Designing with NXP Interface Devices

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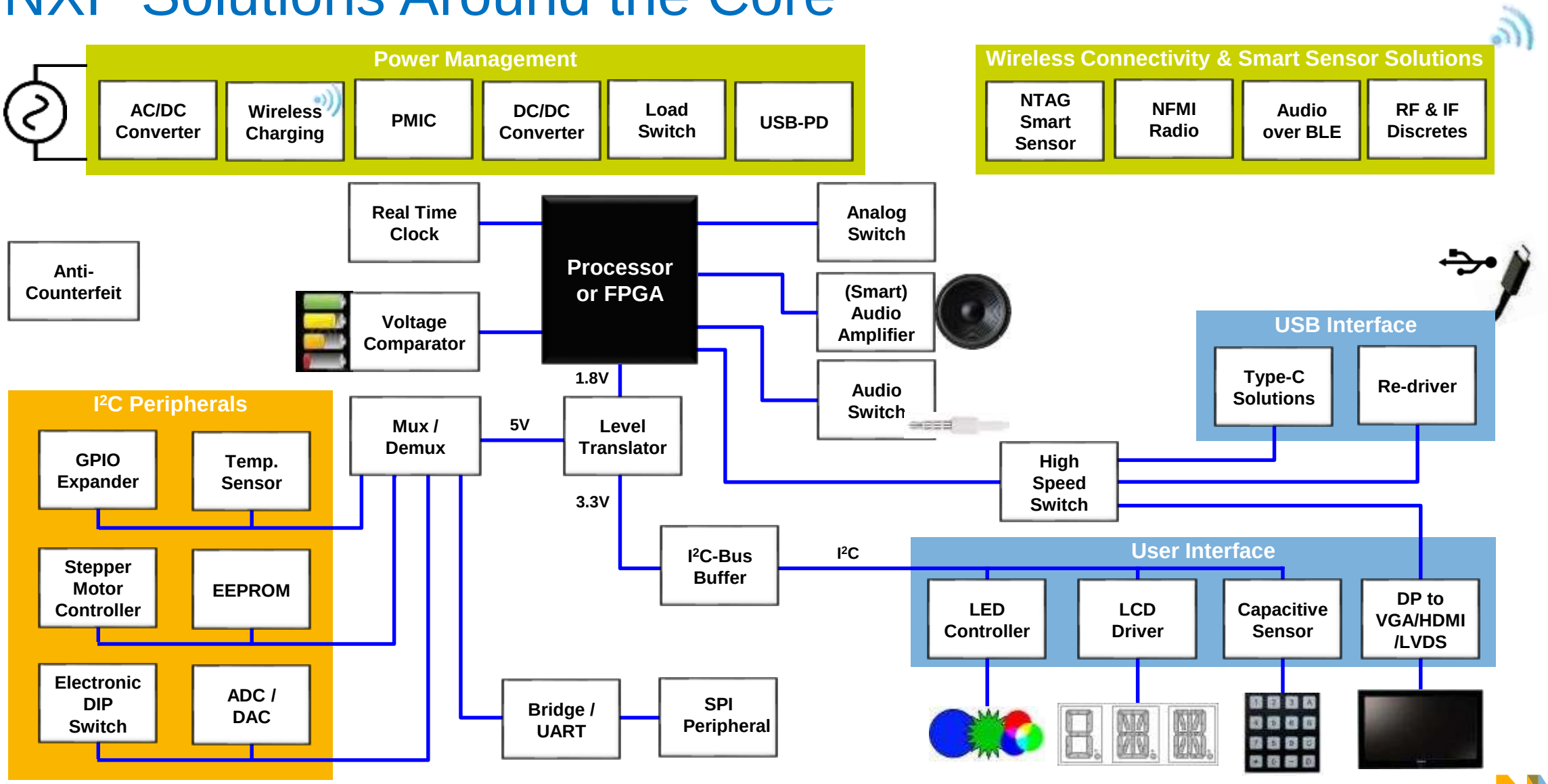
SECURE CONNECTIONS FOR A SMARTER WORLD

Agenda

- Introduction to Interface Solutions
- Signal Switches
- Voltage-Level Translators
- GPIO Expanders
- LED Controllers
- Real Time Clocks

