Chip-to-Chip Interface Solutions

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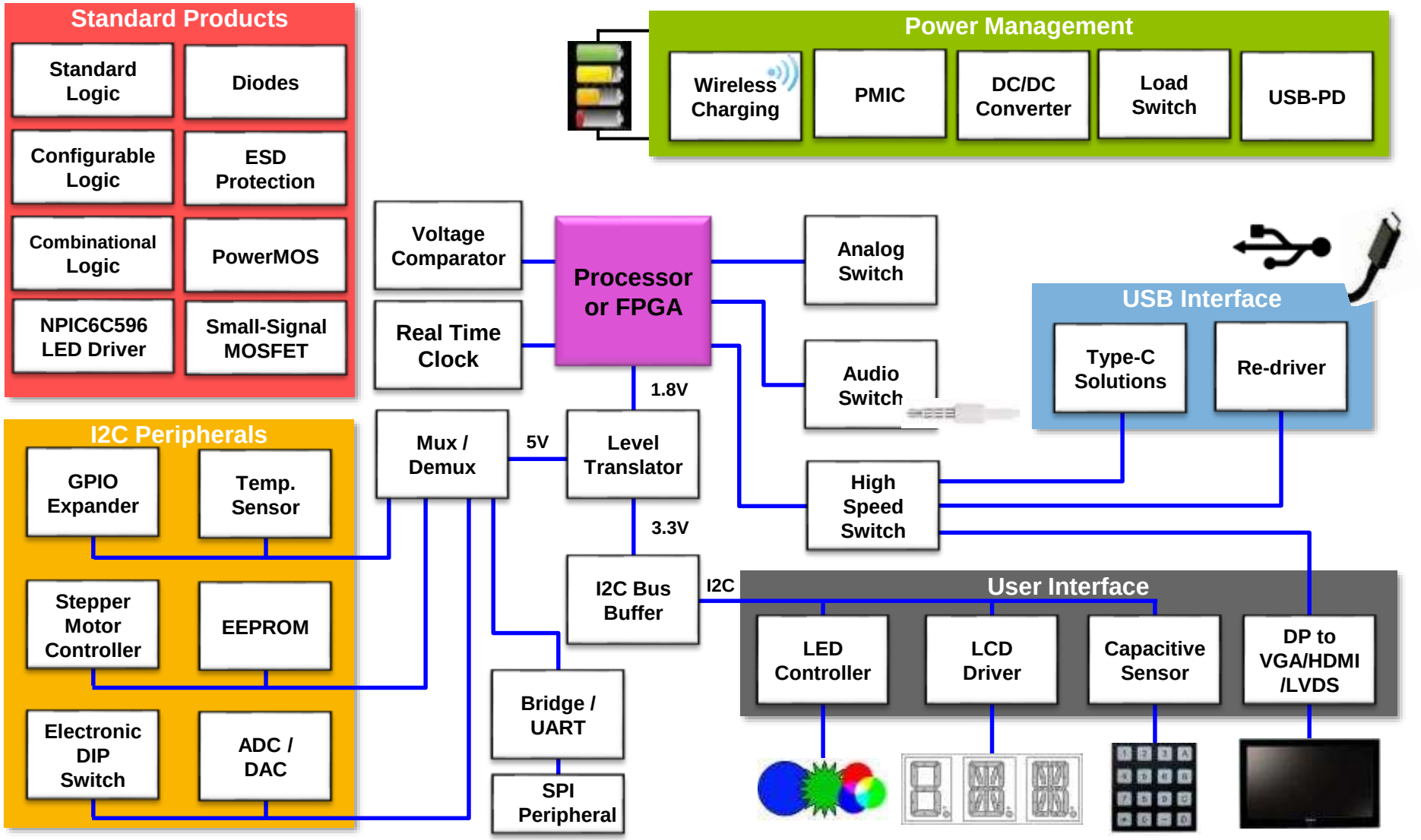
SECURE CONNECTIONS FOR A SMARTER WORLD

Agenda

- Introduction to Interface Solutions
- Signal Switches
- Voltage-Level Translators
- GPIO Expanders

Introduction to Interface Solutions

Solutions Around the Core



Secure Interfaces & Power

Signal Integrity & Routing Solutions

- Signal Switches & Re-drivers
  - USB 3.1, USB Type-C
  - Thunderbolt
  - PCIe, SATA, SAS
  - DP, HDMI, VGA
  - Audio, Data
  - Memory Interface

Industry leader in high-speed switching.

Lowest-power consumption re-drivers

Load Switches

- Over Voltage Protection
- Over Current Protection
- Reverse Current Protection
- Under voltage Lockout
- Thermal Shutdown
- Low R_{ON}
- Low Quiescent Current

HV Load switching with 100V surge protection.

Interface Solutions

- DisplayPort Bridges
- UARTS
- Comparators
- I^2C Bus Buffers
- I^2C Bus Controllers
- I^2C Muxes & Switches
- Voltage Level Translators

Industry's largest I^2C Portfolio for Mobile, Computing and Industrial.

Wireless Connectivity & Smart Sensor Solutions

- NTAG Smart Sensors
- NFMI Radio
- Audio over BLE
- RF & IF Discretes
  - Transceivers
  - LNA's
  - Mixers
  - Switches

Integrated temperature logging solutions.

Ultra low-power single-chip solution, providing robust wireless audio streaming.

Security & Authentication

- Anti-Counterfeit Solution

Industry's smallest package with lowest power.

Power Solutions

- USB Power Delivery
- AC-DC Controllers
- DC-DC Boost Converters
- Direct Charging (Rapid Battery Charging)
- Wireless Charging (Qi/A4WP)
- Micro-PMIC
- Powerline Communication Modem

High efficiency power conversion.

Support of multi-charging protocols (Direct, USB-PD, QC, BC1.2, and proprietary).

Bus Peripherals

- Real Time Clocks
- GPIO Expanders
- Temperature Sensors
- LCD Drivers
- LED Controllers
- Capacitive Sensors
- Stepper Motor Controllers
- EEPROM
- Watch IC
- Data Converter
- DIP Switches

Ultra low-power RTC's.

Widest portfolio of GPIO Expanders.

