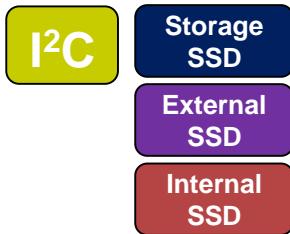
I²C Temperature Sensors



- ▶ Determine temperature and set window for interrupt, shutdown, etc.
- ▶ Applications
 - Server, workstation and storage motherboards, enterprise SSD and hybrid drives power supplies, DIMM modules
- ▶ Large selection of commonly used local and local/remote thermal sensors
 - Wide range of packages
 - Continuous innovation with lower voltage, smaller package and higher accuracy



I²C Temperature Sensor Portfolio

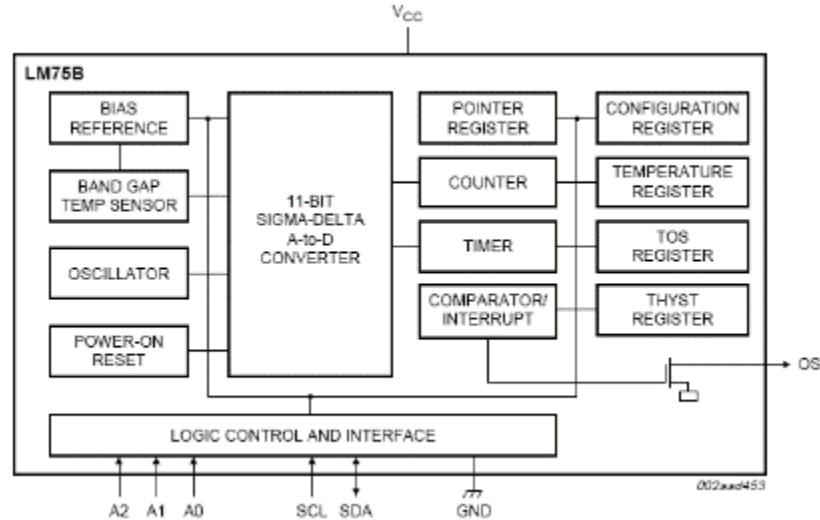


V RANGE	ACCURACY (LOCAL)	ACCURACY (REMOTE)	SMBus TIMEOUT	TEMP RES.	ADC RES.	SUPPLY CURRENT	NOTES	PACKAGE	PART#	
2.8 to 5.5V	±2 °C			YES	0.125	11-bit	operating: 300 µA standby: 1 µA	industry standard,	SO8, SSOP8, XSON8U, HWSN8 (metal pad)	LM75B
2.7 to 5.5V				YES	0.125	11-bit	operating: 200 µA standby: 1 µA		SO8, MSOP8, HWSN8, SOT23-6 (TSOP6)	PCT2075
1.7 to 3.6V				YES	0.125	11-bit	operating: 400 µA standby: 5 µA	low voltage	HWSN8	SE98A
3.0 to 3.6V				YES	0.125	11-bit	operating: 400 µA standby: 3 µA	DDR3, 2K EEPROM	HWSN8	SE97B
NEW	1.65 to 1.95V ±1.0°C typ. (-40 to +125 °C) ± 0.5°C typ. (0 to +85 °C)			YES	0.0625	12-bit	operating: 30µA standby: 1 µA	TMP102 replacement, 1.8V	WLCSP6	PCT2202
3V to 5.5V	±2 °C	±3 °C		1.0	8-bit	operating: 70 µA standby: 3 µA		QSOP16	NE1617A	
3.0V to 3.6V	±2 °C	±1 °C		0.125	11-bit	operating: 500 µA standby: 10 µA		SO8, TSSOP8, HVSN8	SA56004	



Features

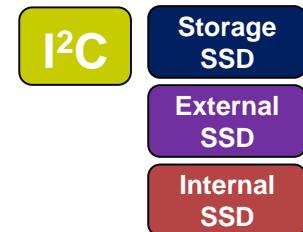
- ▶ Pin-for-pin replacement for industry standard LM75 and LM75A
- ▶ I²C-bus interface - 8 devices on the same bus
- ▶ Power supply range from 2.8 V to 5.5 V
- ▶ Temperatures range from -55 °C to +125 °C
- ▶ Frequency range 20 Hz to 400 kHz with bus fault time-out to prevent hanging up the bus
- ▶ 11-bit ADC - temperature resolution of 0.125 °C
- ▶ Temperature accuracy of:
 - ▶ ±2 °C from -25 °C to +100 °C
 - ▶ ±3 °C from -55 °C to +125 °C
- ▶ Programmable temperature threshold and hysteresis set points
- ▶ Max supply current of 1.0 µA in shutdown mode
- ▶ Stand-alone operation as thermostat at power-up
- ▶ ESD protection exceeds 4500 V HBM per JESD22-A114, 450 V MM per JESD22-A115 and 2000 V CDM per JESD22-C101
- ▶ Small 8-pin package types: SO8, XSON8, and TSSOP8



Type number	Topside mark	Package		Version
		Name	Description	
LM75BD	LM75BD	SO8	plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1
LM75BDP	LM75B	TSSOP8	plastic thin shrink small outline package; 8 leads; body width 3 mm	SOT505-1
LM75BGD	75B	XSON8U	plastic extremely thin small outline package; no leads; 8 terminals; UTLP based; body 3 x 2 x 0.6 mm	SOT996-2
LM75BTP	M75	HWSO8	plastic thermal enhanced very very thin small outline package; no leads, 8 terminals, 2 x 3 x 0.8 mm	SOT1069-2

PCT2075

Digital Temperature Sensor and Thermal Watchdog

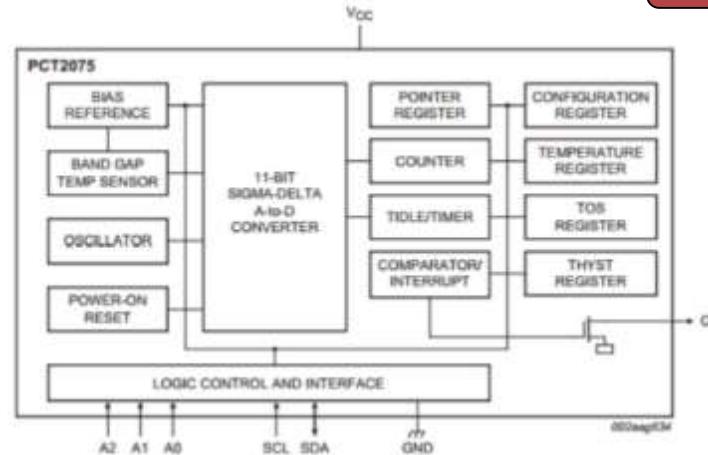


Features

- AEC-Q100 Compliant
- Fm+ I²C-bus (1MHz) with SMBus timeout
- Power supply: - 2.7 to 5.5V
- Temperatures range: -55 to +125 °C
- Accuracy: 11-bit ADC : $\pm 1^{\circ}\text{C}$ (PCT2075)
- Programmable temperature threshold and hysteresis set points allow customer-defined default T_{os} & T_{hyst} set points
- T_{idle} programmable adjustment for temperature sampling reduction in power consumption
- Standalone operation as thermostat at power-up
- Expanded I²C address range with 3 state pins address latched at power up: 27@8-pin & 3@6-pin

Packages

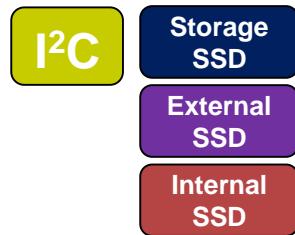
- 8-pin: SO8, MSOP8, HWSO8N8
- 6-pin: SOT23-6 (TSOP6)



PACKAGE	SO8	MSOP8	HWSO8N8	TSOP6 SOT23-6
SOT #	SOT96-1	SOT505-1	SOT1069-2	SOT457
Pitch (mm)	1.27	0.65	0.5	0.95
Width (mm)	3.90	3.0	2.0	3.0
Length (mm)	3.90	5.0	3.0	1.5
Height (mm)	1.75	1.1	0.8	1.1

PCT2202

Local Temperature Sensor



► Features

- Temperature range: -40 to +125°C
- 12-bit resolution
- Accuracy
 - $\pm 1.0^\circ\text{C}$ typ. (-40 to +125 °C)
 - $\pm 0.5^\circ\text{C}$ typ. (0 to +85 °C)
- 1.65 to 1.95V operation
- Frequency: 3.4 MHz
- Current: <10 μA
- 12-bit ADC
- High- and low-temperature set points and an alarm output
- One-shot mode to conserve power
- I²C state machine recognizes: general call, software reset, HS mode, timeout, and SMBus alert

Registers	4, temp, config, high, low
Prog Conv Rate	Yes, 1,4,8 conv/sec
Conv Time	25 ms typ, 35 ms max
Address	90 h, 4 address, 1 pin
Cross Reference	TMP102 ($\pm 2^\circ\text{C}$) Register functionally the same as TMP102 but in different package size (larger and smaller) and only operates at 1.8V



WLCSP6

- ### ► Package: “UK” CSP6 (0.69 x 1.09 x 0.41 mm with 0.4 mm pitch)

SE97B Temp Sensor with Integrated SPD

I²C

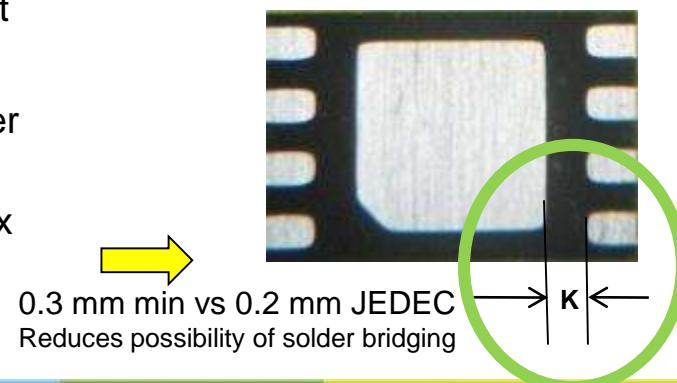
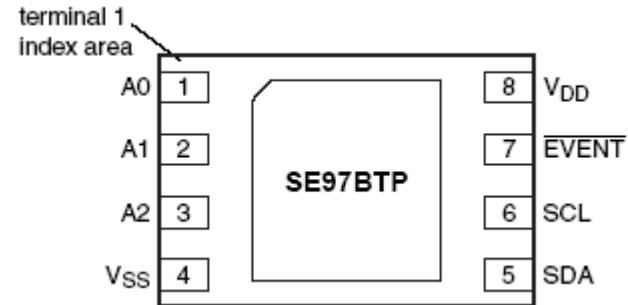
Storage
SSD

External
SSD

Internal
SSD

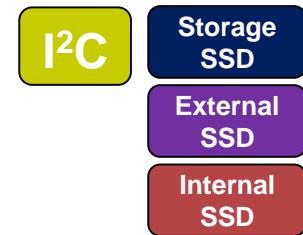
FEATURES

- ▶ 2nd generation Temp Sensor with integrated new JEDEC compliant SPD (2-kbit EEPROM)
- ▶ JEDEC Grade B accuracy
 - $\pm 0.5^\circ\text{C}/\pm 1^\circ\text{C}$ (typ./max.) $+75^\circ\text{C}$ to $+95^\circ\text{C}$
 - $\pm 1.0^\circ\text{C}/\pm 2^\circ\text{C}$ (typ./max.) $+40^\circ\text{C}$ to $+125^\circ\text{C}$
 - $\pm 2.0^\circ\text{C}/\pm 3^\circ\text{C}$ (typ./max.) -40°C to $+125^\circ\text{C}$
- ▶ Temp sensor I²C address of 0011A2A1A0 and EEPROM I²C address of 1010A2A1A0 so master sees two different devices
- ▶ EEPROM is organized as a 256 x 8-bit with 10 years of data retention and 100,000 write/erase cycles
- ▶ Supports SMBus Time-out 25 – 35 mS (typical is 30.5 mS)
- ▶ Support /EVENT pin deasserted during TS shutdown
- ▶ Supports permanent and reversible software write protect
- ▶ Supports 0 – 16-byte write buffer
- ▶ TS and EEPROM operation range 3.0 to 3.6 V with Power Down Reset at 2.4V (up) and 2.0V (down) typical
- ▶ Maximum operating/shutdown current: 320 $\mu\text{A}/10 \mu\text{A}$ max
- ▶ Operating temperature range from -40°C to $+125^\circ\text{C}$
- ▶ JEDEC compliant package from APB – SE97BTP,547



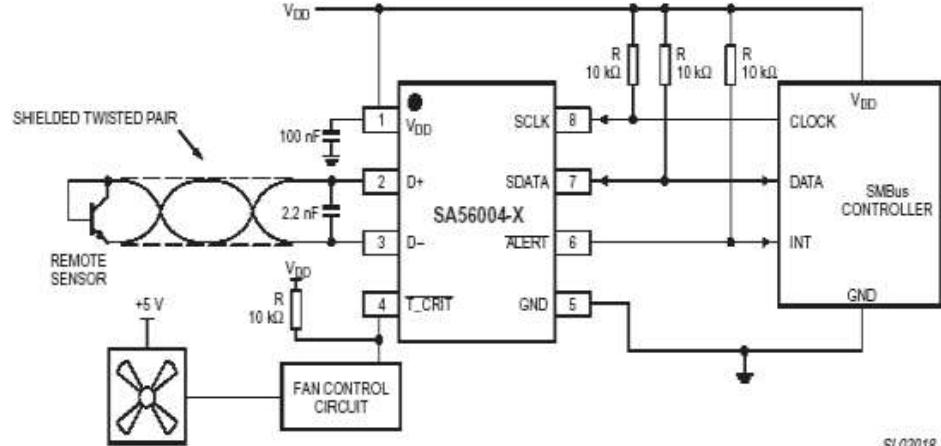
SA56004

Remote/Local Digital Temperature Sensor



► Features

- On-chip local and remote microprocessor thermal diodes or diode-connected transistors temperature sensing within $\pm 1^\circ\text{C}$
- Offset registers for adjusting the remote temperature accuracy
- Programmable under/over temp alarms: ALERT and T_CRIT
- SMBus 2.0 compatible interface supports TIMEOUT and 100/400 kHz I²C interface
- 11-bit, 0.125°C resolution
- 8 different device addresses available for server applications.
- Cross reference: The SA56004-ED/EDH with marking code ARW is address compatible with the National LM86, the MAX6657/8 and the ADM1032.