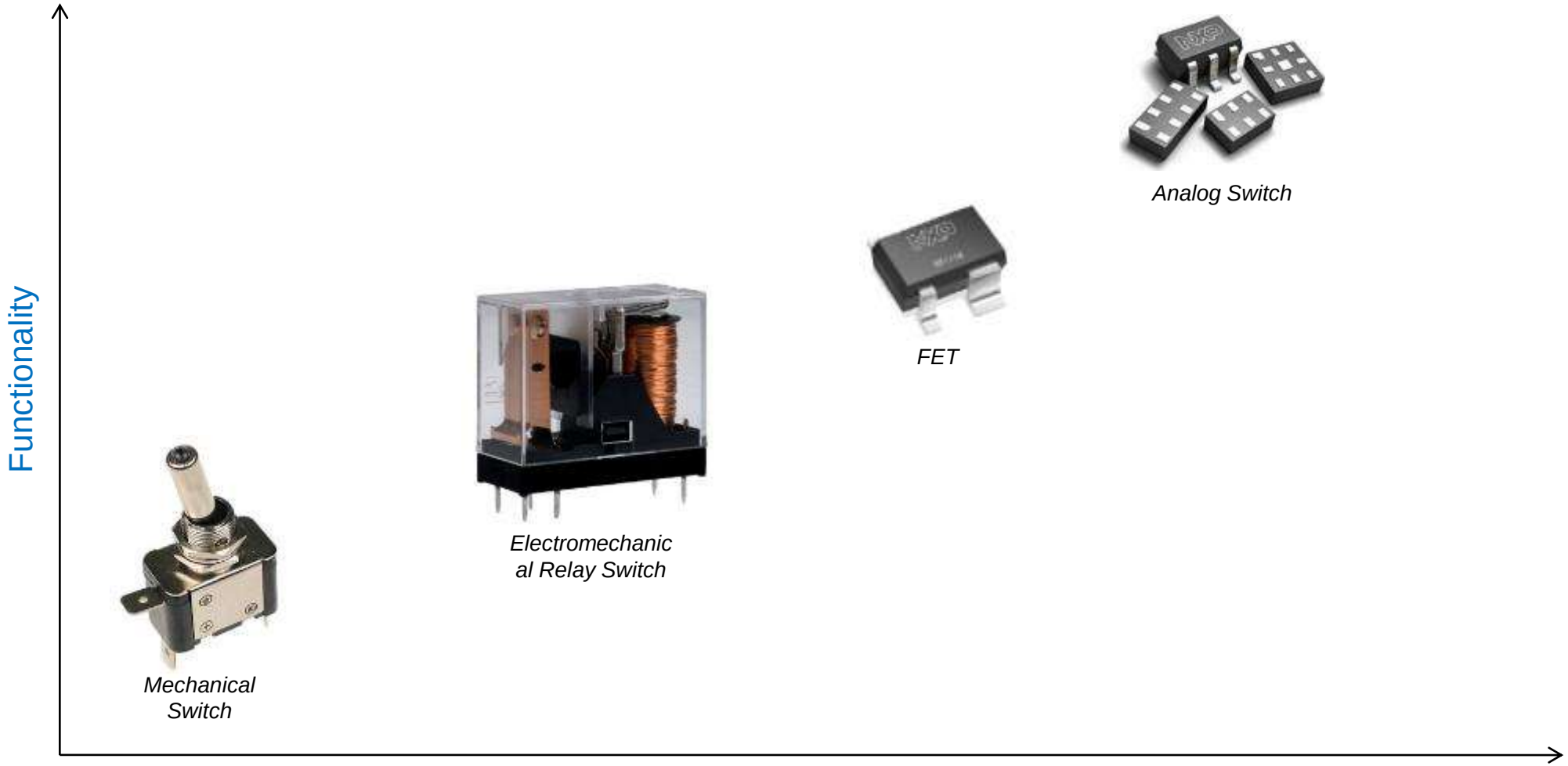
Introduction to Interface Solutions

NXP Solutions Around the Core



Signal Switches

The Evolution of Switches



Selecting a Switch – Critical Parameters

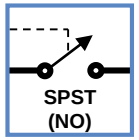
- Switch Configuration
  - SPST, SPDT, DPDT, etc.
  - Pick the configuration and number of controls pins for the application.
- Supply Voltage (V_{DD})
  - Bias voltage required to power the switch.
  - Lower V_{DD} means less head room to pass a signal.
  - Some applications like audio, may require 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 de-asserted).
- ON Resistance (R_{ON} or R_{DS-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 and Nomenclatures



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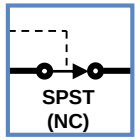

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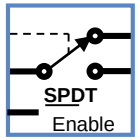

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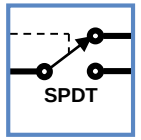

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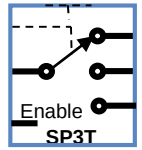

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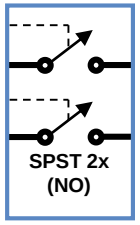

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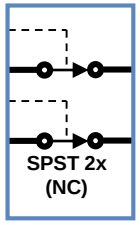

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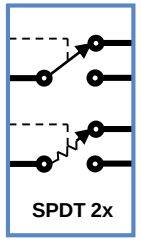

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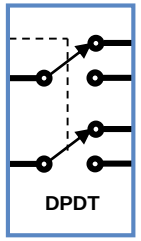