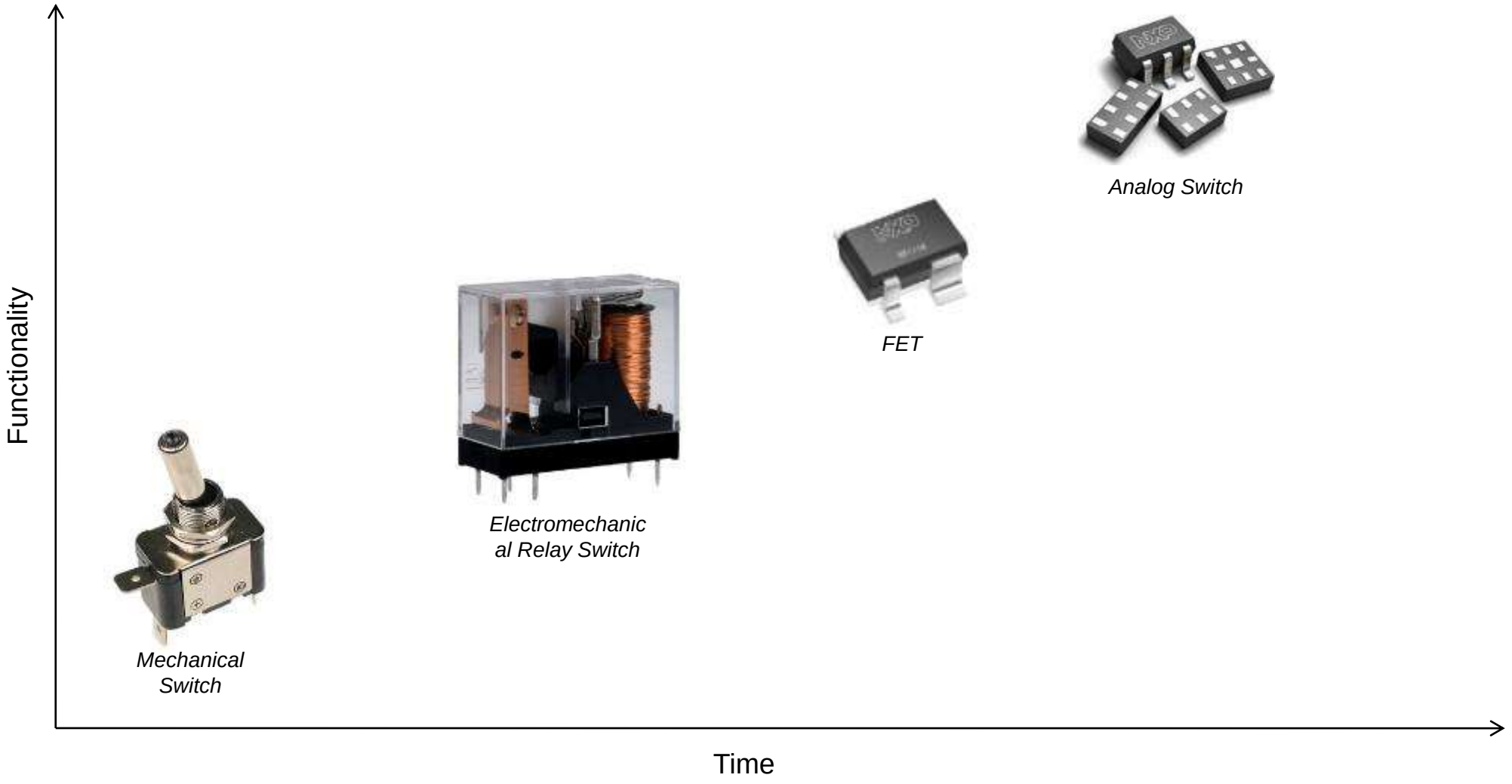
Smart Audio Solutions

- Class AB Amplifiers
- Class D Amplifiers
- Smart Amplifiers (/w integrated DSP)
- Software
- Speaker Protection
- Audio DAC & ADC

Best-in class speaker protection hardware and software Class D Amplifier solutions.

Signal Switches

The Evolution of Switches



Selecting a Switch – Critical Parameters

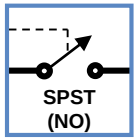
- Switch Configuration
  - SPST, SPDT, DPDT, etc.
  - Pick the configuration and number of controls pins for the application.
- Supply Voltage (V_{DD})
  - Bias voltage required to power the switch.
  - Lower V_{DD} means less head room to pass a signal.
  - Some applications like audio, may require negative voltage capability to maintain signal integrity.
- Switch Voltage (V_{SW})
  - Maximum voltage that can be applied at an input pin with respect to GND.
- Input Voltage Range (V_I)
  - The maximum voltage that can be applied at the control pin to GND.
- Bandwidth (f_{-3dB})
  - Frequency at which the signal is attenuated by -3dB from its DC level.
  - It represents the upper cutoff frequency of the switch.
  - The higher the bandwidth, the higher the data rate it can support.
- Enable & Disable Time (t_{en} / t_{dis})
  - Time it takes for the switch to change state (enabled or disabled) from the time the select pin has been triggered (asserted or deasserted).
- ON Resistance (R_{ON} or $R_{DS\text{-}ON}$)
  - Input-to-output resistance when the switch is closed.
  - The lower the R_{ON}, the less the signal passing through the switch will be attenuated.
  - R_{ON} will vary with voltage, temperature, and load current. A measure of this variation is $R_{ON(flat)}$. Selecting a low $R_{ON(flat)}$ means the device will minimize signal distortion.
- ON State Capacitance ($C_{S(ON)}$)
  - Equivalent capacitance of the switch when closed.
  - This capacitive loading of the line will affect overall bandwidth and drive current.
- Control Pin Threshold Levels (TTL versus CMOS)
  - Switches can be triggered at different threshold levels.
  - TTL trigger low and high levels are typically at 0.7V and 1.4V respectively. CMOS trigger low and high levels are at 30% and 70% of the supply voltage.
- Package Size
  - Based on layout constraints and application.

Switch Design Tradeoffs

It’s all about the size of the FET…..

- Lower R_{DSon} = bigger FET ➔ Higher capacitance = lower bandwidth
- Higher R_{DSon} = smaller FET ➔ Lower capacitance = higher bandwidth
- Higher current = bigger FET ➔ Higher capacitance = slower turn-on

Analog Switch Configurations & Nomenclatures



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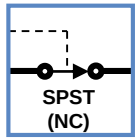

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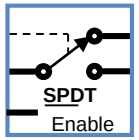

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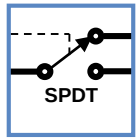

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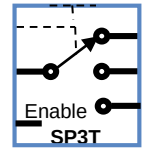

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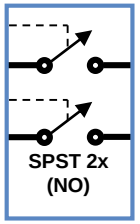

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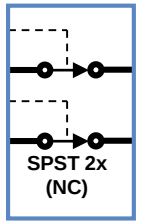

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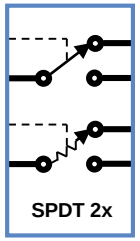
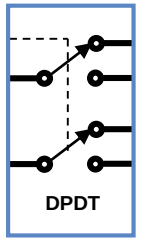
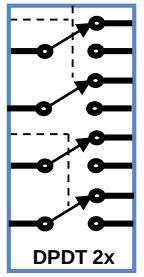


4684
2267



221
42

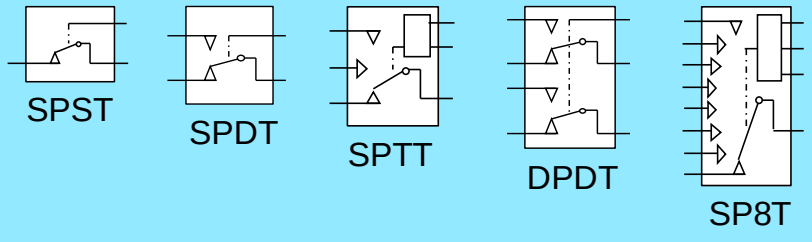


2467
2567
3899

NX3L Switch Portfolio

Config	Device type	R_{ON} (Ω)	f_{-3dB} (MHz)	THD (%)	X-talk (dB)
1x SPST	NX3L1G66	0.75	60	0.024	-90
	NX3VT384	0.45	25	0.01	-90
2x SPST	NX3L2G66	0.75	60	0.024	-90
	NX3VT384	0.45	25	0.01	-90
1x SPDT	**NX3L1G3157GW-Q100**	0.75	60	0.024	-90
	NX3L1T3157	0.75	60	0.024	-90
	NX3L1G53	0.75	60	0.024	-90
	NX3L1T53	0.75	60	0.024	-90
2x SPDT	NX3L4684	0.8	60	0.01	-90
		0.5	25		
	NX3L2267GU-Q100	0.75	60	0.024	-90
2x DPDT or 4PDT	NX3L2467	0.75	60	0.02	-90
	NX3DV2567HR-Q100	9.5	330	-	-60
	NX3DV3899	4.5	200	0.01	-90
1x SPTT	NX3L4357	0.75	30	0.02	-90
1x SP8T	**NX3L4051HR-Q100** **NX3L4051PW-Q100**	0.75	15	0.02	-90
3x SPDT	**NX3L4053HR-Q100** **NX3L4053PW-Q100**	0.8	60	0.02	-90