SL02018

EEPROMs

PCA24S08A

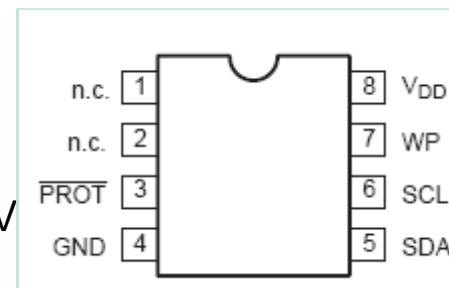
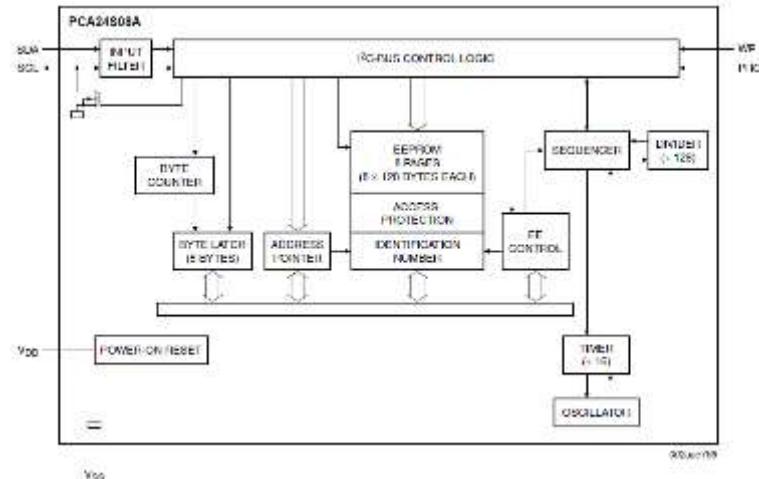
1024 X 8 CMOS Security EEPROM with access protection

DESCRIPTION

- The PCA24S08A functions as a **dual access EEPROM** with a wired serial port used to access the memory. Access permissions are set from the serial interface side to **isolate blocks of memory from improper access**.

FEATURES

- Compatible with a 24C08 Serial EEPROM
- Programmable read/write protection
- Lock/unlock function
- 8 k bits organized as 8 blocks of 128 bytes
- 16-byte page write, 10 ms write time
- Operating temperature range - 40 to +85 ° C
- Operating supply voltage range of 2.5 V to 3.6 V
- Packages offered: SO8 and TSSOP8



10101B₂B₁.

Only 1 device
allowed per bus

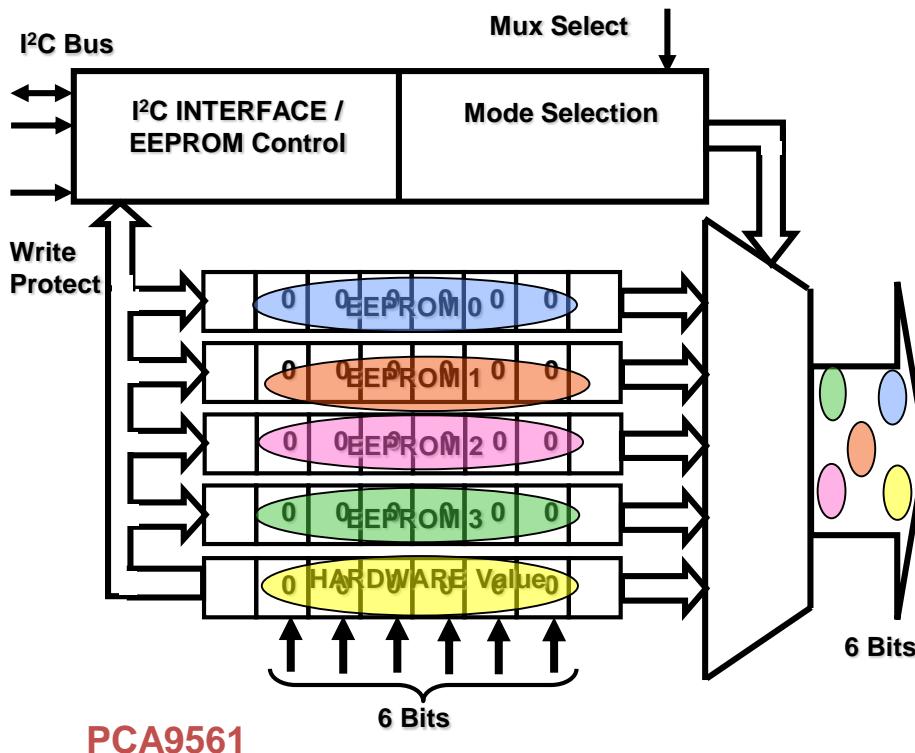
Electronic Dip Switches

I²C DIP Switch Family

I²C

Storage
SSD

- 6 bit output value is dependant on the mux select pin position or command from I²C master
- EEPROM 0 is default output



PCA9561



	# of Pins	# of Non Volatile Registers	# of Register Bits	# of Hardware Input Pins	# of Muxed Outputs	Non-Muxed Output
PCA8550	16	1	5	4	4	YES
PCA9558	28	1	6	5	5	YES
PCA9559	20	1	6	5	5	YES
PCA9560	20	2	6	5	5	YES
PCA9561	20	4	6	6	6	NO

Application Note [AN250](#)

System Bus Bridges (I²C/SPI/UART)

NXP Bridges Value Proposition

I²C

Storage
SSD

- ▶ Why used?
 - To provide an extra serial port, a SPI or I²C controller.
 - To bridge between two different buses: SPI to I²C, I²C to SPI, etc.
 - Three to five wires host interface connection
- ▶ Where used?
 - Telecommunication network routers, Servers, Blades
- ▶ Why NXP Bridges?
 - Low cost, advanced low profile packages and easy to use solutions
 - Sample demo boards and sample software code or drivers are available
 - NXP offers extensive application support including on-line technical support:
Interface.Support@NXP.com



Selecting a Bridge IC

I²C

Storage
SSD

FROM	TO	UART	I ² C	SPI
UART			SC18IM700	
I ² C		SC16IS740 SC16IS75x SC16IS76x		SC18IS602B
SPI		SC16IS850L	SC18IS600	

I²C/SPI-to-UART Bridges

Part #	UART	FIFO	SPI	GPIO
SC16IS740	1	64	4Mbps	–
SC16IS750	1	64	4Mbps	8
SC16IS752	2	64	4Mbps	8
SC16IS760	1	64	15Mbps	8
SC16IS762	2	64	15Mbps	8
SC16IS850L	1	128	15Mbps	–

UART-to-I²C Bridge

Part #	UART	I ² C	GPIO	CLK
SC18IM700	460.8kbps	400kHz	8	Int

SC16IS740IPW/Q900

- ▶ Fully featured standalone UART (IrDA) with I²C/SPI interface and 64byte FIFOs; -40°C to +85°C; TSSOP24; AEC-Q100 compliant automotive qualification

SPI-to-I²C Bridges

Part #	SPI	I ² C	GPIO	CLK
SC18IS600	1Mbps	400kHz	4	Int

I²C-to-SPI Bridges

Part #	SPI	I ² C	GPIO	CLK
SC18IS602B	1.8Mbps	400kHz	4	Int

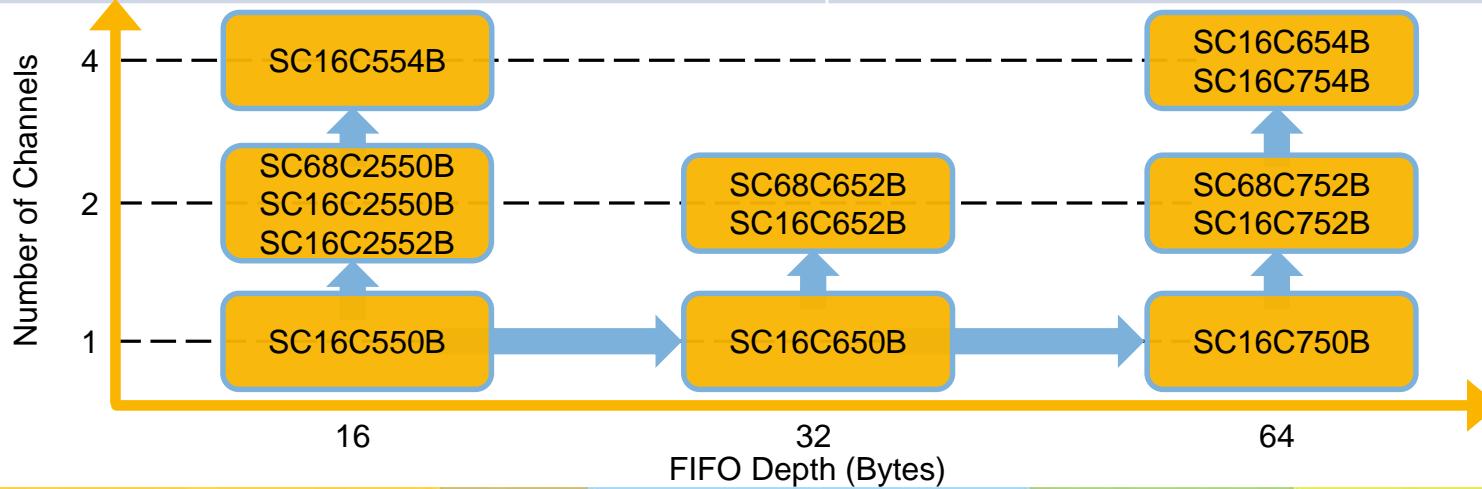


UARTs

Commercial 16CxxxB UART Family



Features	Benefits
Broad line of single to quad channel UARTs	One-stop shopping
Widest supply range (2.5V, 3.3V, 5V) at industrial temperature range (-40°C to 85°C) without price premium	Single part can be used for multiple systems and multiple operating environments. Lower overall cost of ownership – can replace up to four competitor parts.
Fastest device on the market with over 20% faster bus cycle times and baud rates up to 5Mbps	Compatible with high-speed processors
Power-down mode	Ideal for battery-operated systems
HVQFN and BGA package options	Ideal for small, portable systems
Windows and Linux OS-compatible	Simplifies software development
Infrared (IrDA) interface	Enables wireless, short-range applications
Software readily available	Shortens design cycle
Automatic software and hardware flow control	Reduces CPU overhead and data loss
DMA mode and wide variety of FIFO depths	Increases system throughput
Drop-in compatibility with existing 16C devices	Alternative source to other manufacturers



Real Time Clocks

NXP RTC Portfolio



Storage
SSD

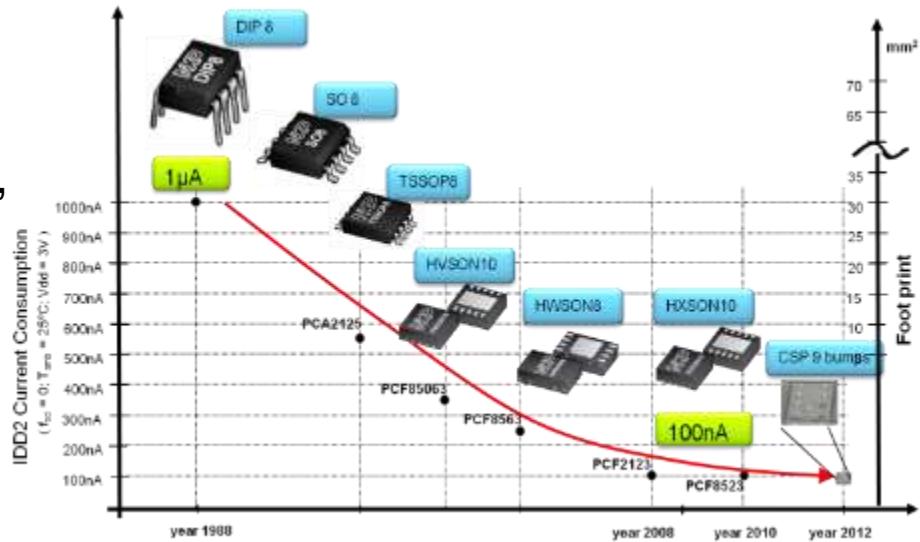
	INTERFACE	KEY FEATURES	PACKAGE	PART#
NEW Tiny footprint, low cost	I ² C-bus	RTC only	HWSON8	PCF85063
	I ² C-bus	RTC + alarm	HXSON10	PCF85063A
	SPI	RTC + alarm	HXSON10	PCF85063B
	I ² C-bus	RTC + alarm, timestamp	SO8, TSSOP8/10, DFN2626-10	PCF85263A
	SPI		TSSOP10, DFN2626-10	PCF85263B
	I ² C-bus	RTC + alarm, timestamp, 64 B RAM	TSSOP8/10, DFN2626-10	PCF85363A
	SPI		TSSOP10	PCF85363B
Lowest power	I ² C-bus	100 nA, electronic tuning, battery management	SO8, TSSOP14 HVSON8,	PCF8523
	SPI	100 nA, electronic tuning	TSSOP14, HVQFN16	PCF2123
Low power	I ² C-bus	industry standard	SO8, TSSOP8, HVSON8	PCF8563
High accuracy	I ² C-bus/ SPI Bus	±3ppm accuracy, battery management, time stamp, metal can quartz; PCF2127A only: 512B RAM		PCF2129A, PCF2127A
	I ² C-bus/ SPI Bus	±3ppm accuracy, battery management, time stamp, ceramic quartz		PCF2129



PCF85063/A/B Low-Power Real-Time Clocks

Key Benefits

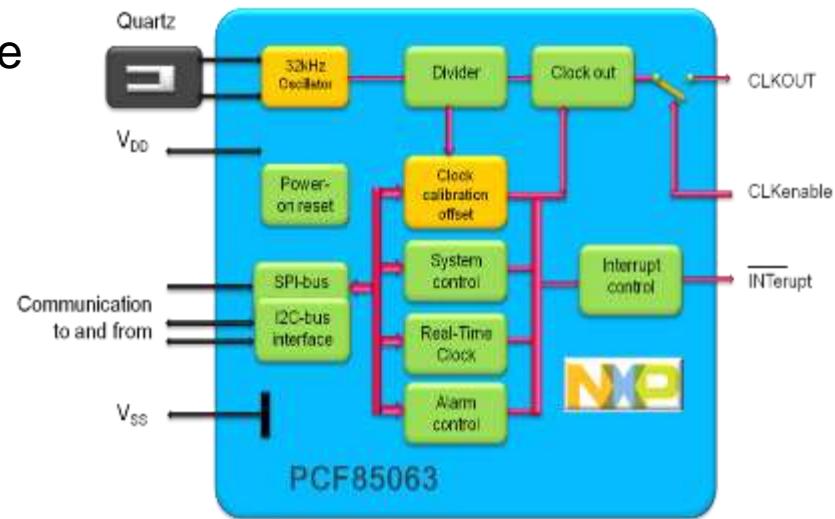
- ▶ Cost optimized
- ▶ Tiny packages: HWSO8,
HXSOn10
- ▶ Electronic tuning
- ▶ Family approach
- ▶ Time tracking
 - 1/100sec, sec, min, day, week, month, year
 - Based on 32 kHz
- ▶ Quartz options
 - 6 or 7pF for low power
 - 12.5pF low cost