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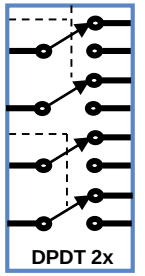
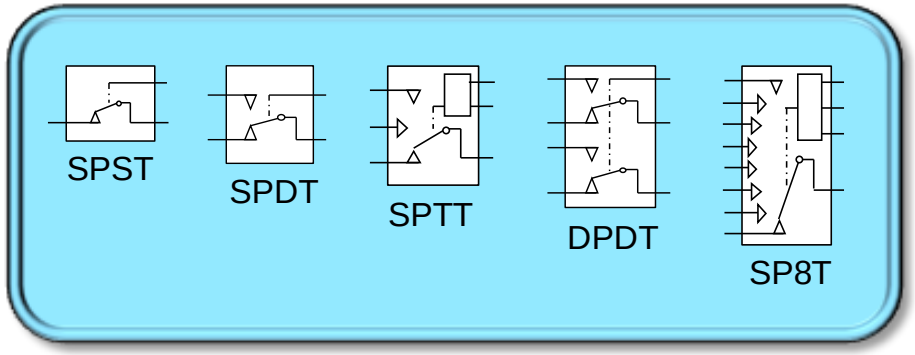


2467
2567
3899

NX3L Analog Switch Portfolio

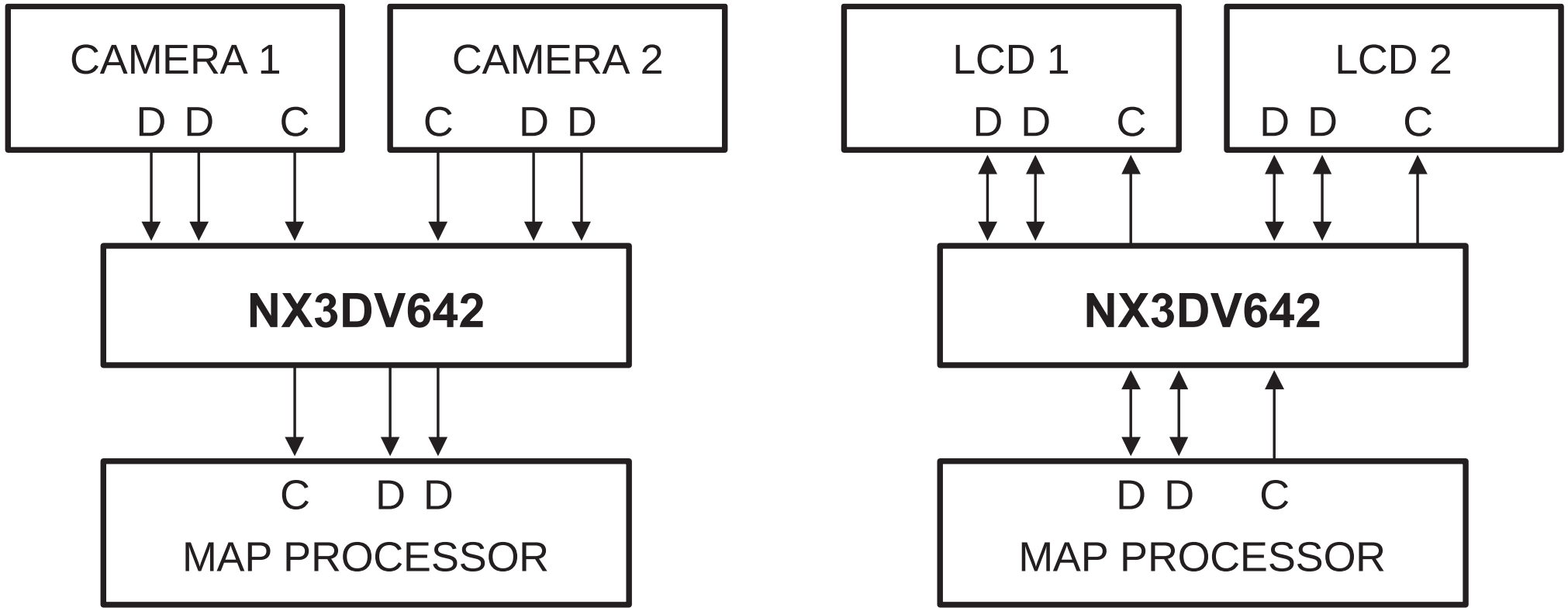
Config	Device type	R_{ON} (Ω)	f_{-3dB} (MHz)	THD (%)	X-talk (dB)
1x SPST	NX3L1G66	0.75	60	0.024	-90
	NX3VT384	0.45	25	0.01	-90
2x SPST	NX3L2G66	0.75	60	0.024	-90
	NX3VT384	0.45	25	0.01	-90
1x SPDT	**NX3L1G3157GW-Q100**	0.75	60	0.024	-90
	NX3L1T3157	0.75	60	0.024	-90
	NX3L1G53	0.75	60	0.024	-90
	NX3L1T53	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