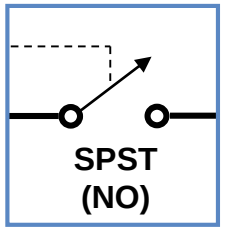
Devices listed in Blue are AEC-Q100 Qualified



Suffix	GW	GT	PW	BQ	GU
	 SOT363	 SOT833	 SOT403	 SOT763	 SOT1161
	6-pin	8-pin	16-pin	16-pin	16-pin
Width (mm)	2.10	1.00	6.40	2.50	1.80
Length (mm)	2.00	1.95	5.00	3.50	2.60
Pitch (mm)	0.65	0.50	0.65	0.50	0.40

NX3L Switch Competition

NX3L1G66



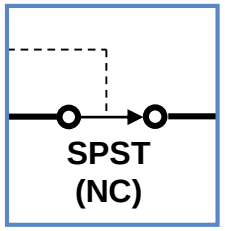
Fairchild
- FSA2156
- FSA1156
- FSA66

ON Semi
- NLAS4501

TI
- TS12A4514
- TS12A4515
- TS12A4516
- TS12A4517

Pericom
- PI5A121

NX3L1G384

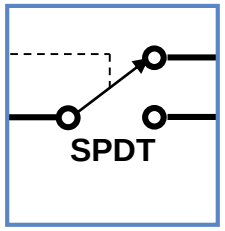


Fairchild
- FSA1157

TI
- TS5A3167
- TS5A4597

Pericom
- PI5A124

NX3L1G3157

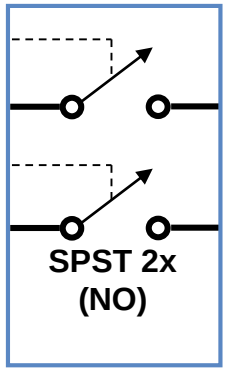


Fairchild
- FSA5157
- FSA4157
- NC7SBU3157

ON Semi
- NLASB3157
- NLAS4157

Pericom
- PI5A3157
- PI3A3159

NX3L2G66

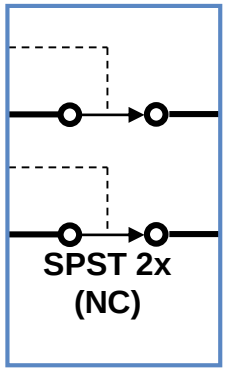


Fairchild
- FSA1256A
- FSA266
- FNC7WB66

ON Semi
- NLAS323

TI
- TS5A23166
- TS5A2066
- TS3A4741

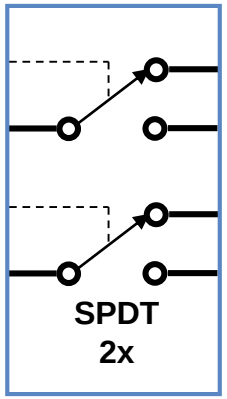
NX3L2G384



Fairchild
- FSA1257/A

TI
- TS5A23167

NX3L4684
NX3L2267



Fairchild
- FSA2267/A
- FSA2257
- FSA2268/T

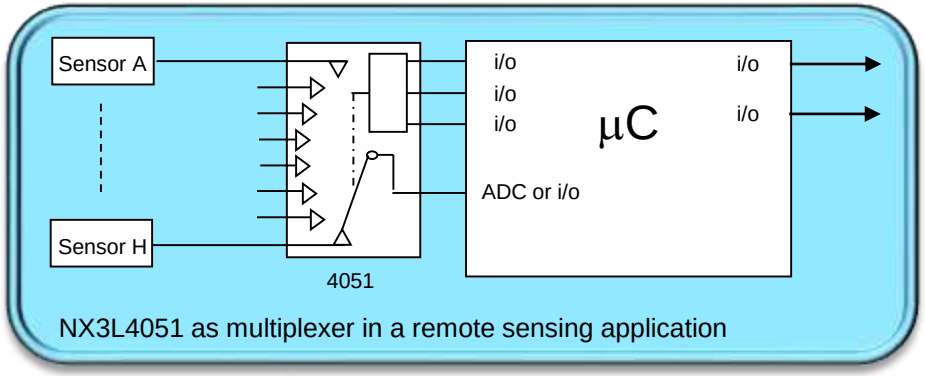
ON Semi
- NLAS5223
- NLAS4684
- NLAS4717

Pericom
- PI5A3158

= Drop-in equivalent
All others are electrical equivalent

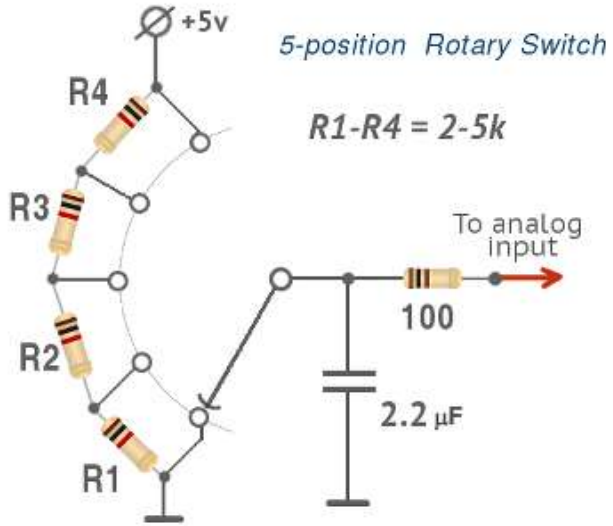
Analog Sensing Application Example with NX3L4051

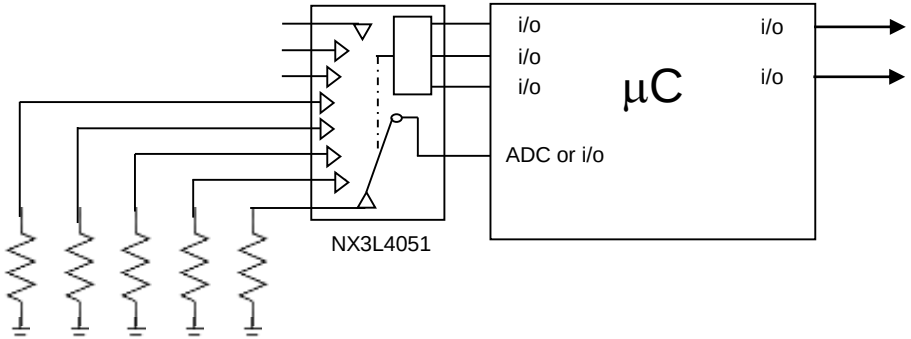
- Multiple analog sensors are used in chassis & safety functions
  - Climate control (temperature)
  - Collision prevention (proximity)
  - Passenger detection (pressure)
  - Steering (angle)
  - Windshield wipers (humidity)
- Analog multiplexers are used to
  - Reduce number of microcontrollers (ADC) required
  - Enable use of lower cost (lower pin count) microcontrollers
- Feature Low leakage ($I_{S(ON)}$ < 50 nA @ 85°C)
  - Reduces the inaccuracy introduced by multiplexing