PCF85063/A/B Low-Power Real-Time Clocks

Key Features

- ▶ Clock operating voltage: 1.0 to 5.5V
- ▶ Integrated tuning capacitance C_{Load} : 12.5 and 7.0 pF
- ▶ Tiny footprint
- ▶ Frequency adjustment via programmable offset register (electronic tuning)
- ▶ General purpose RAM byte
- ▶ 400 kHz I²C-bus interface or 6 MHz SPI
- ▶ Interrupt output with 4 options:
every 30 sec, every 60 sec,
programmable alarm, off
- ▶ Operating temp. range: -40 to +85 °C
- ▶ Packaging: HWSON8, HXSON10



PCF85063/A/B Low-Power Real-Time Clocks

Function	PCF85063TP	PCF85063ATL	PCF85063BTL	Comment
RTC with electronic tuning Quartz, $C_L = 7\text{pF} / 12.5\text{pF}$	Yes Yes/Yes	Yes Yes/Yes	Yes Yes/Yes	Quartz with 7pF reduces power consumption
I ² C-bus interface SPI-bus interface	Yes No	Yes No	No Yes	400 KHz I ² C 6 MHz SPI
30 s and 1 min interrupt	Yes	Yes	Yes	
Alarm facility Timer	No No	Yes Yes	Yes Yes	
CLK out CLK enable Interrupt output	Yes No Yes	Yes Yes Yes	Yes YES Yes	For frequency tuning or general purpose
Package SOT number Dimensions	HWSO8* SOT1069 2 x 3 x 0.8 mm	HXSON10* SOT1197 2.6 x 2.6 x 0.5 mm	HXSON10* SOT1197 2.6 x 2.6 x 0.5 mm	* both package variants feature, 0.5mm pitch

Tiny foot print



PCF85263A/B Real-Time Clocks

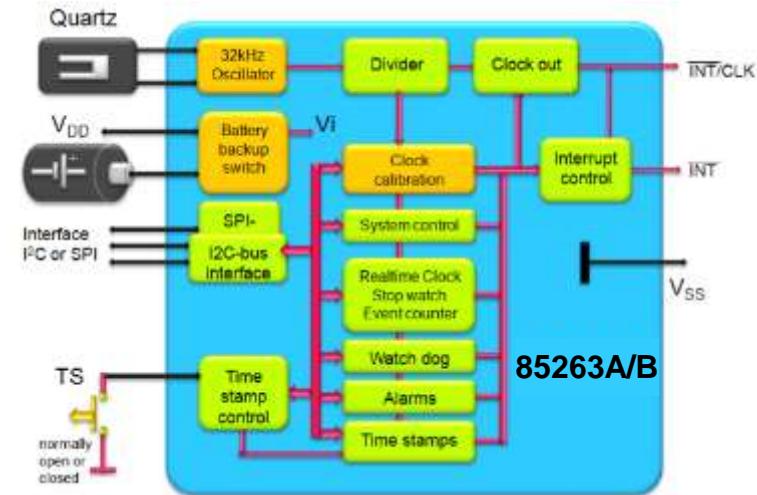
I²C

Storage
SSD

With Battery Backup and Time Stamp

Features

- ▶ Three modes: RTC, stop watch, elapsed time counter
- ▶ Options for
 - I²C (PCF85263A)
 - SPI (PCF85263B) IN DEVELOPMENT
- ▶ High resolution: years to 1/100 sec
- ▶ Battery backup: battery voltage can be lowered or higher than VDD
- ▶ **Timestamps**
 - Tamper and intrusion detection
 - or/and battery switching monitoring
- ▶ Two independent alarms
 - Resolution: Alarm1: s, m, h, d, month
 - Alarm2: m, h, w



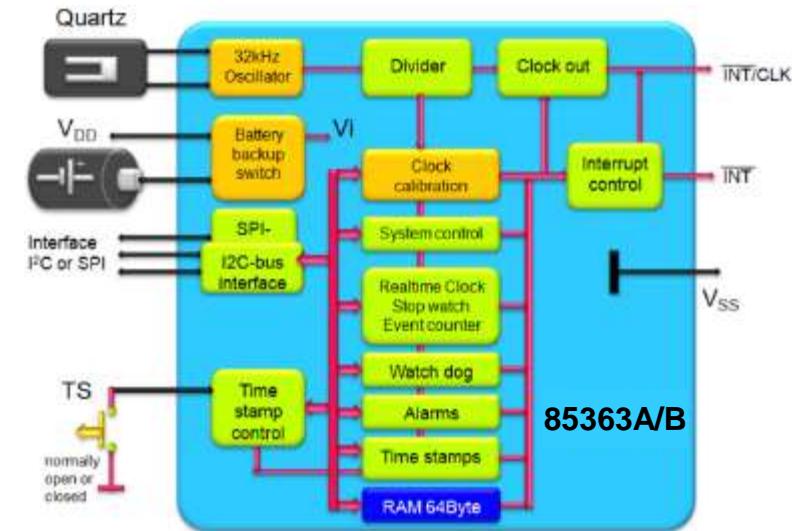
PCF85363 Real-Time Clock

I²C

Storage
SSD

With Battery Backup, Time Stamp and RAM

- ▶ 64B RAM: functions as ‘nonvolatile RAM’ since battery backed
- ▶ Three modes: RTC, stop watch, elapsed time counter
- ▶ Options for
 - I²C (PCF85363A)
 - SPI (PCF85363B) IN DEVELOPMENT
- ▶ High resolution: years to 1/100 sec
- ▶ Battery backup: battery voltage can be lowered or higher than V_{DD}
- ▶ **Timestamps**
 - Tamper and intrusion detection
 - And/or battery switching monitoring
- ▶ Two independent alarms
 - Alarm1 resolution: s, m, h, d, month
 - Alarm2 resolution: m, h, w



PCF85x63 Real-Time Clocks

I²C

Storage
SSD

I²C Family Overview

	PCF8563/5	PCF85063	PCF85063A	PCF85263A	PCF85363A
RTC, resolution Elapsed time counter	1s... years no	1s... years no	1s... years no	1/100s... years yes	1/100s... years yes
Alarm facility Timer, Watchdog	1 Alarm Timer, counter	No No	1 Alarm 1 Timer	2 Alarms Watch dog	2 Alarms Watch dog
Time Stamp	No	No	No	Yes 2	Yes 2
Battery backup input	No	No	No	Yes	Yes
RAM	No	1 B	1 B	1 Byte	64 Byte
Interrupts Interrupt pins	Universal 1	30 sec,1 min 1	30 sec,1 min, universal 1	universal 2, 1 in SO8	universal 2, 1 in SO8
I ² C-bus Interface	400 kHz	400 kHz	400 kHz	400 kHz	400 kHz
RTC electronic tuning Quartz, load capacity C _L =	No with external C	Yes 7pF / 12.5pF	Yes 7 pF / 12.5 pF	Yes 6pF/ 7pF / 12.5pF	Yes 6pF/ 7pF / 12.5pF
Package	SO8, TSSOP8, HVSON10	HWSON8 2 x 3 x 0.8 mm Tiny package	HXSON10 2.6 x 2.6 x 0.5 mm SO8 (PCF85063A only)	SO8, TSSOP8/10, DFN2626-10	TSSOP8/10, DFN2626-10

Lowest power I²C-bus RTC with Battery Backup



Features

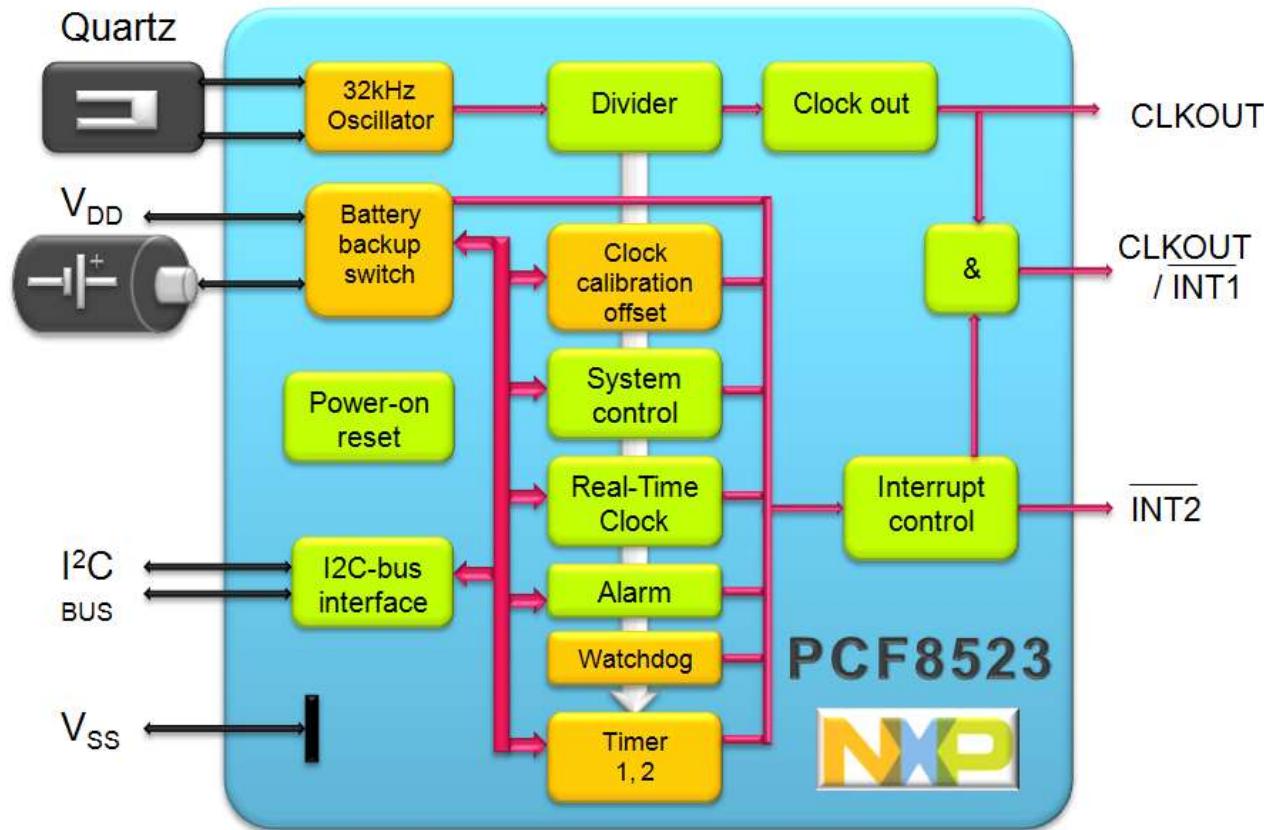
- Lowest power 150 nA/3V/25°C (typ.)
- Battery back up and switch-over function
 - Standard mode ideal for Li-Ion batteries
 - Direct switching mode
- Trimming and offset calibration register
 - Compensation once per 1 min
 - Compensation once per 2 h
- One or two programmable interrupt outputs
 - SO8, HVSON8 → one interrupt output
 - TSSOP14 package → two interrupt output
- Integrated programmable oscillator caps
 - to accept quartzes with CL=7 pF or 12.5
 - 7 pF results in lower power
- I²C Interface 400 kHz
- SO8, HVSON8 and TSSOP14 package U/12 (thin die of 150 / 200µm, gold bumps)

PCF8523

I²C

Storage
SSD

Lowest power I²C-bus RTC with Battery Backup

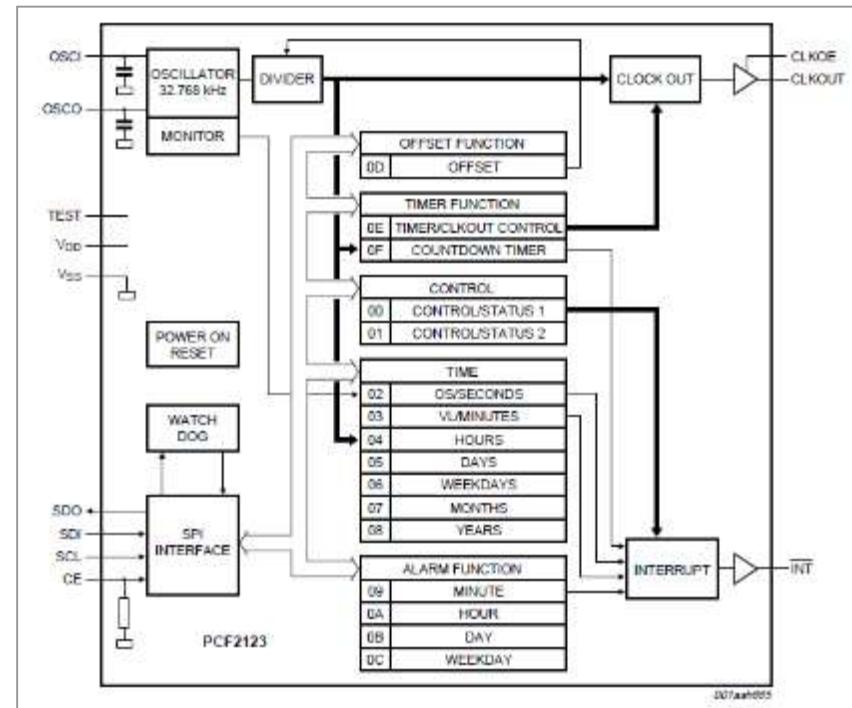


Lowest power SPI-bus RTC



Features

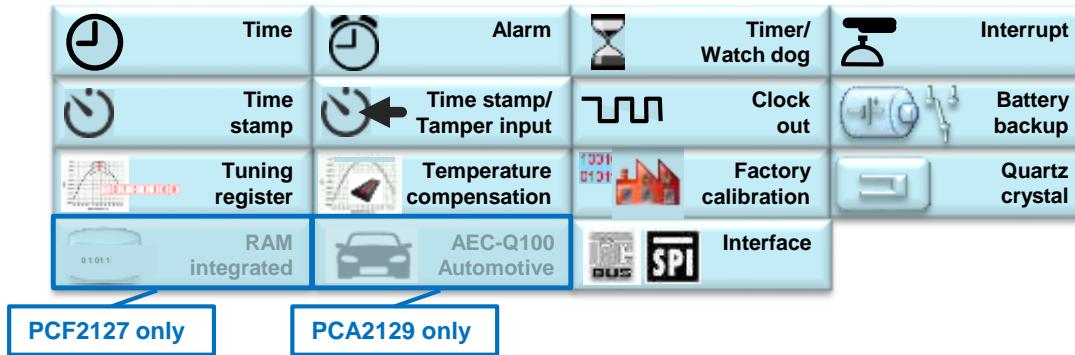
- Lowest power 100 nA/2V/25°C (typ.)
- Large voltage range 1.5...5.5V
- SPI bus up to 6MHz
- Clock from seconds to 99 years
- Programmable Countdown Timer
- Programmable Output Clock Frequency with Output Enable pin
- **Electronic tuning**
- Small packages TSSOP14, HVQFN16 and U (bare die)