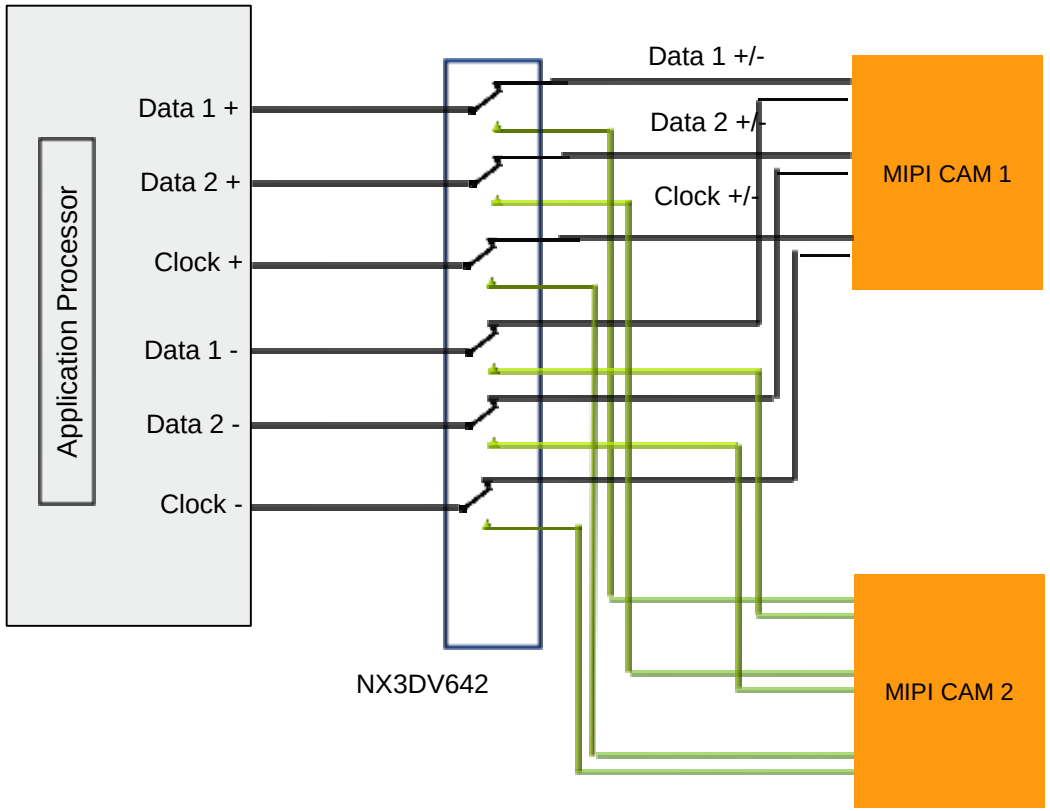


Suffix	GW	GT	PW	BQ	GU
					
	SOT363	SOT833	SOT403	SOT763	SOT1161
	6-pin	8-pin	16-pin	16-pin	16-pin
Width (mm)	2.10	1.00	6.40	2.50	1.80
Length (mm)	2.00	1.95	5.00	3.50	2.60
Pitch (mm)	0.65	0.50	0.65	0.50	0.40

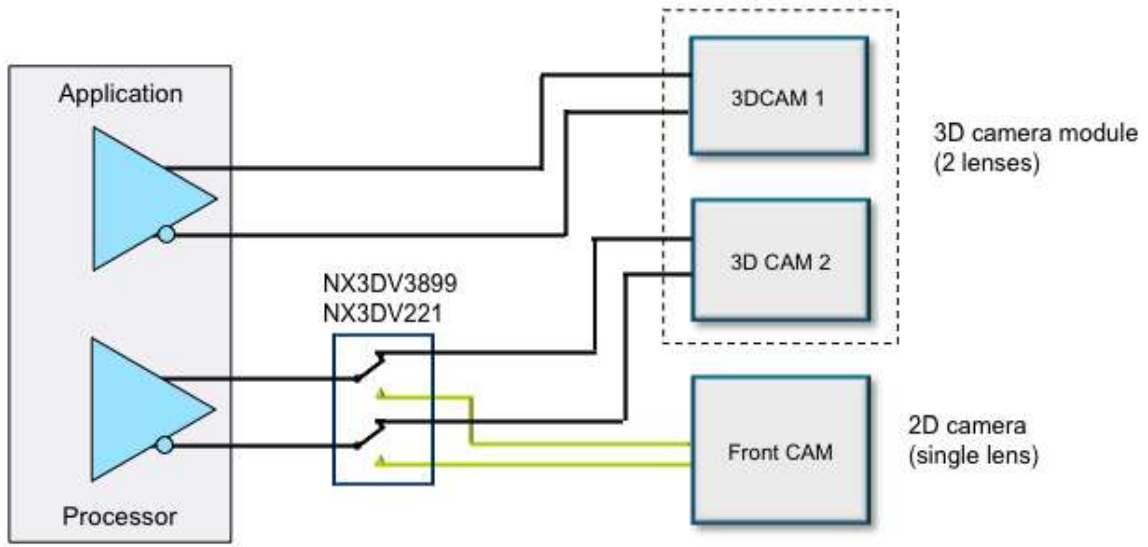
MIPI Application Example – Dual Signal Switching