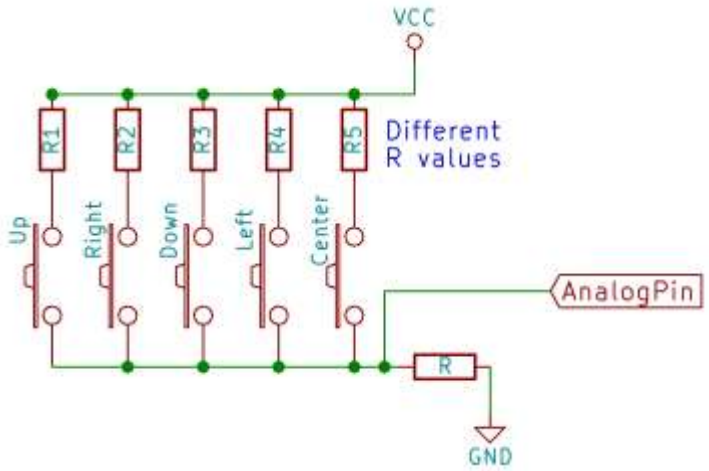


NX3L4051 as multiplexer in a remote sensing application

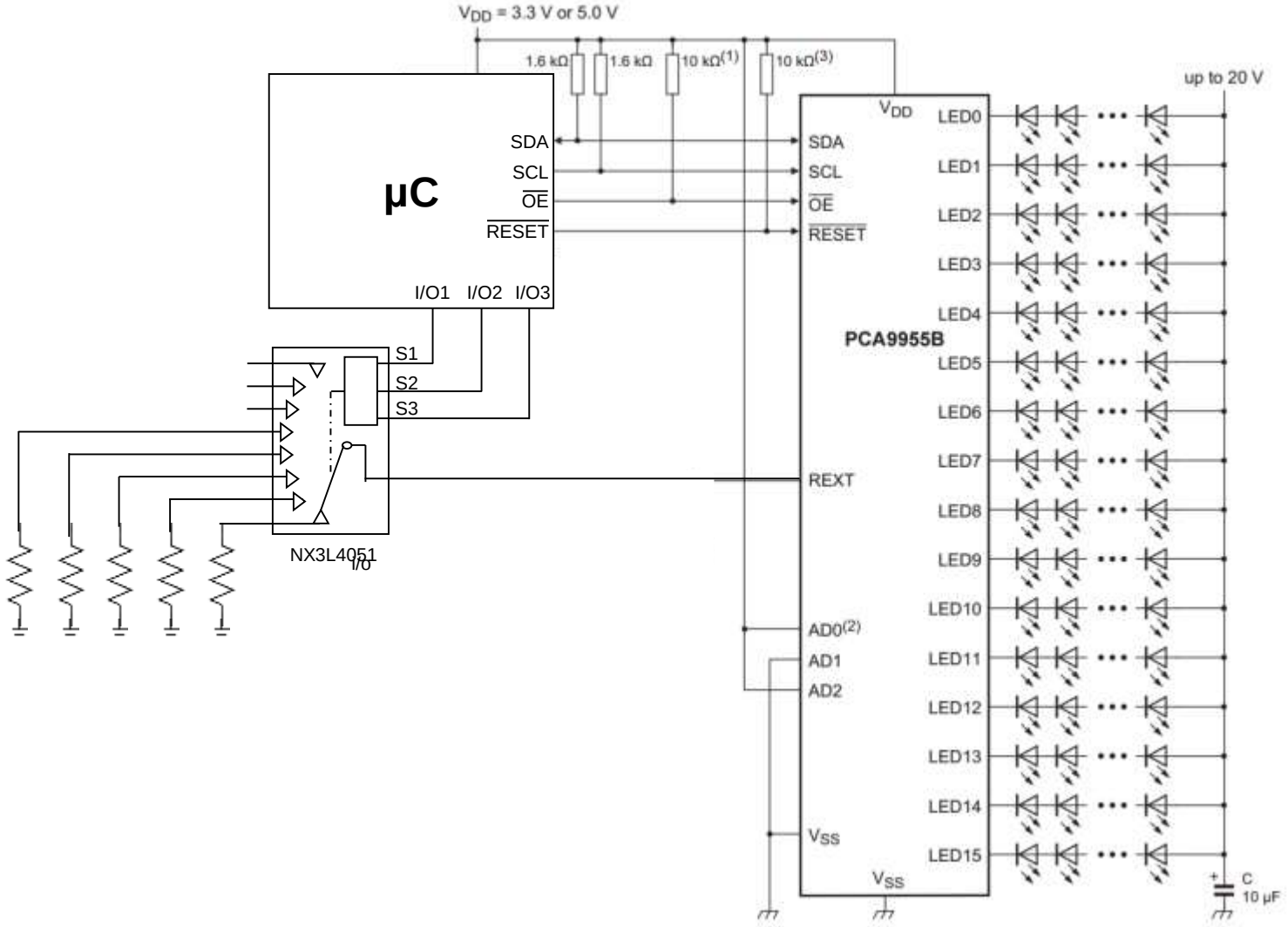
Rotary Switch Replacement with NX3L4051



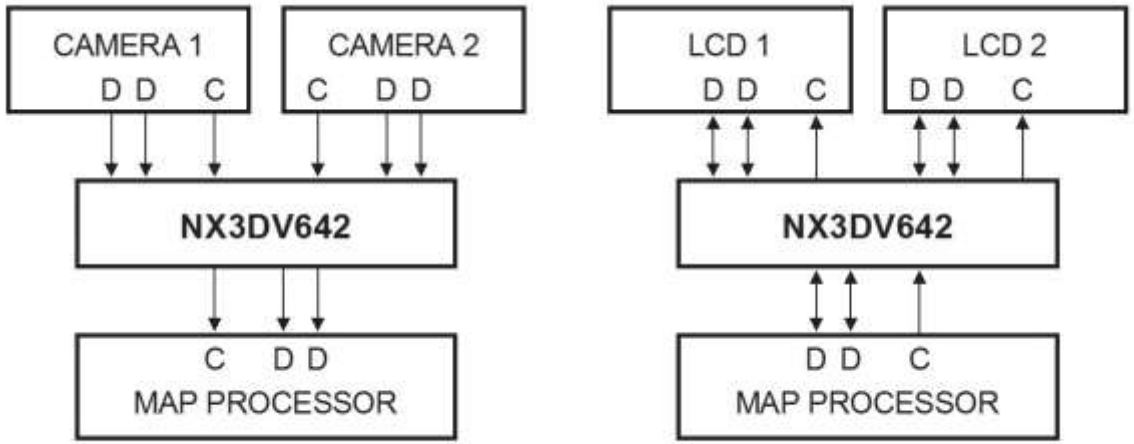


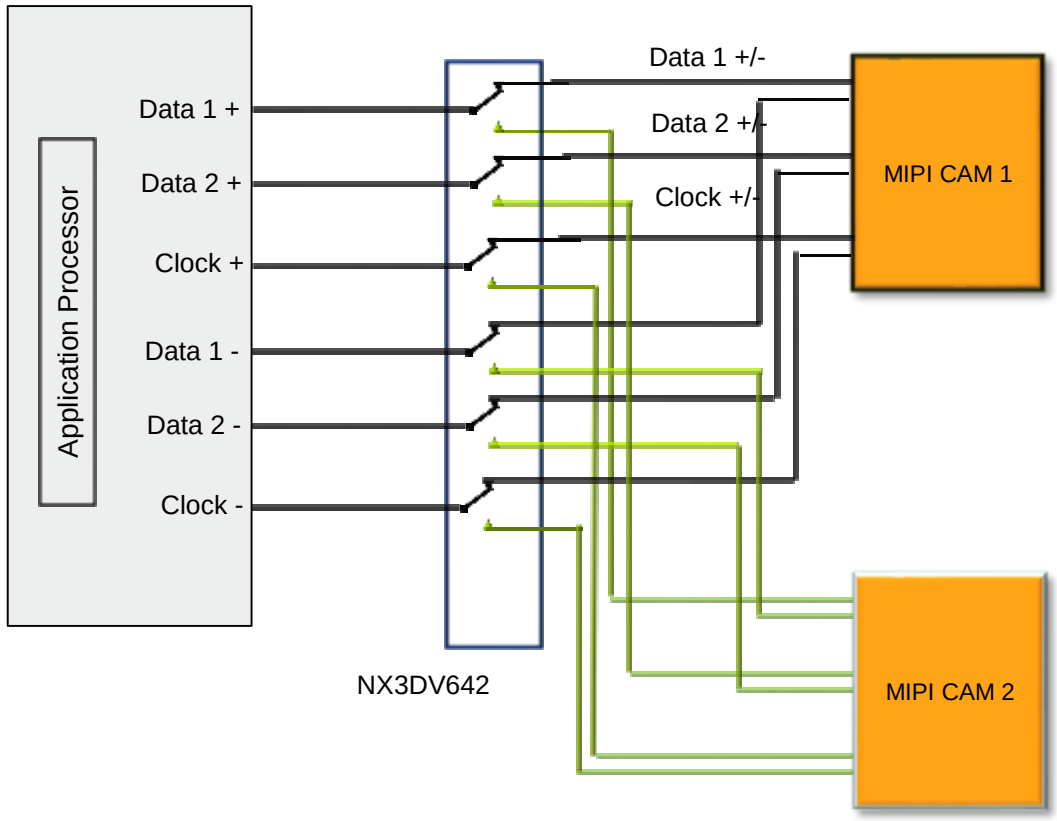


Configurable REXT Select with NX3L4051



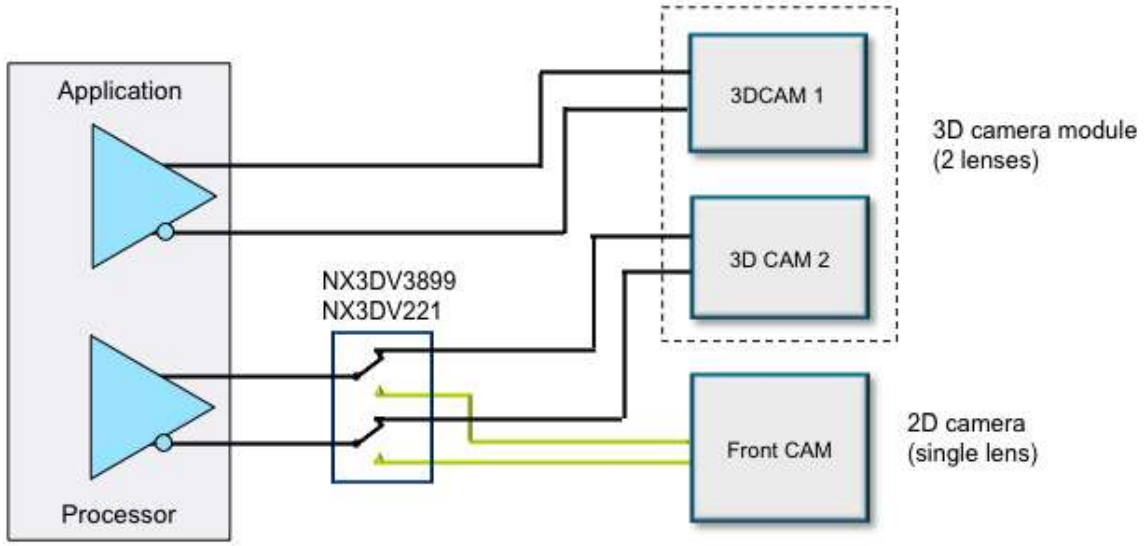
MIPI Application Example – Dual Signal Switching





MIPI cameras requiring four data signals and 2 clock signals can be supported with dual 3 port switch such as NX3DV642.