PCF2127/9 & PCA2129 aRTC Modules

I²C

Storage
SSD



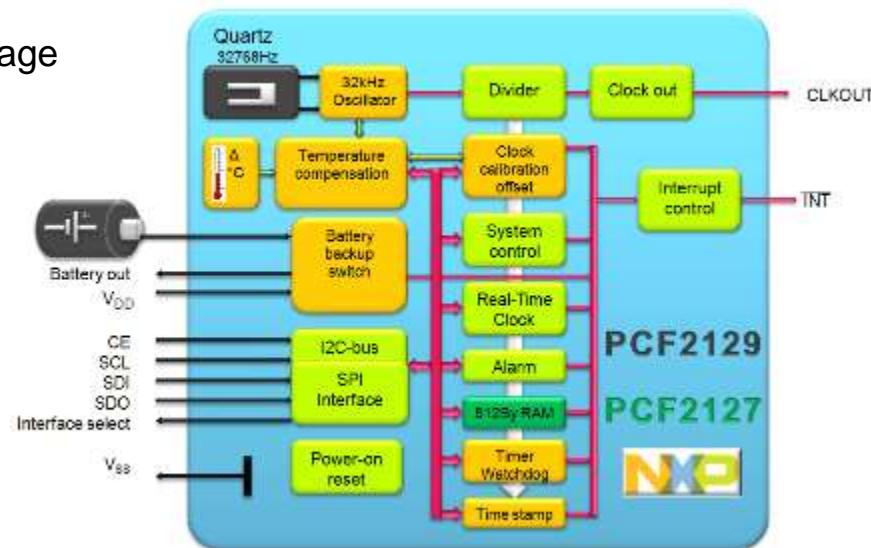
Added Value

- High Integration: Quartz, temp sensor, battery switch, tamper detection; factory calibrated



Features

- Integrated solution: RTC and quartz in one package
- Temperature compensated oscillator with high accuracy (+/- 3 ppm typ) over wide temperature range
- Both I²C and SPI buses supported
- Battery management
- Time stamp
- RAM (PCF2127)
- AEC-Q100 compliant (PCA2129T)
- SO20 or SO16 package → small footprint



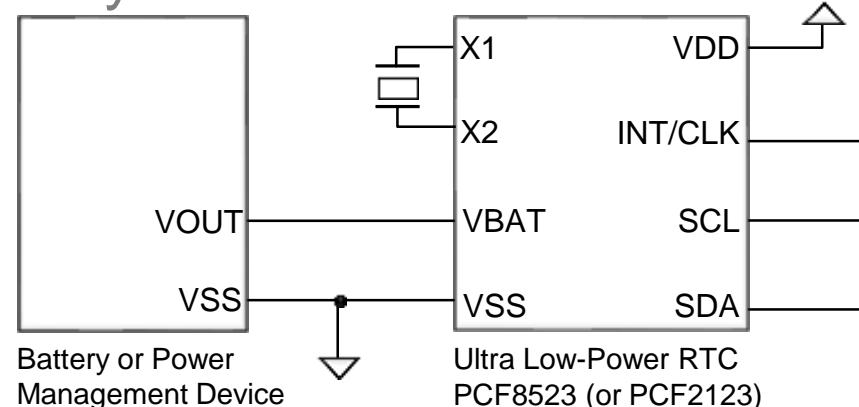
RTC Application

I²C

Storage
SSD

Battery Backup and Extended Battery Life

- ▶ Ultra-low power RTCs enable back-up time keeping with very small capacity batteries
 - The **PCF8523** and **PCF2123** draw as low as **100nA** and still keep time even during system down time.
 - Can be powered from a very small battery or energy harvested from the environment.
 - Can maintain timekeeping function for days or weeks.
- ▶ Applications:
 - Timekeeping modules for:
 - Industrial Control
 - Medical Devices
 - Networking and Communication Systems
 - Security and Tamper Detection
 - Time-stamping collected data in remote electronic environmental (temperature, pressure, humidity, etc.) sensors for building control



Current Consumption	Battery Capacity	Back-up Time
100 nA	50 µAh	20 days
	100 µAh	41 days
	1 mAh	416 days
	5 mAh	5.7 years
150 nA	50 µAh	13 days
	100 µAh	27 days
	1 mAh	277 days
	5 mAh	3.8 years

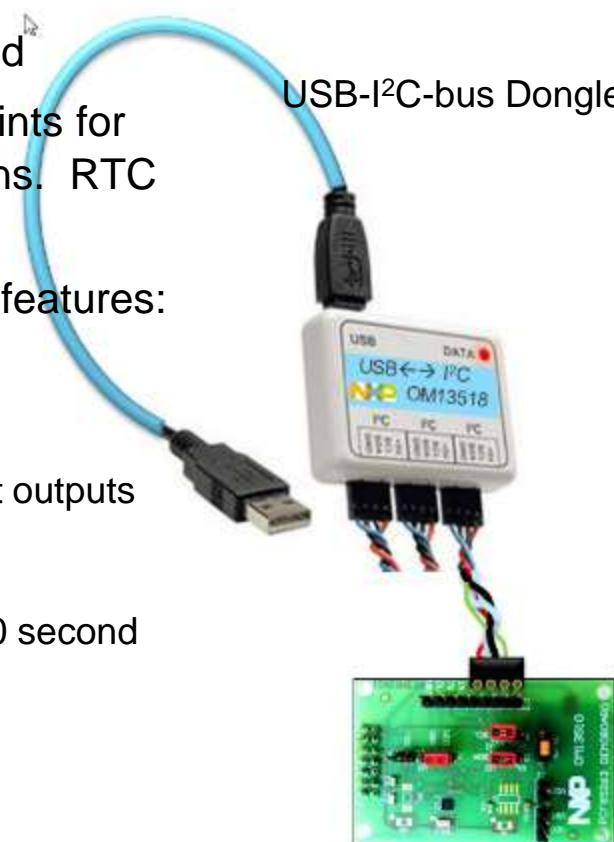
Real Time Clock (RTC) Design Support

I²C

Storage
SSD

Key Features

- ▶ I²C or SPI bus interface
- ▶ Back-up battery installed
- ▶ Multiple package footprints for different package options. RTC Selectable by jumper.
- ▶ Demonstrates different features:
 - Timekeeping
 - Calendar
 - Two alarms with two configurable interrupt outputs
 - Clock Output
 - Counter
 - Stopwatch with 1/100 second resolution
 - Interrupt Feature
 - Timestamp
 - Low Power



RTC Evaluation Boards



RTC	Eval Board	User Manual
PCF2123	OM13512 †	UM10759
PCF8523	OM13511	UM10670
PCF2127, 29	OM13513 †	UM10762
PCF85063B	OM11059 †	UM10699
PCF85063A	OM11059A	UM10698
	OM13515 †	UM10788
PCF85263A	OM13510 †	UM10766
PCF85363A	OM13514 †	UM10787
USB-I ² C dongle	OM13518 †	UM10789

† Available on eDemoboard

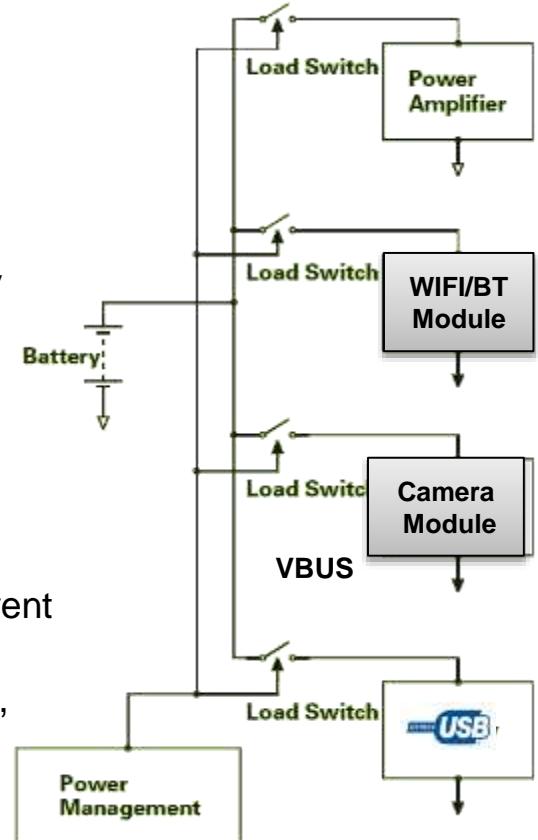


Load Switches & Comparators

Integrated Load Switches, Surge Protection/eFuse ICs and USB Power Switches

Storage SSD
External SSD
Internal SSD

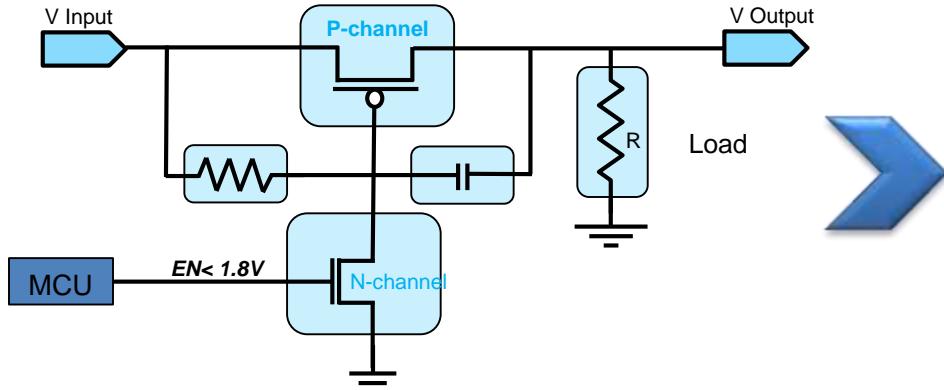
- ▶ Simple, effective way to optimize system power consumption with excellent protection and control
 - In power distribution to subsystem blocks
 - To connect/disconnect loads to power supply rails
 - To extend battery life
 - Low voltage drop across switch, compared to LDO
 - Very low current consumption and leakage current.
 - Disconnecting unused blocks minimizes load drawn from battery
- ▶ Lowers cost
 - Varies power rating and Low R_{ON} for better efficiency
 - Reduces overall part count
 - Reduces PCB space
- ▶ Portfolio includes
 - Products with over-voltage protection (OVP) and/or over-current protection (OCP)
 - Smallest leading package options for maximum performance, flexibility and quick time to market
- ▶ Typical mobile applications
 - All USB 2.0 and 3.0 ports
 - Smart phones, tablets



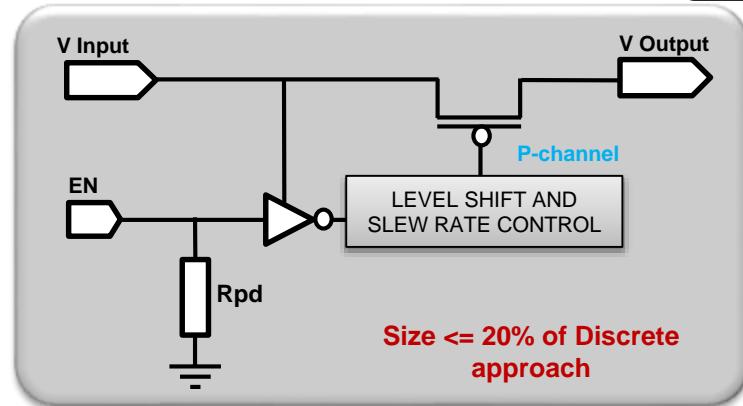
Why Integrated Load Switch for Power Distribution?



Discrete Multi-component Approach



Integrated Load Switch



Size <= 20% of Discrete approach

- ▶ Pros: standard discrete
- ▶ Cons
 - Multiple (5 discrete) components
 - Large real estate
 - High power consumptions
 - No slew rate control
 - Requires Low enable voltage control
 - Time to market: design variations
 - Sensitive to board layout

- ▶ Pros
 - 1-chip solution
 - Miniature package: 0.8X0.8X0.5mm
 - Low current consumption
 - Enable pin: Voltage tolerant
 - Integrated Slew rate control
 - Ease of design or use: TTM
 - Power Isolation
 - Lower cost of PCB assembly
 - Reduce the inventory count

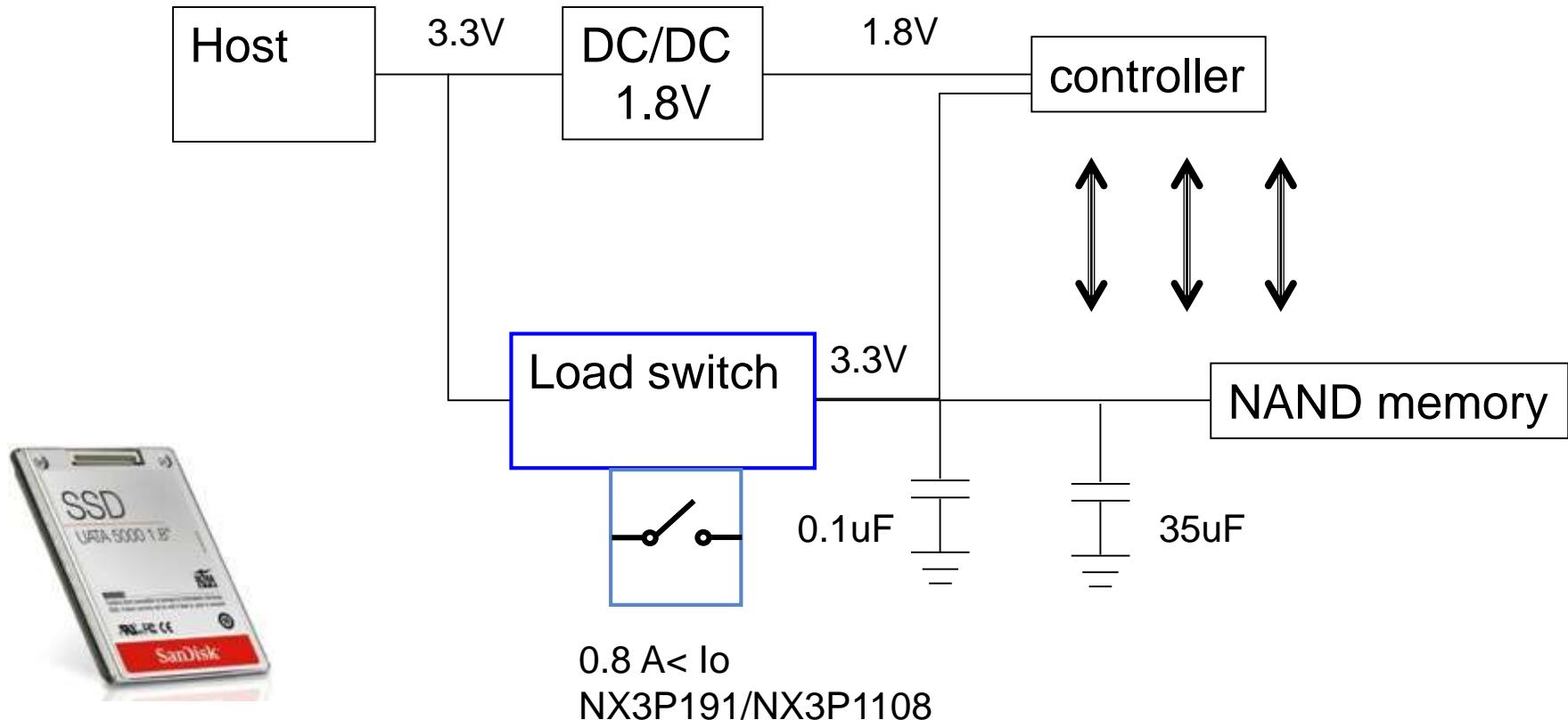
Integrated Load Switches



- ▶ NX3P/NX5P Family of integrated load switches
 - Simple, effective solution for driving and optimizing system power consumption
 - Excellent protection and control
 - Designed for Mobile and Portable electronic power management
 - Easy to design-in
 - Smallest leading package options enabling top performance, flexibility, and reduced time to market

INPUT V	R _{ON} TYP (mΩ)	FEATURE(S)	QUIESCENT CURRENT TYP	OUTPUT CURRENT	PART #(S)
1.1 to 3.6V	95	slew rate, load discharge option	100 nA	0.5 A	NX3P190
					NX3P191
					NX3P2902B
0.9 to 3.6V	35	slew rate, load discharge option	100 nA	1.5 A	NX3P1107
0.9 to 3.6V	35		100 nA	1.5 A	NX3P1108
0.9 to 5.5V	14		500 nA	2.5 A	NX5P2924

NX3P1108 in SSD Applications



Key Feature

In-rush current protection by slew rate control

Storage
SSD

External
SSD

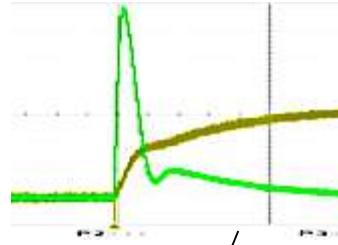
Internal
SSD

Case study: Notebook supplying power to Hard drive.