MIPI Camera – Dual Camera & 3D Camera Applications



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

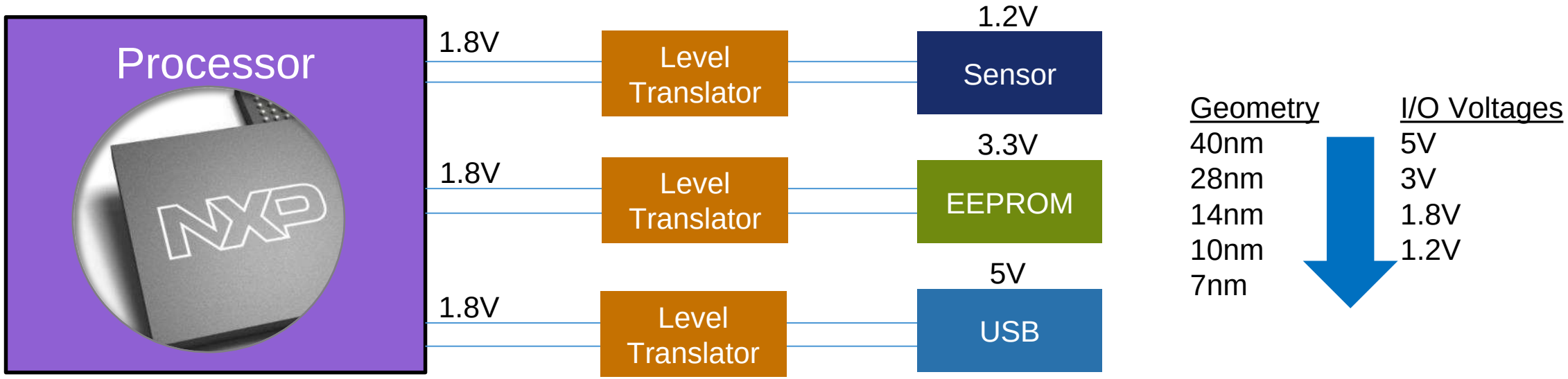


- NX3DV3899 & NX3DV221/42 can be used for 3D camera systems that use a second regular camera.
- 3D camera requires 2 lenses, and occupy both I/O of the processor.
- Utilizing a high speed switch allows to also activate a second camera for video conferencing application when only 2 I/Os are available.