3D Camera Application with NX3DV221/42 or NX3DV3899

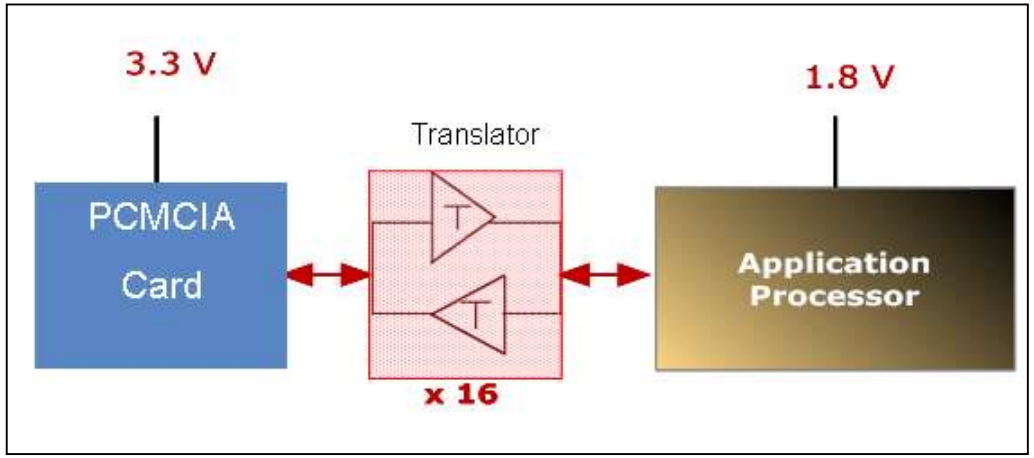


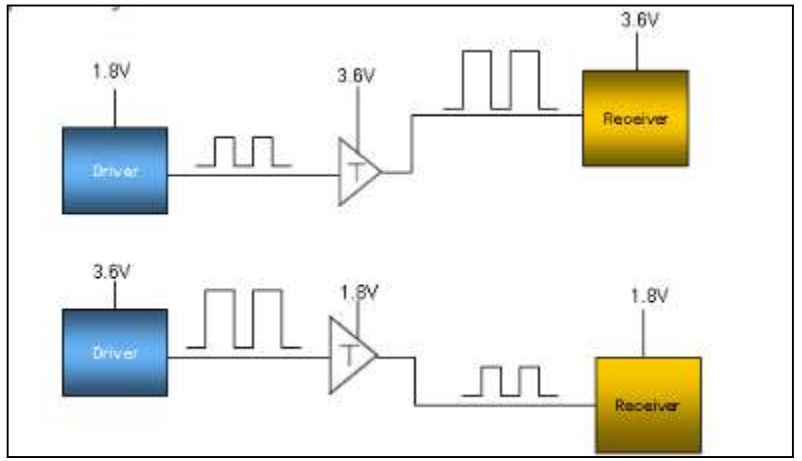
- NX3DV3899 & NX3DV221/42 can be used for 3D camera systems that use a second regular camera.
- 3D camera requires 2 lenses, and occupy both I/O of the processor.
- Utilizing a high speed switch allows to also activate a second camera for video conferencing application when only 2 I/Os are available.