Notebook or
cellphone

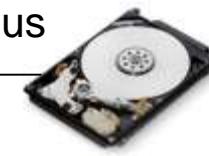


USB Vbus



supply current: green
supply voltage; brown

HDD Vbus



- When initially turned on, HDD demands a large supply current to boot-up.
- This can create a large current spike on Vbus line, and a droop of input voltage if using a low power rating supply.
- The current spike can be very destructive to sensitive electronic components
- The voltage droop can force a device to shutdown prematurely and prevent startup all together.



affected area, location of current limiting device

NX3P190/191 0.5A High-side load switch

Description

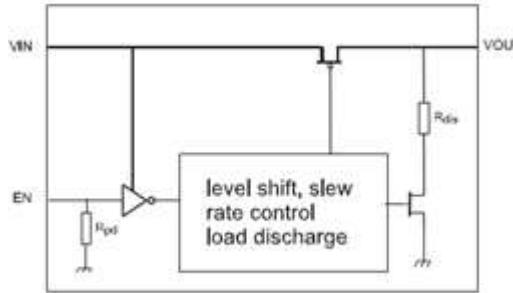
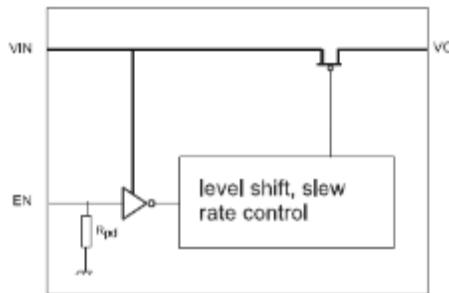
Low ON resistance P-channel MOSFET supporting 500 mA of continuous current. Operates from 1.1 V to 3.6 V, it is used in power domain isolation to reduce power consumption & extend battery life. Enable pin includes level translation making the device compatible with low voltage processors.

Both 190 & 191 include slew rate control to limit inrush current.

NX3P191 includes active pull down to discharge any residual output charge.

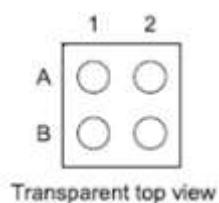
Available in: WLCSP-4: 0.76 x 0.76 x 0.61 mm, 0.4 mm pitch

Replaces: ADP190/191, TPS22901/2



A	1	2
VIN		VOUT
EN		GND

Pin/out



Features

- Operates from 1.1 to 3.6 V.
- Low R_{ON} = 65 mΩ typ.
- Low power mode with EN = low.
- Continuous current of 500 mA.
- Leakage current with 0.2uA
- Slew rate control 40 uSec @3.6V.
- Load discharge circuit for NX3P191UK

NX3P190/191 Specification comparison

	NX3P190	ADP190	TPS22901	NX3P191	ADP191	TPS22902B	NX3P2902B
Input Voltage (V)	1.1 to 3.6	1.1 to 3.6	1.0 to 3.6	1.1 to 3.6	1.1 to 3.6	1.0 to 3.6	1.1 to 3.6
Ron @ 1.8V Ron @ 3.6V mOhms	✓ 95 ✓ 65	105 80	109 78	✓ 95 ✓ 65	105 80	- 78	✓95 ✓65
Output rise time 3.6V us	40	50	40	40	50	40	110us
Slew Rate at 3.6V (Turn ON delay)	1.8us	1.5us	46us	40us	50us	183us	277us
Quick discharge	No	No	No	Yes	Yes	Yes	Yes
Max Output current A	0.5	0.5	0.5	0.5	0.5	0.5	0.5(0.6)
Package	WCSP 4 0.8X0.8mm						

- NXP has 10% Lower RDson
- NXP also provides best in class supply chain and is cost competitive

NX3P1107/1108 1.5A High-side load switch

Description

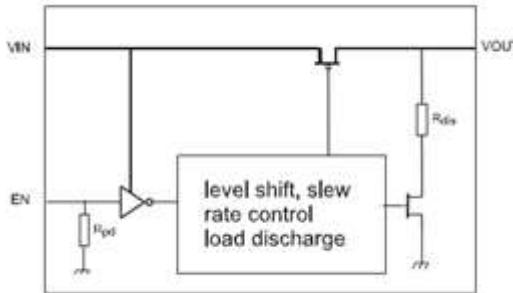
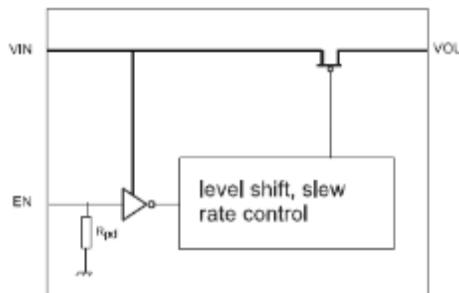
Low ON resistance P-channel MOSFET supporting **1.5 A** of continuous current. Operates from 0.9 V to 3.6 V. It is used in power domain isolation to reduce power consumption & extend battery life. Enable pin includes level translation making the device compatible with low voltage processors.

Both devices include slew rate control to limit inrush current.

NX3P1108 also includes active pull down to discharge any residual output charge.

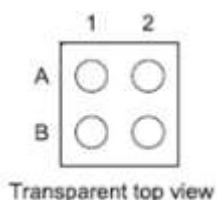
Available in: WLCSP-4: 0.96 x 0.96 mm, 0.5 mm pitch

Replaces: FPF1107/1108, TPS22902/22907



	1	2
A	VOUT	VIN
B	GND	EN

Pin-out top view



Features

- Operates from 0.9 to 3.6 V
- Low RON = 32 mΩ typ at 3.3 V
= 50 mΩ typ at 1.8 V
- Low power mode with EN = low
- Supplies 1.5A of continuous current,
Highest industry rating / area
- Slew rate control.
- Load discharge circuit.

NX3P1107/1108 Specification comparison

	NX3P1107	NX3P1108	TPS22906	TPS22907	Fpf1107	Fpf1108	Comments
Input Voltage	0.9 to 3.6	0.9 to 3.6	1.0 to 3.6	1.0 to 3.6	1.2 to 4.0	1.2 to 4.0	NXP has Lower Voltage
Ron @ 3.3V (mΩ)	35	35	78	44	35	35	> NXP 10% Lower R _{DS(ON)}
Slew Rate Control	Yes	Yes	Yes	Yes	Yes	Yes	similar
Quick discharge	No	Yes	Yes	No	No	Yes	similar
Max Output current (A)	1.5	1.5	1.0	0.5	1.2	1.2	similar
Package (mm)	WCSP 4 0.96 x 0.96	similar					
Pitch (mm)	0.5	0.5	0.5	0.5	0.5	0.5	similar

- Lower Operating voltage of 0.9V
- Highest current rating of 1.5A
- Lowest Ron

NX5P2924(B) Low Ron, 2.5A High-side load switch

Storage
SSD

- Low ON-resistance across all Vin and temperature (-40 to 85°C).
- Switch controlled by 1.2V logic enable pin, optional internal pull-down resistor to prevent false triggering.
- Internal output shunt resistor/MOSFET quickly discharges residual load when power switch is turned off.
- Slew rate control limits device rise time to prevent inrush current.

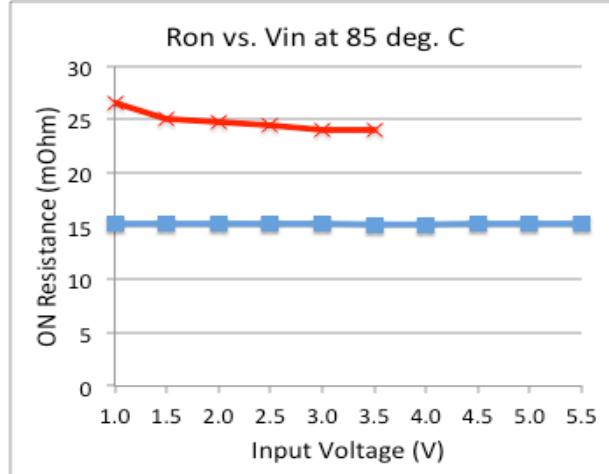
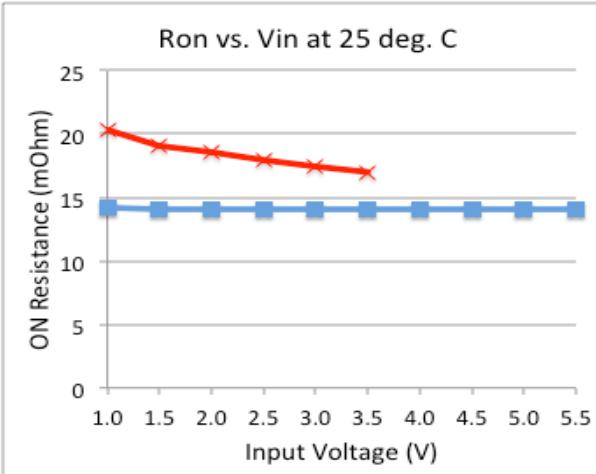
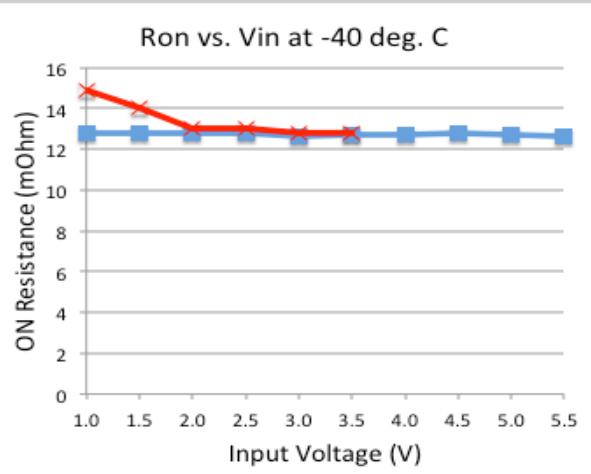
Pin-to-pin to TPS22924(B)YZPR



6-ball WLCSP Package
1.4 mm x 0.9 mm x 0.5mm
0.5 mm pitch

Features

- Operates from 0.8 V to 5.5V
- Low R_{ON} = 14 mΩ typ. at 1.8V
- Low power mode with EN = low.
- High continuous current of 2.5A.
- Switch leakage current of 0.5 uA
- Off-state supply current of 0.1 uA
- Slew rate control, 100us.
- Load discharge circuit.
- On-chip Enable pull-down resistor
- B-version is without EN pull-down.



NX5P2924 Blue TPS22924 RED

NX5P2924(B) Specification comparison



Key inputs	NX5P2924	NX5P2924B	TPS22924B	Comments
Operating voltage	0.8 ~ 5.5V	0.8 ~ 5.5V	0.75 ~ 3.6V	Wider operating range.
Max continuous current	2.5 A	2.5 A	2.0 A	Higher current
EN pin Pull-down resistor	Integrated Pull-down resistor	No Pull down resistor	No Pull down resistor	NX5P2924: EN pin: Integrated pull down resistor
Ron @1.0V (typ/max) @1.8V	14 / 18 mΩ 14 / 18 mΩ	14 / 18 mΩ 14 / 18 mΩ	20 / 28 mΩ 19 / 27 mΩ	NXP Ron better
Package and size	1.4*0.9mm WCSP6	1.4*0.9mm WCSP6	1.4*0.9mm WCSP6	Pin-to-Pin compatible



NXP offers very low, flat Ron over operating voltage range.