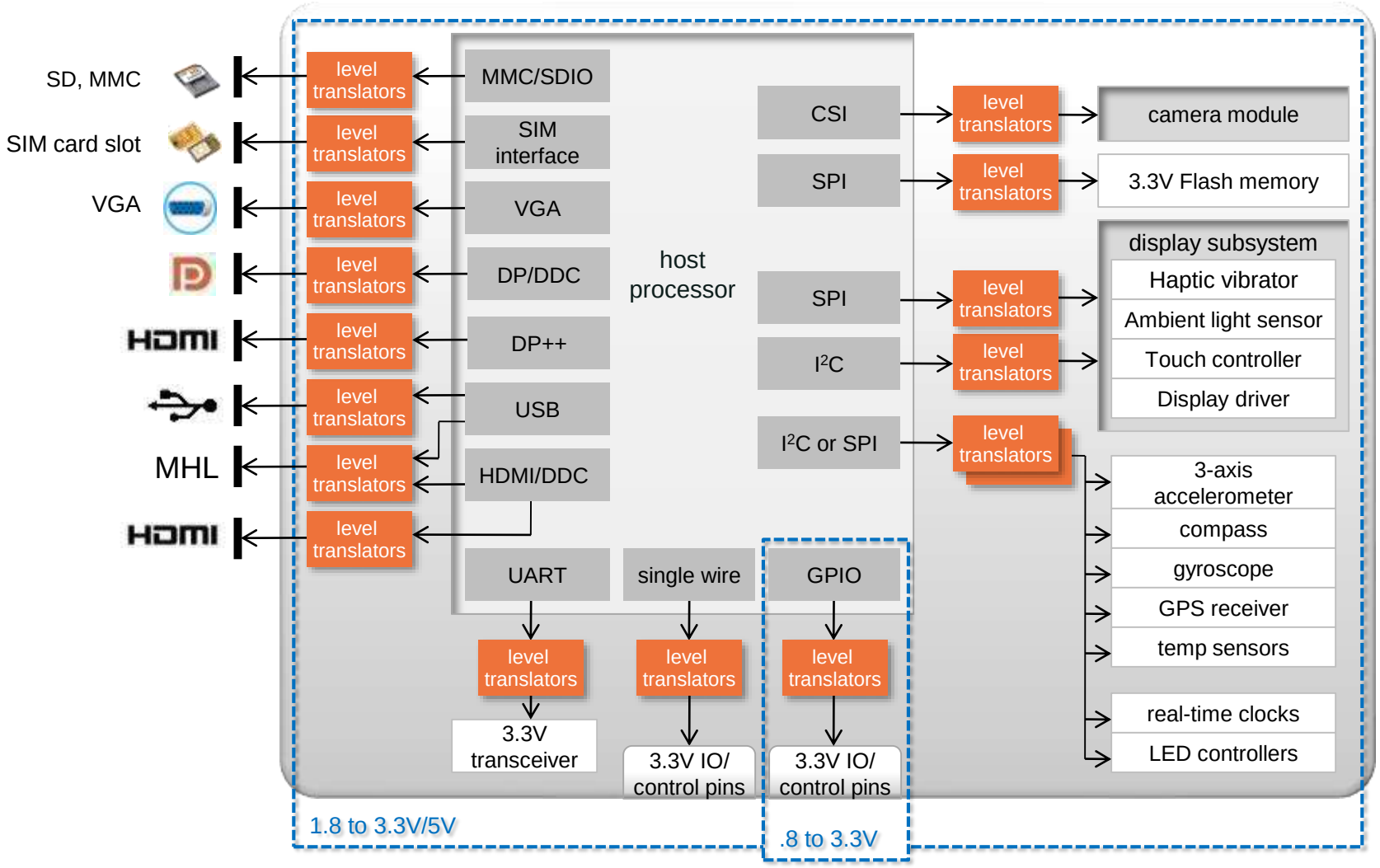
Voltage-Level Translators

Why Voltage Level Translators are 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 (e.g. memory, sensors, RF transceivers, etc.) uses higher supply voltage e.g. 3.3V.
- Voltage-Level Translator is used to prevent the current flow in mismatched voltage supplies



Different Applications for Voltage Level Translators



Voltage Level Translators 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
- Operates down to 0.95V

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

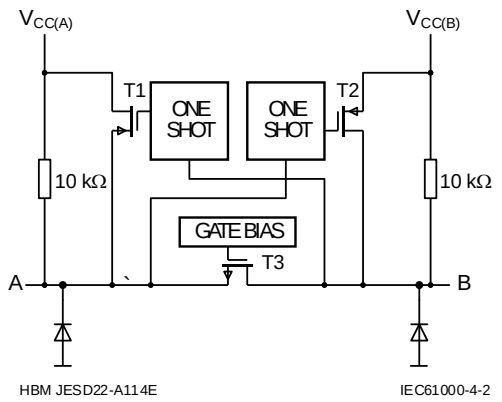
Features:
- Dual supply
- Bidirectional
- Passive
- Open Drain
- Integrated Pull up resistors
- NTSX family has high sink current capability

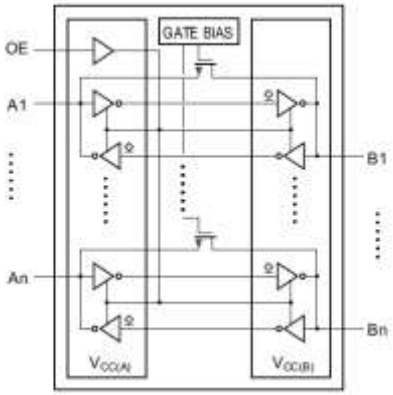
Applications
- Control Interfaces

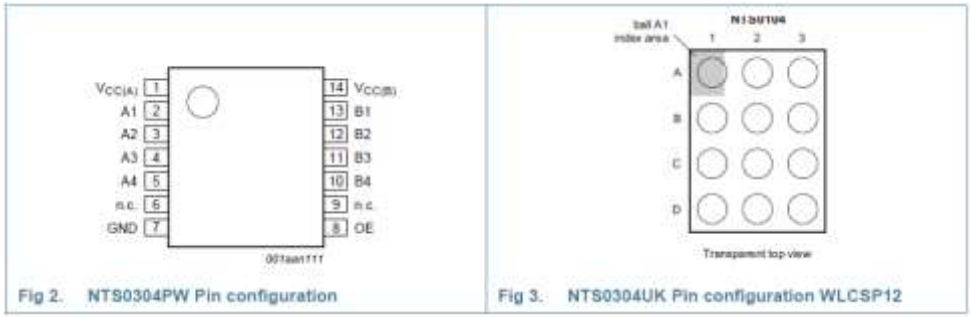
NTS030x: Universal Level Translators

Maximum Data Rates – 20Mbps (Push Pull) / 10Mbps (Open Drain)

- Number of channels: 1, 2, 4, & 8-Bit Bi-directional level-shifting
- Supply voltage range
  - Number of channels: 1, 2, 4, & 8-Bit Bi-directional level-shifting
  - Supply voltage range:
    - A-Side Voltage: 0.95V to 3.6V
    - B-Side Voltage: 1.65V to 5.5V
    - $V_{CC(A)} \leq V_{CC(B)}$
- ESD: 8kV IEC61000-4-2, Class4, contact on the B-Side
- Smart one-shot with ~40 ns ($50ns_{max}$) pulse and slew-rate control for EMI reduction
- Compatible with most competitor footprints adding wider supply range and reducing EMI
- Packaging:
  - 8-channel: TSSOP20,VQFN20 and USON20
  - 4-channel: **TSSOP14†**, **WLCSP12†**, DHVQFN14, XQFN12
  - 2-channel: 8 Pin, TSSOP8, SSOP8, **X2SON8†**, XQFN8 and WLCSP8
  - 1-channel: 6-Pin, TSSOP6, SC-88