Voltage-Level Translators

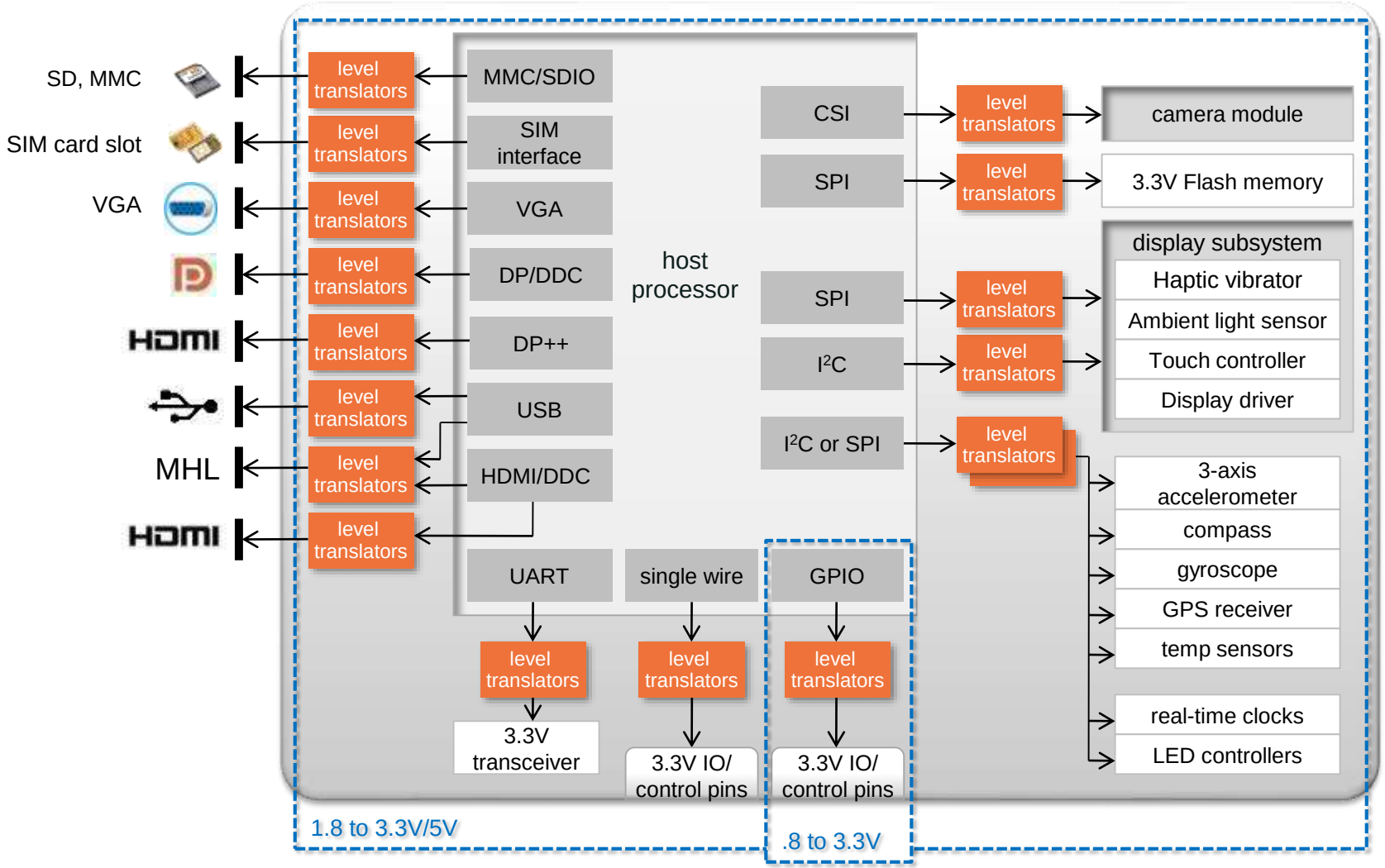
Why Voltage-Level Translator is Needed?

- New designs/applications use lower supply voltage i.e. 3.0V or lower
- All the devices used in a design/application do not use same supply voltage
- A newly designed CPU, uses a lower voltage e.g. 1.8V but a proven old peripheral uses higher supply voltage e.g. 3.3V. Memory devices, image sensors, PCMCIA cards, RF transceivers are some peripheral examples.
- Voltage-Level Translator is used to prevent the current flow in mismatched voltage supplies





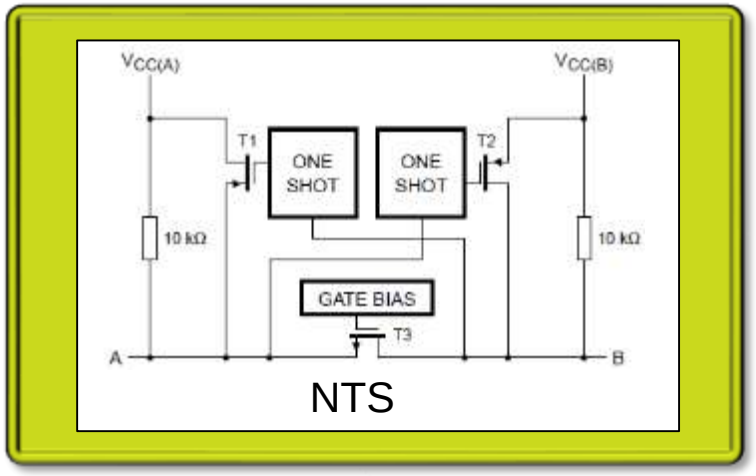
Wide Selection of Voltage-Level Translators



NTS & NTB Family of Auto-Direction Sensing Translators

Features

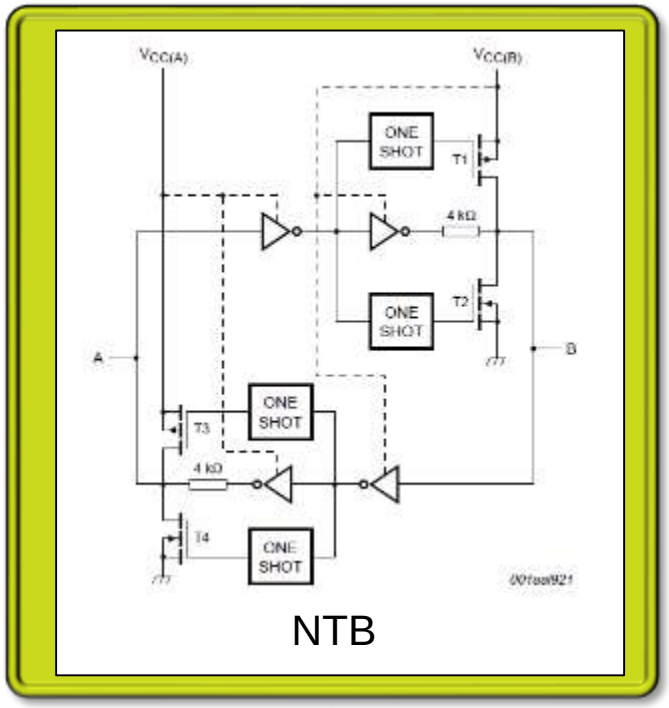
- Flow through architecture
- Auto direction sensing
- High speed (t_{PD} = 3.2 ns typ.)
- Low power dissipation (C_{PD} = 10 pF typ.)
- 3-state outputs
- AEC Q100, grade 1
- 8 kV ESD IEC61000-4-2 contact
- Fully specified (–40 to 85 and –40 to 125°C)
- Pb-free, RoHS and Dark Green compliant