Load Switches Portfolio

Surge Protection & eFuse ICs



- ▶ Ultra-low current consumption
- ▶ Low and flat on-resistance (R_{ON})
- ▶ Wide Supply Voltage Range

Surge Protection & eFuse ICs

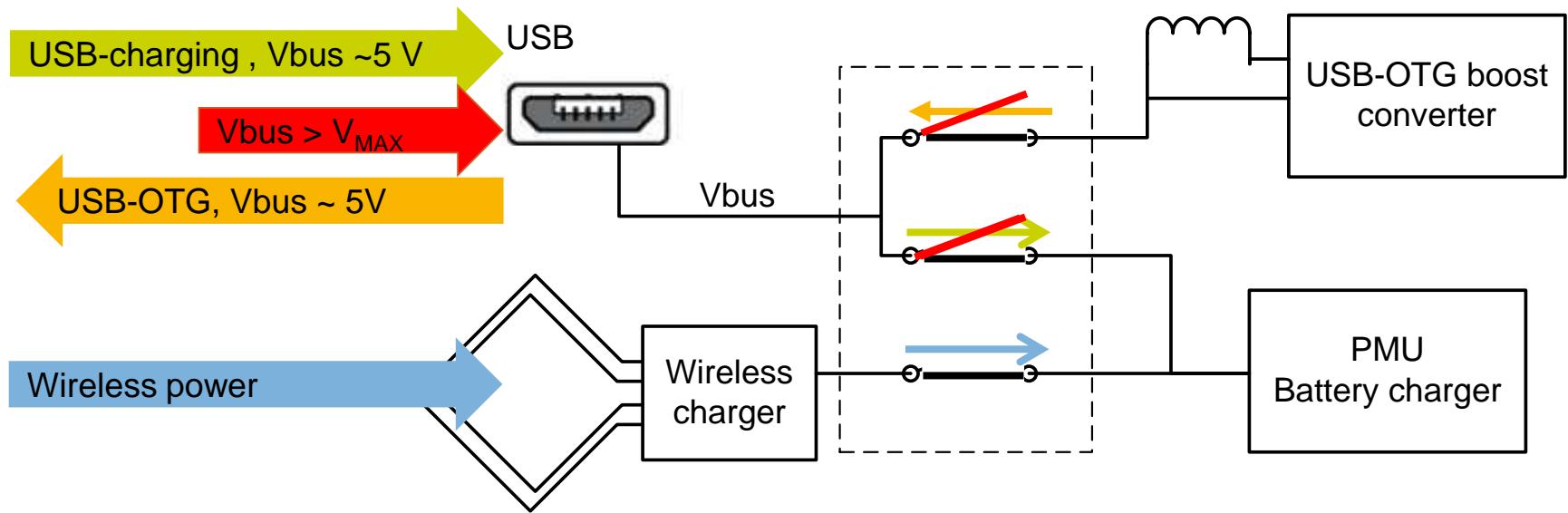
INPUT V	R_{ON} TYP (mΩ)	FEATURE(S)	QUIESCENT CURRENT TYP	OUTPUT CURRENT	PART #(S)
3.0 to 5.5V	60	30V tolerant, UVLO/OVLO, OCP, OTP, reverse polarity	200 nA	1.0 A, adjustable	NX5P1000 (USB OTG 3.0)
		30V tolerant, UVLO/OVLO, OCP, OTP, reverse polarity, 8ms OCP trigger delay			NX5P1100 (USB OTG 3.0)
3.0 to 5.75V 3.0 to 17.5V	65	30V+ tolerant, UVLO/OVLO, OTP, bidirectional, OTG & charging	100 nA	3.0 A	NX5P3001
					NX18P3001
2.5 to 6.5V	60	30V+tolerant, power detect, soft-start, current limit, UVLO,OVLO/ OTP	200 nA	2.0 A, adjustable	NX5P2090 (USB 3.0 and OTG)
2.5 to 5.5V	90	Soft-start, adj. current limit, UVLO, OTP	TBD	1.7 A, adj.	NX5P2553

OVP & OCP for USB Charging



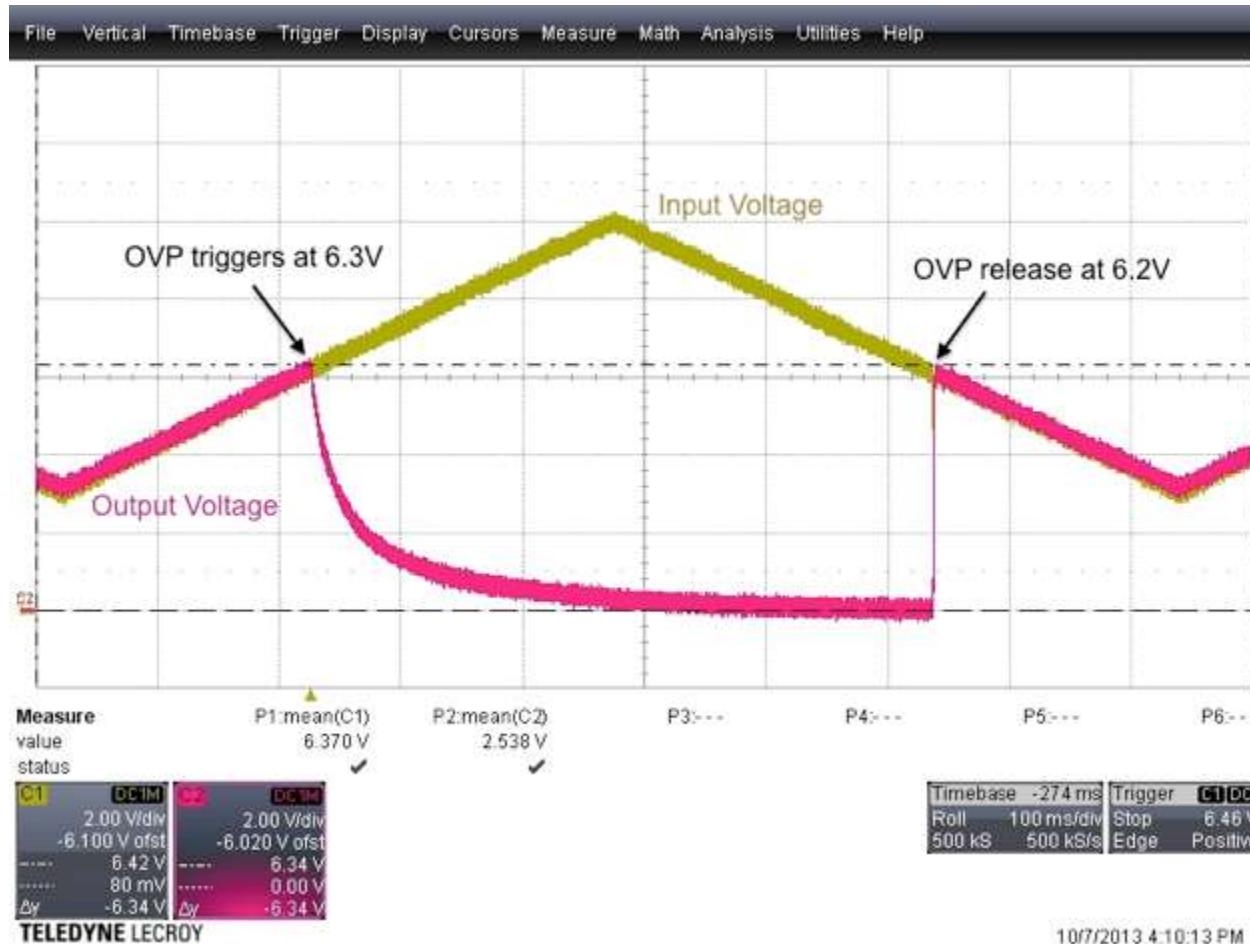
Operation modes

1. USB charging – port isolation
2. Over Voltage Protection, OVP (P1000 with Over Current Protection OCP)
3. Reverse polarity protection
4. Charger path select (USB or wireless)
5. Quick Charging for higher current and Higher voltage



Key Feature: Over-Voltage Protection

Storage
SSD
External
SSD
Internal
SSD



Stepped from 3.8 to 10V
OVP set at 6.35V (internal)

When
 V_{BUSI} = OVP threshold
Switches open, isolating
 V_{BUSO} from V_{BUSI}

OVP is released when
 $V_{BUSI} < V_{th} - 95mV$

Note, UVLO is 3.2V
 V_{BUSI} never crosses UVLO th.
10uF cap on V_{BUSI}

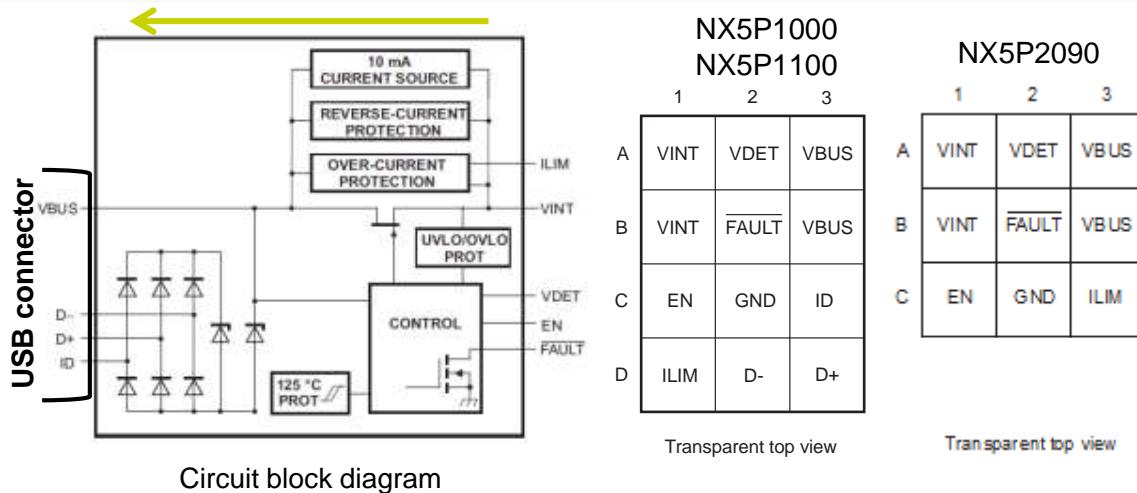
NX5P1000 / NX5P1100 – Uni-directional OVP/OCP IC With ESD Protection Diodes for Data Lines

Description

- Uni-directional power switch and ESD protection device for USB OTG supply.
- Similar to NX5P2090/2190 with the addition of ESD Protection Diodes so that the device may be placed closer to the USB Connector.
- Operates from 3.0 to 5.5V. Protect the inside circuitry from external voltages up to 30V.
- Designed to isolate a VBUS OTG voltage source from an interface pin during over-current or over-temperature events.
- Features an externally adjustable current limit; an output voltage detect, OVP, OTP, and a fault indicator.

Available in: NX5P1000: W CSP12 1.4 x 1.7, 0.4 mm pitch
NX5P2090: W CSP9 1.4 x 1.4, 0.4 mm pitch

Competes with: TI TPD4S214



Circuit block diagram

The NX5P1000 is very similar to the NX5P1100 with the addition of an 8ms OCP trigger delay in the NX5P1100.

Features

- Isolates/protects up to 30V on VBUS
- Operates from 3.0 - 5.5V
- Adjustable current limit
 - NX5P1000 200 mA – 1.0 A
 - NX5P2090 200 mA – 2.0 A
- Low ON resistance: R_{ON} 60 mΩ
- Soft start turn-on, slew rate controlled
- Over-/under-voltage protection
- Over-temperature protection @125C
- Reverse bias current protection
- ESD IEC contact to 8kV

NX5P3001/NX18P3001 Bi-directional OVP Load Switch for USB OTG & Charge

Storage
SSD

External
SSD

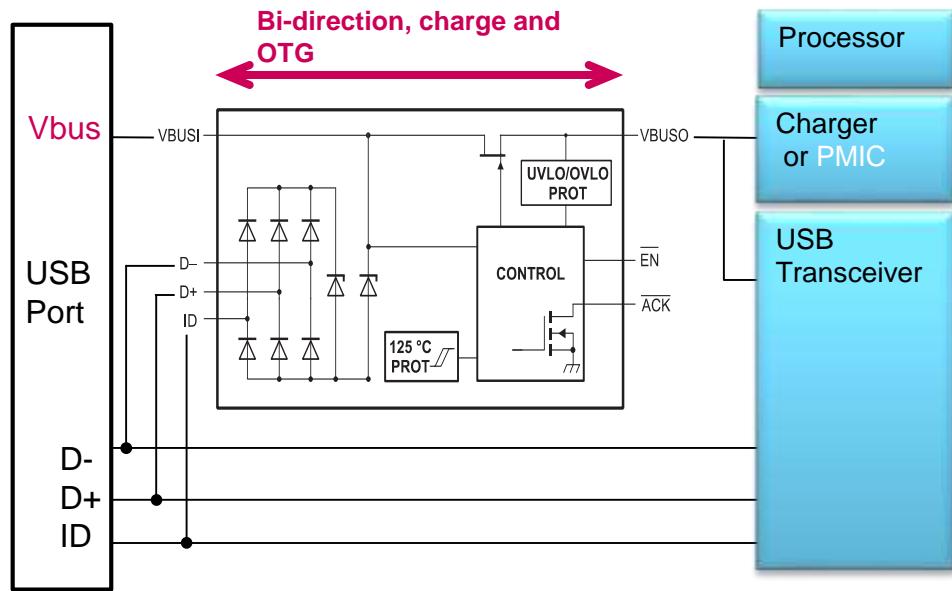
Internal
SSD

Description

Bi-directional power switch w/ ESD-protection for USB-OTG charger port applications. Features under & over voltage lockout protection to automatically isolate the power switch terminals during fault conditions, as well as slew-rate control to protect from inrush currents.

Low capacitance TVS are built-in on D+ and D- lines.

Available in: WCSP12 1.2 x 1.6 x 0.5, 0.4 mm pitch



Features

- Isolates/protects up to 30V on VBUSi
- Operates from 3.0 - 5.75V (NX5P...)
- Operates from 3.0 – 17.5V (NX18P...)
- Switch continuous current: 3 A max
- Low ON resistance: R_{ON} 65 mΩ.
- Soft start (slew rate control)
- Over voltage protection
- Under voltage protection
- Over-temperature protection
- ESD IEC contact to 8kV, HBM of 2kV

NX5P3001: typical 5V charging with OVLO and UVLO protection

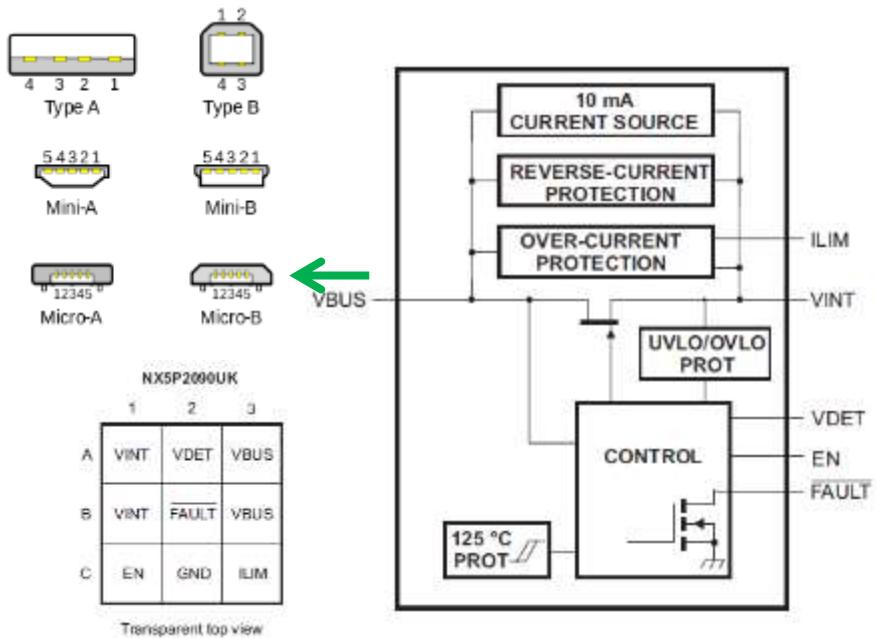
NX18P3001: Tablet application typical 17.5V max charging with OVLO and UVLO.