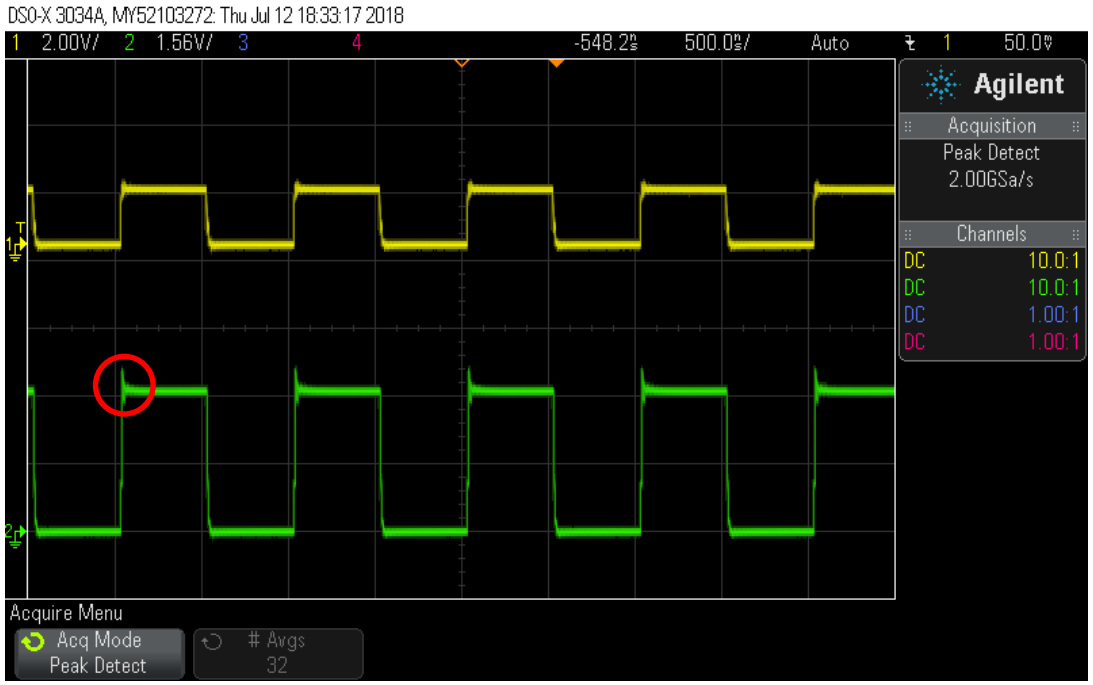




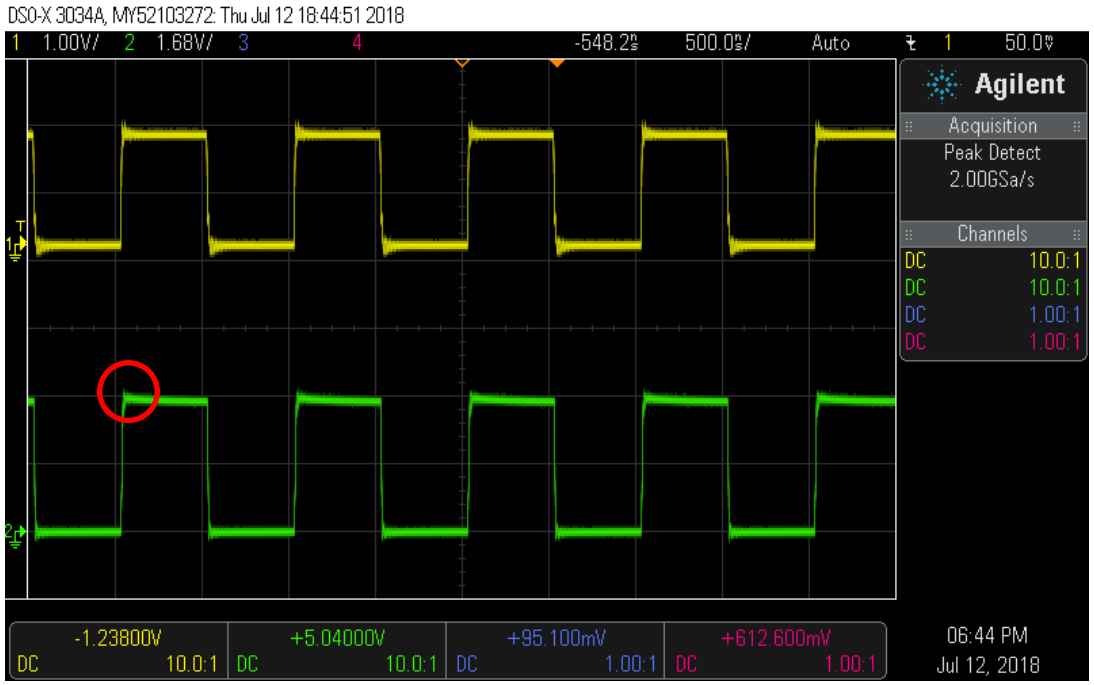
† **Package options that are currently released**