NTS

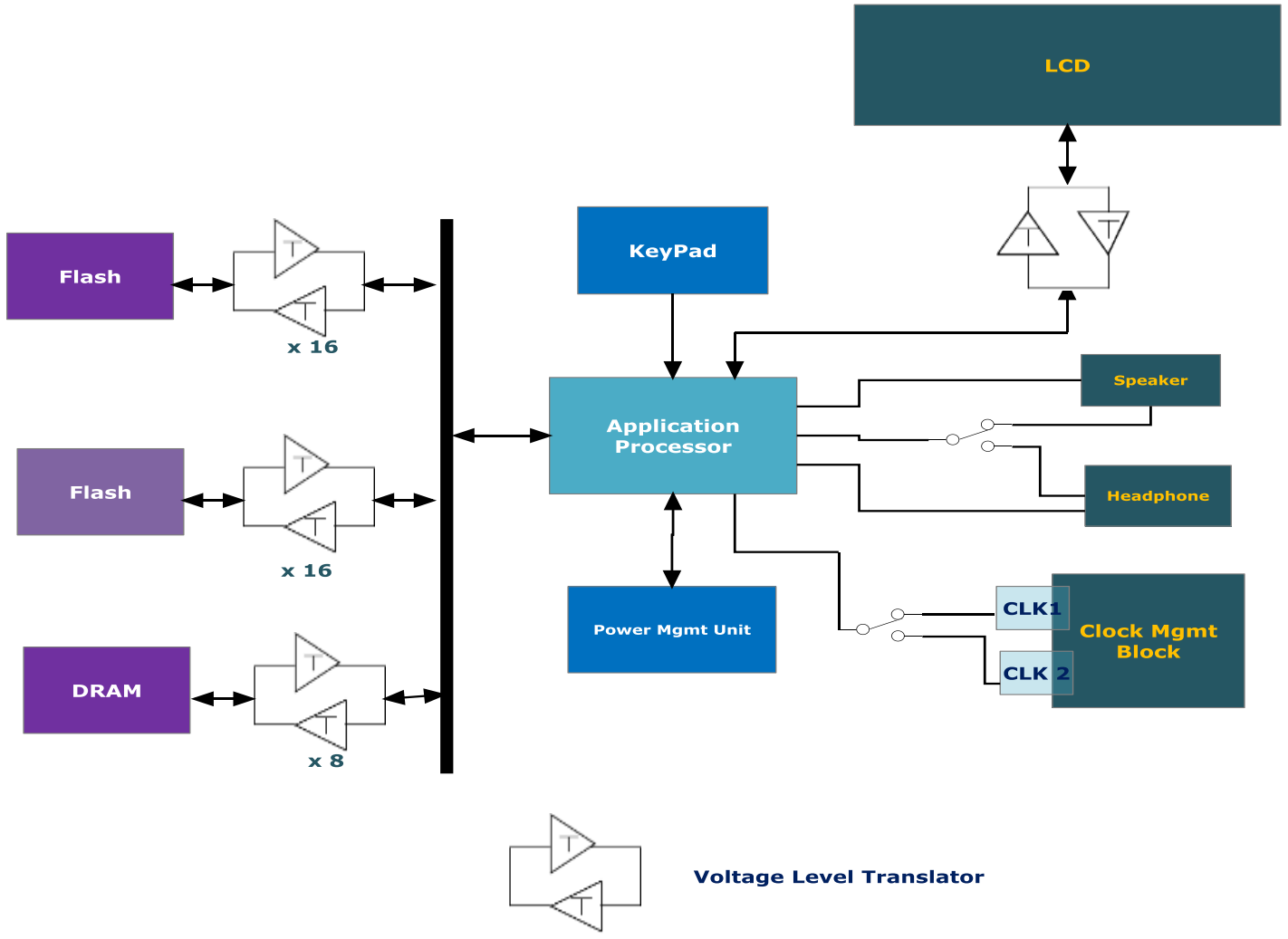
Automotive Qualified Versions:

NTB0102DP-Q100
NTB0102GD-Q100
NTB0104BQ-Q100
NTB0104UK-Q100
NTS0102DP-Q100
NTS0102GD-Q100
NTS0104BQ-Q100
NTS0104PW-Q100



NTB

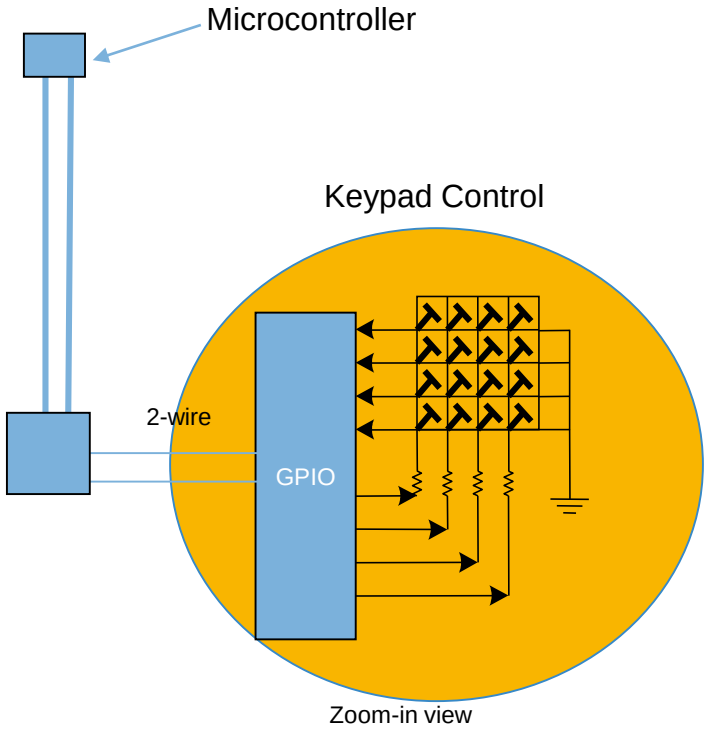
Voltage-Level Translators in Media Player



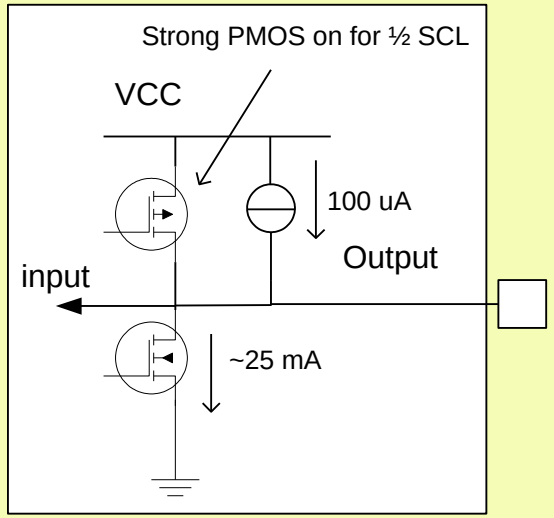
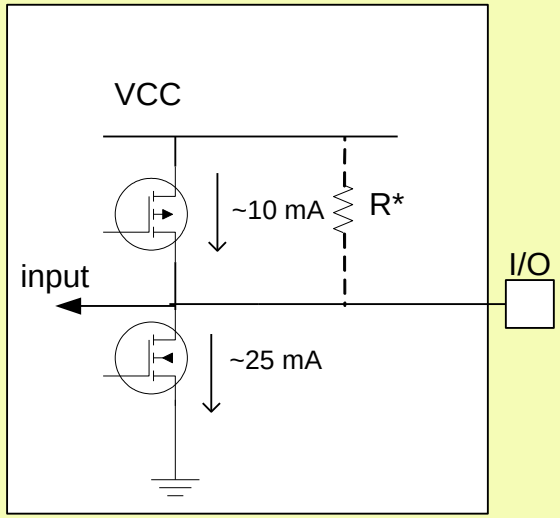
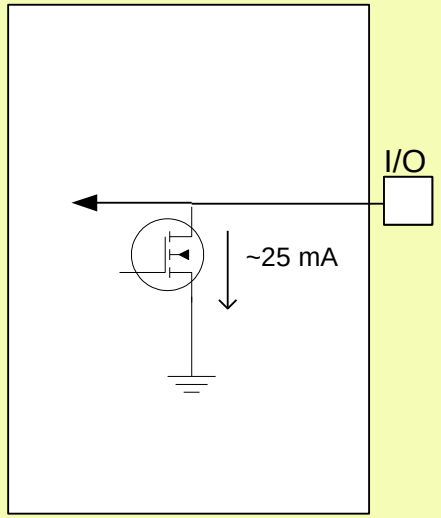
GPIO Expanders

GPIO Expanders Overview

- **Why used?**
  - Easily adds I/O via I²C-bus
  - Additional inputs for keypad, switch, signal monitoring, etc.
  - Additional outputs for LED control, relay, timers and sensor.
- **Where used?**
  - Automotive
  - Computing
  - Industrial Controls
  - Medical Equipment
  - Cell Phones
  - Gaming Machines
- **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
  - Invented the I²C-bus. Continuously developing newer devices with added features to support different applications.