NX5P2090 Load Switch with OVP/OTP

Storage
SSD
External
SSD
Internal
SSD

- ▶ Power switch for USB OTG 3.0 applications
 - NX5P2090 is designed for USB OTG and general USB applications.
 - Isolates VBUS OTG voltage source from interface pin during over-current or over-temperature events
 - Externally adjustable current limit; output voltage detect, OVP, OTP, and fault indicator
 - Used in power domain isolation applications to reduce power dissipation and extend battery life
- ▶ Features
 - Operates from 3.0 to 5.5 V
 - Low ON resistance: R_{ON} typ 60 mΩ
 - VBUS 30V Tolerant
 - Short circuit protection
 - OVLO and UVLO protection
 - Adjustable current: 200 mA to 2000 mA
 - Over-temperature protection at 125 °C
 - Reverse bias current protection
 - Soft start turn-on, slew rate controlled
 - ESD IEC contact 8kV
- ▶ Package: W CSP9, 1.4X1.4, 0.4mm pitch



NX5P2090 Specification comparison (typical/max)



	NX5P2090UK (typ/max)	TPS2065DBV (typ/max)	Unit s
Input Voltage (V)	3.0 – 5.5	2.7 – 5.5	V
Current limit	Adj. to 2.0A	1.9A, non Adj.	A
Over voltage tolerant input	✓ 30V	NA	-
Ron @ 2.7V Ron @ 3.3-5.0V	73 @ 3V ✓ 60/100	75/150 70/135	V
Auto short removal detect and reset	10mA current source to Reset	NA	-
Slew Rate control	Yes	Yes	-
Reverse current protection	Yes	No	-
UVLO (min-max)	3.0 – 3.4	2.0 – 2.5	V
OVP	5.75/6.0	NA	V
Thermal shutdown threshold/hysteresis	125, 10	135, 25	Deg C
Max output cont. current Short ckt trip current	2.0 2.0	1.0 1.5/2.1	A
Package	WCSP 9 1.4x1.4mm, 0.4 mm pitch	Leaded 5 3.0x3.0 mm, 0.95mm pitch	

NXP provides:

- 25% smaller footprint
- Lowest Ron
- Overvoltage tolerant input to 30V
- OVLO protection
- Reverse biase/current protection
- 2A CC capability
- Tighter tolerance on thresholds

NX5P2553 Adjustable High-Side Load Switch

Storage
SSD
External
SSD
Internal
SSD

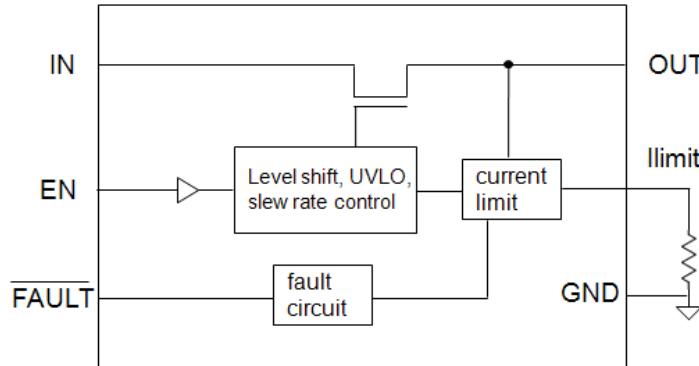
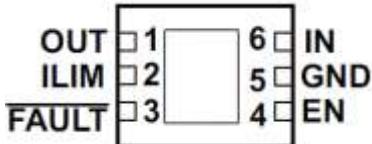
Description

High-side load switch with low ON resistance P-channel MOSFET supporting up to 1.5 A of continuous current. Current limit is adjustable from 75 mA to 1.7 A with external resistor. When current limit is reached, device can either be latched off (255x) or load regulated (255x) at a desired level. Reverse voltage protection is also integrated for situations where output voltage is higher than input. Switch operates from 2.5 V to 5.5 V.

It is ideal for power distribution & reducing consumption in battery operated devices.

Available in: 6 pin 2.0 x 2.0 x 0.75 mm, 0.65 mm pitch.

Similar function and pin to pin with: TI TPS2553



Features

- Operates from 2.5 to 5.5 V
- Low R_{ON} = 90 m Ohm typ.
- 1.5 A continuous current load.
- High accuracy current limit $\pm 6\%$
- Reverse voltage protection.
- In-rush current protection.
- 8kV contact IEC-6100-4-2 ESD.

Comparators

Rail to Rail I/O with Low Power Consumption

- ▶ Low-power, rail-to-rail I/O
- ▶ Available with one or two comparators per package
- ▶ Very low supply current (6 µA)
- ▶ Leading MicroPak and PicoGate packages
- ▶ Voltage range ideal for mobile: 1.3 to 5.5 V



V _{CC} (min – max)	CURRENT (TYP)	PROP DELAY	INPUT OFFSET V	OPERATING TEMP	OUTPUT	# COMPARATORS	PACKAGE	PART#
1.3 to 5.5V	drive: 68 mA supply: 5 µA	0.5 ms	0.5 mV	-40 to 85°C	push pull	2	SOT972, SOT902	NCX2220
	drive: 68 mA supply: 6 µA				open drain			NCX2222
					push pull	1	SOT886, SOT353	NCX2200
					open drain			NCX2202

NCX2200/2202 – Low Power Rail to Rail Single Comparator

Description

Single low voltage low power comparator. The NCX2200 has a very low supply current of 6 μ A per comparator and is guaranteed to operate at a low voltage of 1.3 V and is fully operational up to 5.5 V which makes this device convenient for use in 1.8, 3.0, and 5.0 V systems. It is the perfect fit for any low power application.

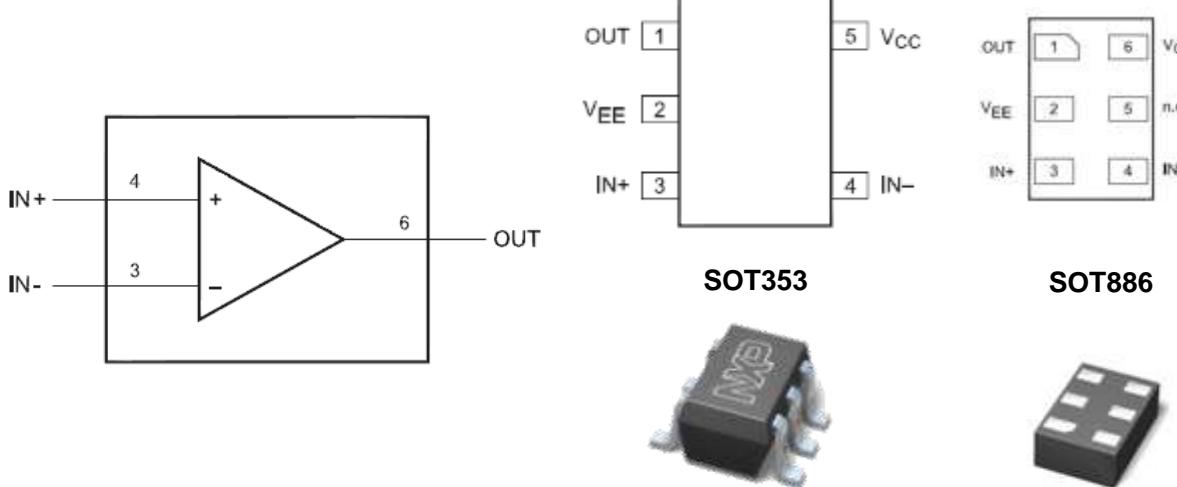
Available in

- NCX2200GM : SOT886 1.0 x 1.45, 0.5 mm pitch;
- NCX2200GW : SOT353, 2.0 x 2.0, 0.65 mm pitch
- NCX2200GF: SOT891, 1.0X 1.0, 0.35 mm pitch
- NCX2202GM: SOT886 1.0 x 1.45, 0.5 mm pitch Open drain

Replaces: NCS2200A

Applications

- Notebook and tablet PC
- Cellular handsets
- Portable media players
- Set top boxes
- Navigation devices
- Lcd displays



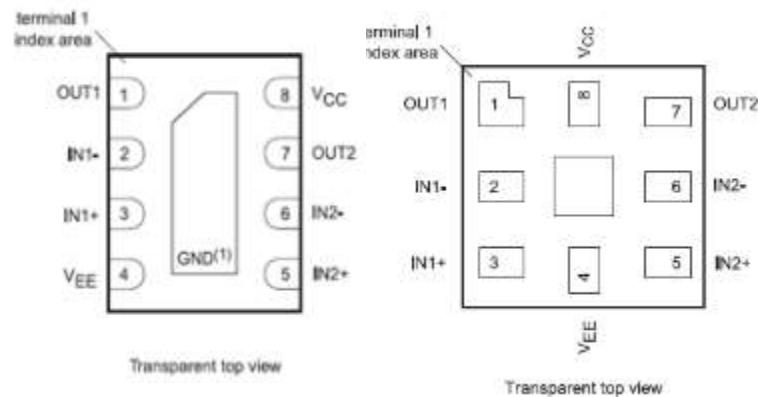
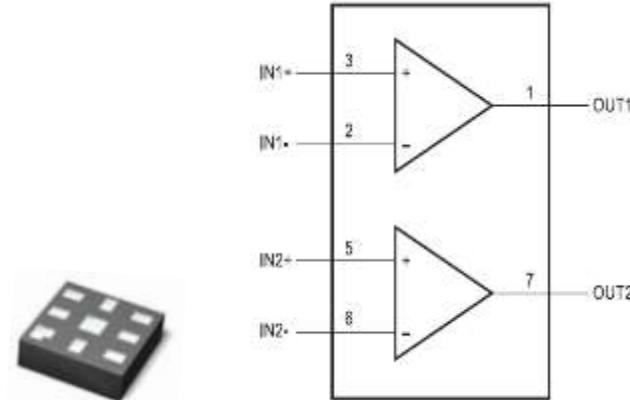
Features

- Operates at 1.3-5.5V supply.
- Rail to rail input/output.
- Supply current $I_{CC} < 6 \mu A$.
- No phase inversion w/ overdriven input.
- Excellent noise rejection.

NCX2220/2222 – Low-Power Rail-to-Rail Comparator

Storage
SSD

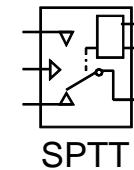
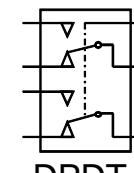
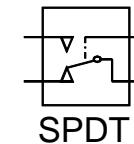
- ▶ Two comparators in one package
 - Very low supply current: $I_{CC} < 5 \mu A$
 - Supply voltage: 1.3 to 5.5 V
 - Rail to rail input/output
 - No phase inversion with overdriven input signals
 - Excellent noise rejection
- ▶ Convenient for use in 3.0V & 5.0V systems
- ▶ Perfect fit for audio & accessory plug-in detection
- ▶ Packages
 - HXSON8 (SOT972) 1.3 x 1.7 x 0.5 mm,
0.4 mm pitch
 - Micro-Pak (SOT902) 1.6X1.6 X 0.5mm,
0.5mm pitch
- ▶ Replaces: NCS2220A



General Purpose Analog Switches

NX3x Analog Switch Portfolio

DESCRIPTION	BW	CH	R _{ON}	THD	XTALK	PART#
1x SPST	60 MHz	1	0.75 Ω	0.024	-90 dB	NX3L1G/T66
	25 MHz	1	0.45 Ω	0.01		NX3L1G/T384
2x SPST	25 MHz	2	0.75 Ω	0.024	-90 dB	NX3L2G/T66/384
			0.45 Ω	0.01		NX3V2G/T66/384
1x SPDT	60 MHz	1	0.75 Ω	0.024	-90 dB	NX3L1G3157
						NX3L1T3157
						NX3L1G53
						NX3L1T53
2x SPDT	20 MHz	2	0.8Ω	0.01	-90 dB	NX3L4684
	15 MHz		0.5Ω	0.01		
	60 MHz		0.75 Ω	0.024		NX3L2267
2x DPDT or 4PDT	60 MHz	2	0.75 Ω	0.02	-90 dB	NX3L2467
	330 MHz		9.5 Ω	-	-60 dB	NX3DV2567
	200 MHz		4.5 Ω	0.01	-90 dB	NX3DV3899
2x DPDT + 1x 3PDT	500 MHz		4.0 Ω	-	-40 dB	NX5DV715
			9.0 Ω			
1x SPTT	30 MHz	1	0.75 Ω	0.02	-90 dB	NX3L4357
1x SP8T	15 MHz	1	0.75 Ω	0.02	-90 dB	NX3L4051
3x SPDT	60 MHz	3	0.8 Ω	0.02	-90 dB	NX3L4053



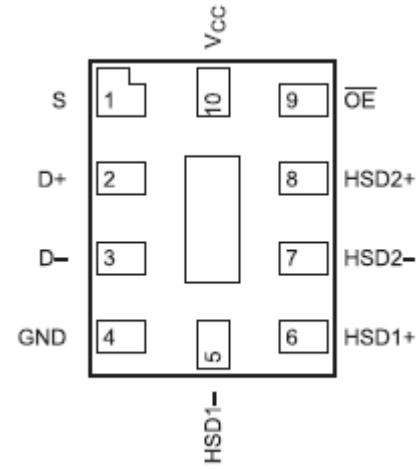
NX3DV42 – Dual USB 2.0 Switch

Description

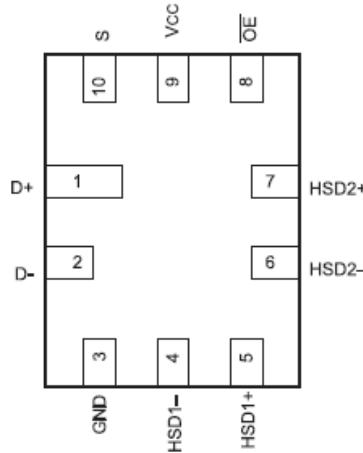
DPDT analog switch designed for switching USB 2.0 high speed (480 Mbps) signals in applications with limited USB I/Os. The wide bandwidth allows to pass signals with minimum edge & phase distortion. Designed for low bit-to-bit skew and high channel-to-channel noise isolation, it is perfect for any high bandwidth application.

Available in: XQFN10U (SOT1049) 1.55 x 2.0 x 0.5 mm, 0.5 mm pitch
 XQFN10 (SOT1160) 1.40 x 1.8 x 0.5 mm, 0.4 mm pitch
 XQFN10 (SOT1337-1) 1.3 x 1.6 x 0.5 mm, 0.4mm pitch

Replaces: FSUSB42/6, MAX4983/4, NLAS7222, NLAS7242, PI3USB102/3, TS3USB30, DG2722DN.



SOT1049
1.55 x 2.0 mm



SOT1160
1.4 x 1.8 mm

Applications

- Notebook and tablet PC
- Cellular handsets
- Portable media players
- Set top boxes
- Navigation devices
- Lcd displays

Features

- Operates at 1.65 – 4.3 V supply.
- On resistance $R_{ON} < 4.0 \Omega$
- Typical $C_{S(ON)} = 6.0 \mu F$
- High Bandwidth $f_{(-3dB)} = 950$ MHz
- ESD HBM to 4kV on all pins
- ESD HBM >12kV on power-GND.