Flexible I/O (Output) Structures

Quasi Output	Totem-Pole Output	Open-Drain Output
		
• Strong PMOS transistor is turned on only during the LH transition • PMOS transistor is off during static drive • Weak current source at the output	• Upper PMOS transistor is turned on during static high drive • Some devices have weak pull-ups at the output	• No upper PMOS transistor • No pull-up resistor • No weak current drive

GPIO Expanders with **Totem-Pole** Output Structure

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 & I²C	PCA9502
	2.3 to 5.5V			YES			PCA9534
	2.3 to 5.5V		YES	YES		Open Drain Interrupt output	PCA9538
	2.3 to 5.5V			YES	100 KΩ	Use PCA9554A for alternate I²C address	PCA9554/A
	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 trans. selectable open drain	PCA9574
16	2.3 to 5.5V	400 kHz	NO	YES			PCA9535
	2.3 to 5.5V		YES	YES			PCA9539
	2.3 to 5.5V					"R" version resets I²C-bus state machine	PCA9539R
	2.3 to 5.5V			YES	100 KΩ		PCA9555
	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
40	2.3 to 5.5V	400 kHz	YES	YES	100 KΩ	Output enable	PCA9505
			YES	YES		Output enable	PCA9506
	2.3 to 5.5V	1 MHz	YES	YES		Output enable, selectable open drain	PCA9698
LOW VOLTAGE							
8	1.65 to 5.5V	400 kHz	YES	YES		Low standby current: 1.5 µA typ at 5V supply; 1.0 µA typ at 3.3V supply	PCA9538A
				YES	100 KΩ	Use PCA9554C for alternate I²C address	PCA9554B/C
			YES	YES		Standby current: 3 µA max dual V_{CC}	PCA6408A
16	1.65 to 5.5V	400 kHz	NO	YES		Low standby current: 1.5 µA typ at 5V supply; 1.0 µA typ at 3.3V supply	PCA9535A
			YES	YES			PCA9539A
			YES	100 KΩ			PCA9555A
			YES	YES		Dual $V_{CC;}$ low standby current: 1.5 µA typ at 5V supply; 1.0 µA typ at 3.3V supply	PCA6416A

GPIO Expanders with **Quasi** Output Structure

BITS	V RANGE	BW	RESET	INT	I/O PULL-UP [1]	NOTES	PART#
8	2.5 to 6.0V	100 kHz	NO	YES	weak PU		PCF8574/A
	2.3 to 5.5V	400 kHz	NO	YES	weak PU		PCA8574/A
	2.2 to 3.6V	400 kHz	NO	NO	weak PU	2 Kb EEPROM	PCA9500
		400 kHz	NO	YES	weak PU	2 Kb EEPROM	PCA9501
	2.3 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	4.5 to 5.5V	400 kHz	NO	YES	weak PU		PCF8575
	2.3 to 5.5V	400 kHz	NO	YES	weak PU		PCA8575
	2.3 to 5.5V	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}.

GPIO Expanders with **Agile I/O** (PCA**L**xxxx)

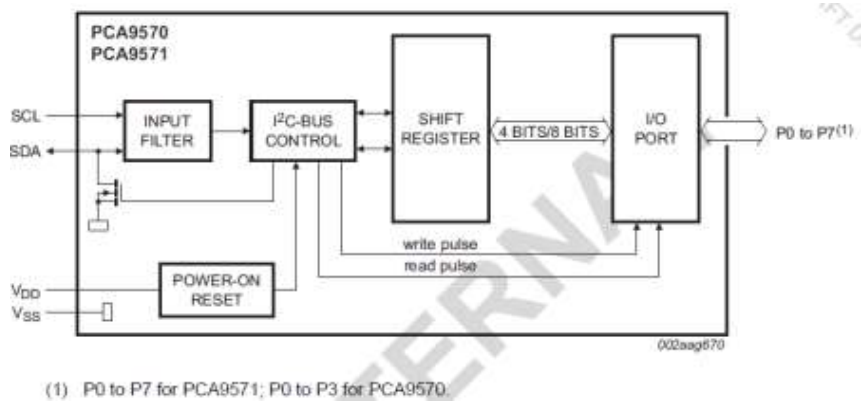
	BITS	V RANGE	BW	RESET	INT	I/O PULL-UP	NOTES	PACKAGE	PART#
	8	1.65 to 5.5V	400 kHz	YES	YES	programmable	single V_{CC}	HVQFN16, TSSOP16	PCAL9554B PCAL9554C
				YES	YES	programmable	single V_{CC}	HVQFN16, TSSOP16	PCAL9538A
				YES	YES	programmable	dual V_{CC}	HVQFN16, TSSOP16, XQFN16, XFBGA16	PCAL6408A
	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

- Operate down to 1.65V and Up to 5.5V
- PCAL95XX are pin-to-pin compatible with PCA95xx devices
- Features input latch, /INT mask and other new Agile IO features
  - Input latch (bit-by-bit, default not latched): lock I/O pin changes on input until register read
  - Output drive strength control (bit-by-bit, default 10 mA/25 mA). User can program I/O drive strength: 25%, 50%, 75% and Full (default).
  - Open drain control (bank-by-bank, default push-pull). Provide an optional open-drain output for each I/O pin and an additional wired-OR plane.
  - Pull-up or pull-down (bit-by-bit, default no PU/PD): user programmable each I/O pin.
  - 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

Small, Low-Cost, Low-Voltage GPO Expanders

FEATURES

- 1.1 V to 3.6 V operation with 4- or 8-bit, 4mA push-pull outputs
- 1 MHz I^2C-bus interface with 6mA SDA sink capability for lightly loaded buses and improved power consumption
- Compliant with the I^2C-bus Fast and Standard modes
- Readable device ID (manufacturer, device type, and revision)
- Software Reset and power-on reset
- Low standby current
- −40° C to +85° C operation
- ESD protection exceeds 2000 V HBM per
  - JESD22-A114 and 1000 V CDM per
  - JESD22-C101
- Latch-up testing is done to JEDEC standard
  - JESD78 which exceeds 100 mA
- Packages offered: XQFN8 and XQFN12



(1) P0 to P7 for PCA9571; P0 to P3 for PCA9570.

Part Number	Package Type	Package Description	Version
PCA9570GM4 (In Dev)	XQFN8	plastic, extremely thin quad flat package; no leads; 8 terminals; body 1.20 × 1.40 × 0.50 mm; 0.4mm pitch	SOT1309-1
PCA9570GM	XQFN8	plastic, extremely thin quad flat package; no leads; 8 terminals; body 1.6 × 1.6 × 0.5 mm; 0.5mm pitch	SOT902-2
PCA9571GU	XQFN12	plastic, extremely thin quad flat package; no leads; 12 terminals; body 1.70 × 2.00 × 0.50 mm; 0.4mm pitch	SOT1174-1

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