NX3DV221 - USB 2.0 Switch w/ Charge Pump

Storage
SSD

Description

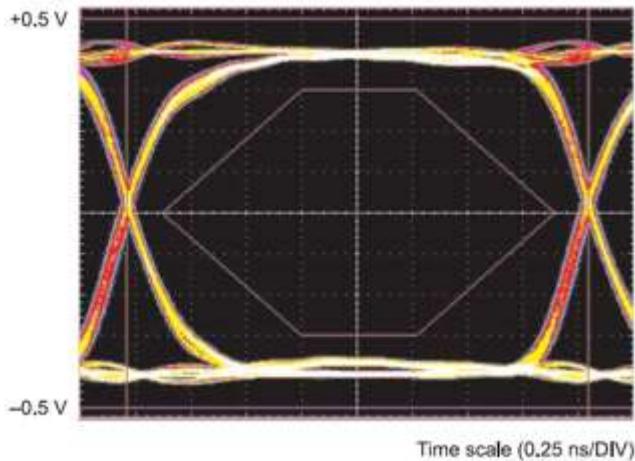
Dual SPDT analog switch designed for switching USB 2.0 high speed (480 Mbps) signals in applications with limited USB I/Os. The wide bandwidth (1.0 GHz) allows to pass signals with minimum edge & phase distortion. The switch is bidirectional & offers little or no attenuation at the outputs. Designed for low bit-to-bit skew and high channel-to-channel noise isolation, it is perfect for any high bandwidth application.

Available in: XQFN10U (SOT1049) 1.55 x 2.0 x 0.5 mm, 0.5 mm pitch

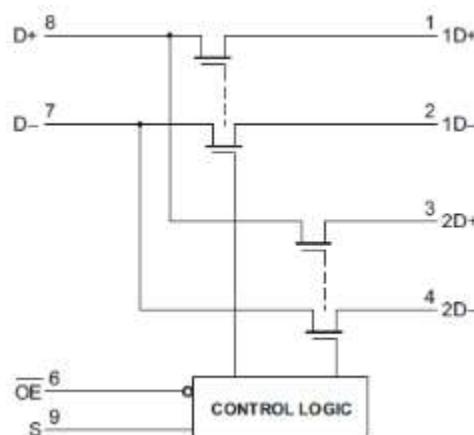
Replaces: TS3USB221, PI3USB221, FSUSB30L10X, FSA221L10X

Applications

- Notebook and tablet PC
- Cellular handsets
- Portable media players
- Set top boxes
- Navigation devices
- Lcd displays



Eye pattern 480 Mbps USB Signal of NX3DV221 switch

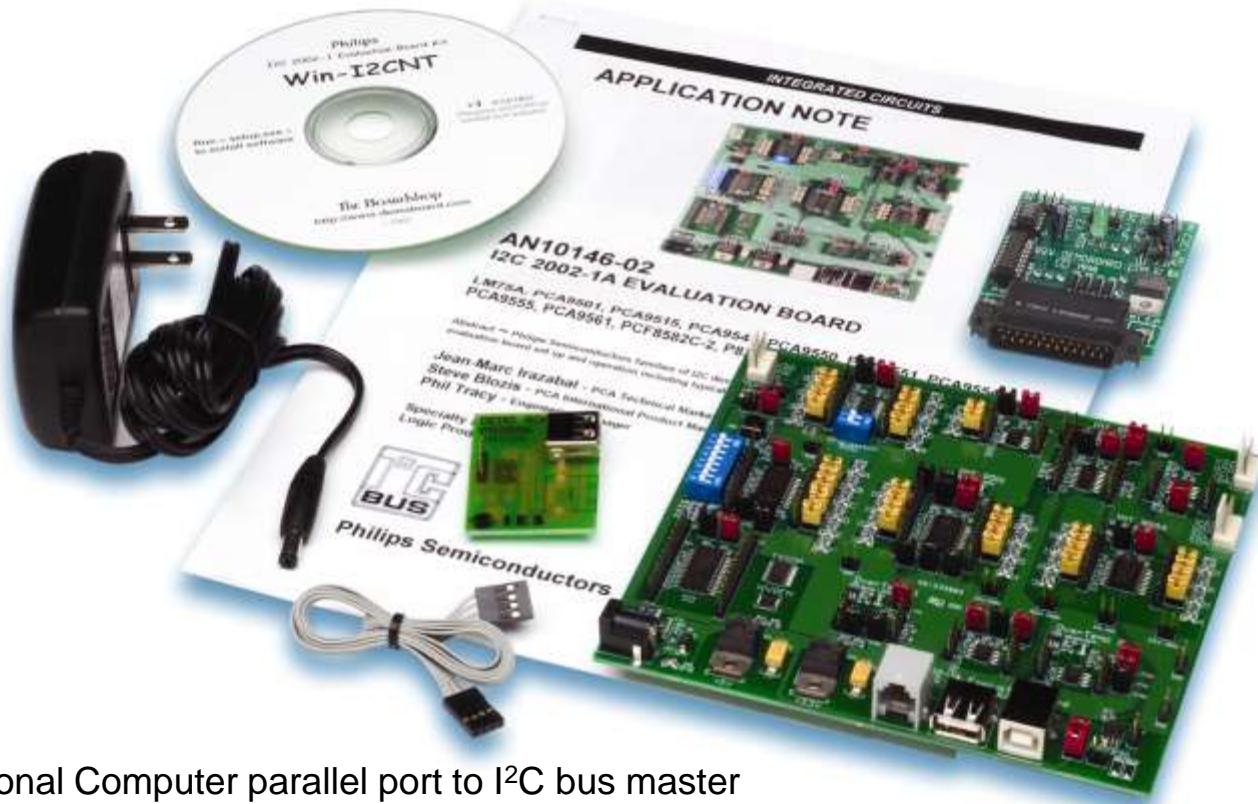


Features

- Operates at 2.3 - 3.6 V supply.
- Switch inputs up to 5.5 V.
- Supply current $I_{CC} < 2\mu A$ in low power mode.
- On resistance $R_{ON} < 6.0 \Omega$
- Typical $C_{S(ON)} = 6.0 \text{ pF}$
- High Bandwidth $f_{(-3\text{dB})} = 1.0 \text{ GHz}$

Support Tools

I²C2002-1A Demo Board Kit (OM6278 & OM6285)



Features

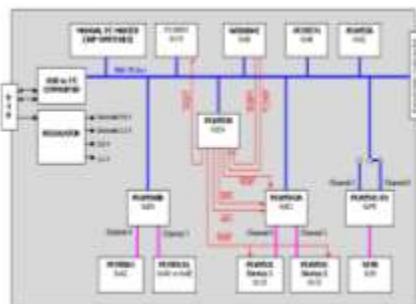
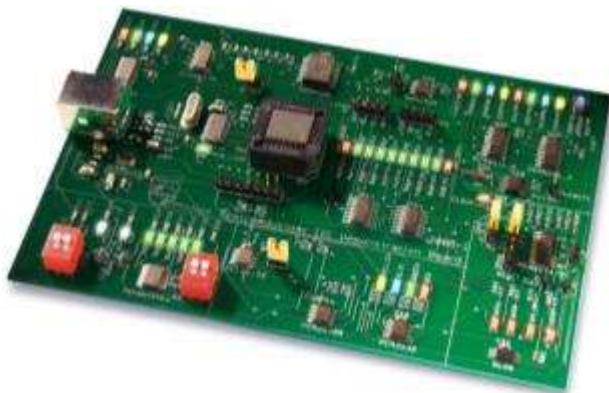
- Converts Personal Computer parallel port to I²C bus master
- Simple to use graphical interface for I²C commands with expert mode
- Win-I2CNT software compatible with Windows 95, 98, ME, NT, XP and 2000
- OM6285 is without the controller
- Order kits at www.demoboard.com or eTools

OM6278 and OM6285 are available on eDemoboard

I²C2005-1 Demonstration Board Kit (OM6275)

Features

- Easy experimentation and training.
- I²C-bus I/O Ports, Temperature Sensors, LED Drivers, Real-time Clock daughter cards
- Use USB to Windows PC/Laptop GUI/power
- See details in User Manual ([UM10206](#))
- Order kits at www.demoboard.com or eTools



Available on eDemoboard

Devices on Board		
Device	Description	Address
SE98	Temperature Sensor	0x30
PCF8574	8-bit Quasi Output GPIO Expander with Interrupt	0x40
PCA9536	4-Bit GPIO Expander	0x82
SA56004E	Local & Remote Temperature Sensor	0x98
PCF85116	2048 x 8-bit EEPROM	0xA0 to 0xAE
PCF8563	Real Time Clock	0xA2
PCA9551	8-Channel LED Blinker / Controller	0xC0
PCA9531	8-Channel LED Dimmer / Controller	0xC8
PCA9540B	2-Channel Mux	0xE0
PCA9543A	2-Channel Mux with Reset & Interrupt	0xE2
PCA9538	8-Bit Totem-Pole Output GPIO Expander with Reset & Interrupt	0xE4
PCA9541/01	2-Channel Demux (Master Selector)	0xFE

I²C Fm+ Development Kit ([OM13320](#))

I²C

Fm+ Development Board Kit OM13320



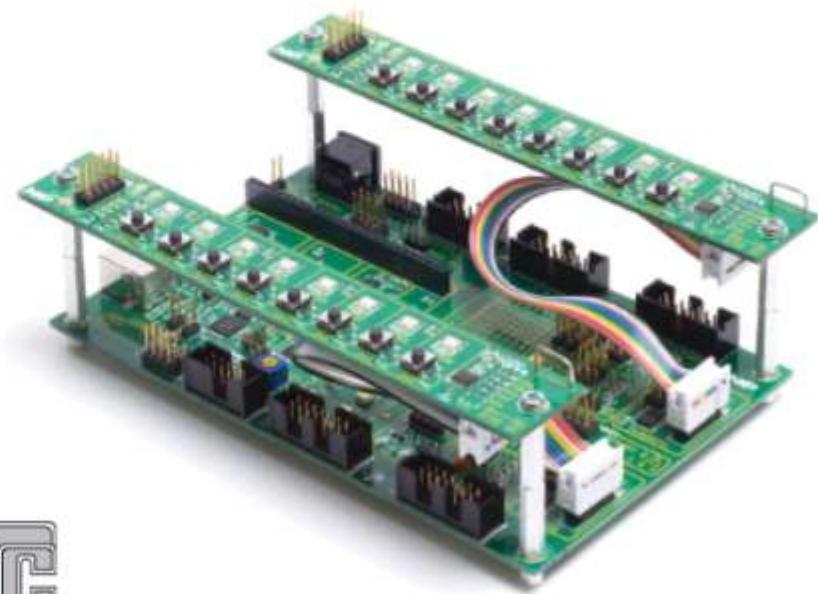
- Explore the I²C-Bus
- Run demonstrations of NXP's I²C Fm+ Slaves and Bus Controllers
- Develop I²C Hardware
- Expand this kit with add-on I²C Daughter Cards

BOX CONTENTS:

OM13320 Fm+ Development Board

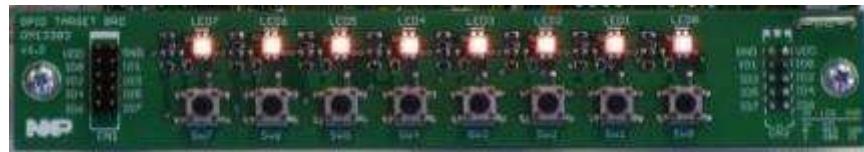
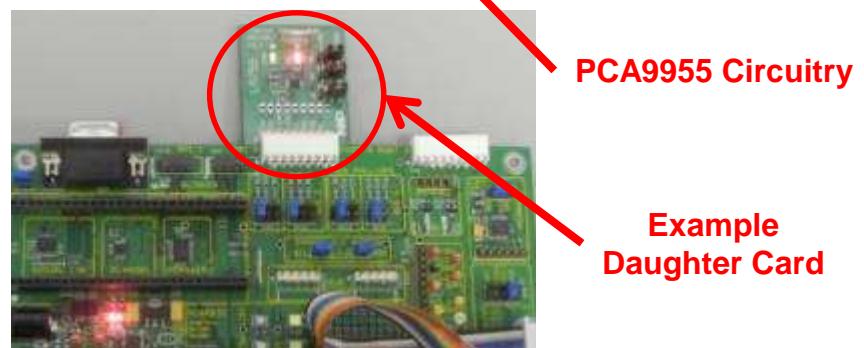
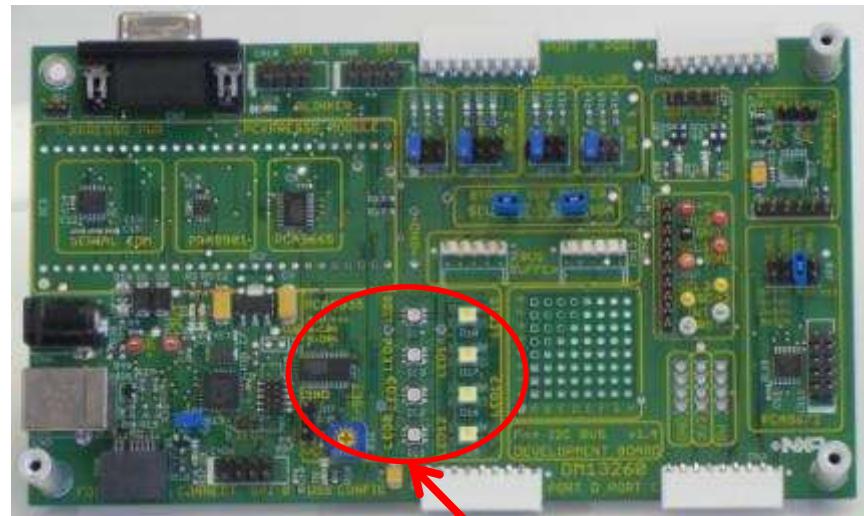
Plus

- OM13303 GPIO Target BRD (x2)
- OM13398 PCA9617A Bus Buffer Demo Board
- OM13399 Bridge Board
- Cables and Mounting Hardware



I²C Fm+ Development Kit (OM13320)

- ▶ Modular evaluation board for I²C-bus Fast-mode plus (Fm+) devices
- ▶ Easy experimentation and training board
- ▶ Used to develop software and evaluate device performance
 - GPIO Expander
 - LED Controller
 - Bus Buffer
 - Bus Controller
 - Temperature Sensor
 - Stepper Motor Controller
- ▶ USB connection for direct control of peripheral devices with GUI
- ▶ Standalone processor for developing code to control peripheral devices
- ▶ Used in conjunction with associated daughter cards for GPIO Expanders, LED Controllers, Temperature Sensors, Bus Buffers, etc.



Technical Contact

- ▶ Product Information: www.nxp.com
- ▶ NXP Technical Support: www.nxp.com/support/
- ▶ E-mail: i2c.support@nxp.com