NTS0304 vs NTS0104: No Overshoot with Smart One Shot

Older generation: NTS0104



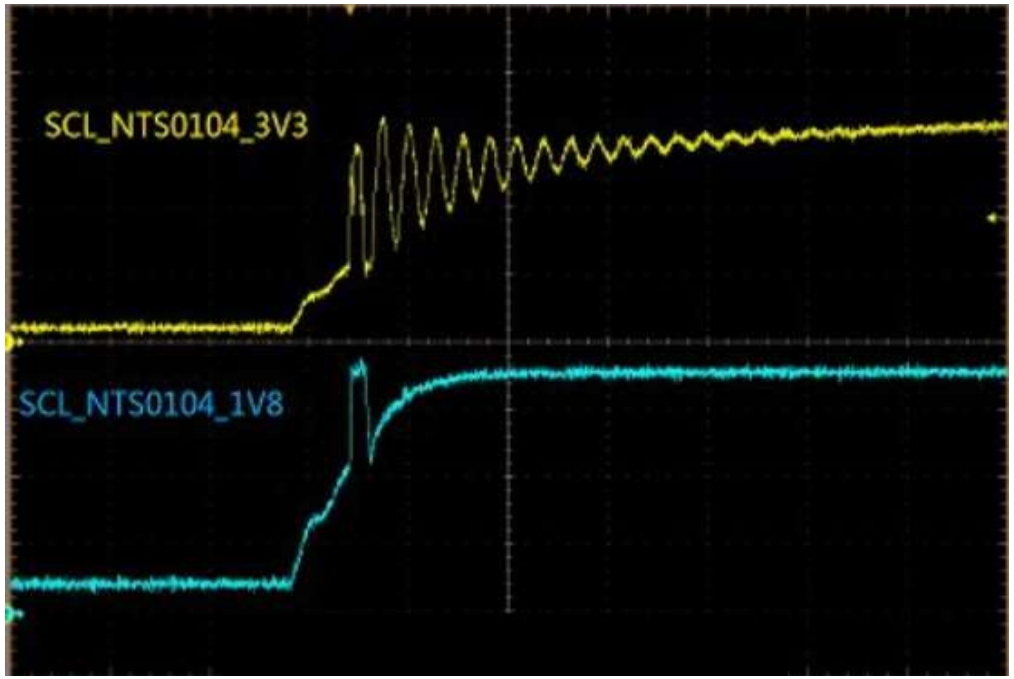
Newer generation: NTS0304



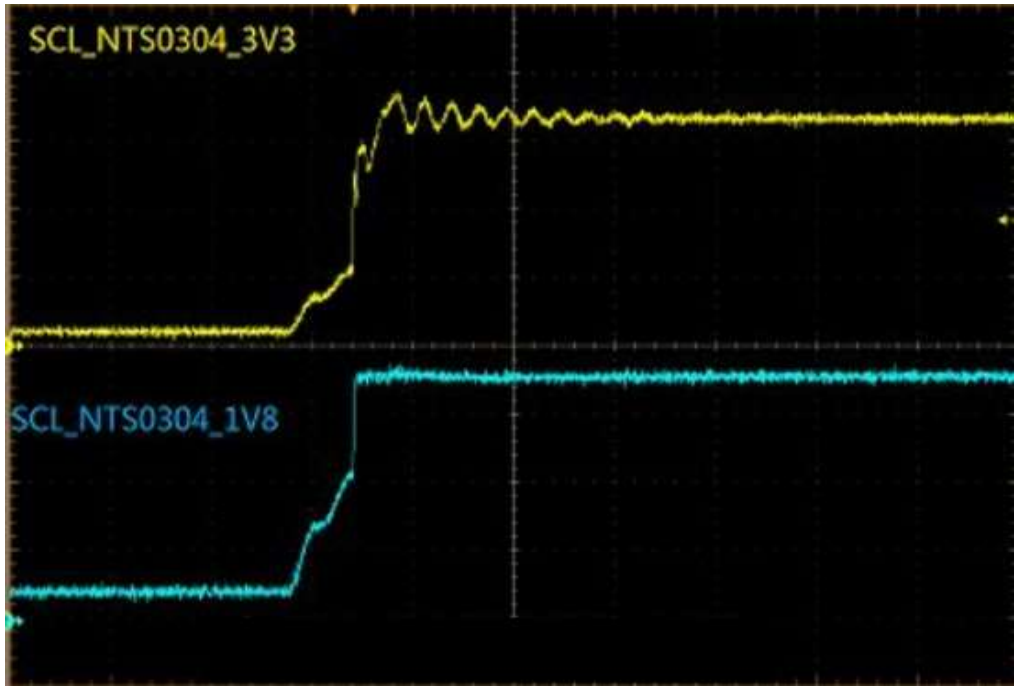
V_{CCA} = 1.65V and V_{CCB} = 3.3V
NTS0104 shows visible overshoot with the same operating condition

NTS0304 vs NTS0104: No Transition “Glitch” with 50-ns One-Shot

Older generation: NTS0104



Newer generation: NTS0304



V_{CCA} = 1.8V and V_{CCB} = 3.3V
NTS0104 shows visible “glitch” with the same operating condition

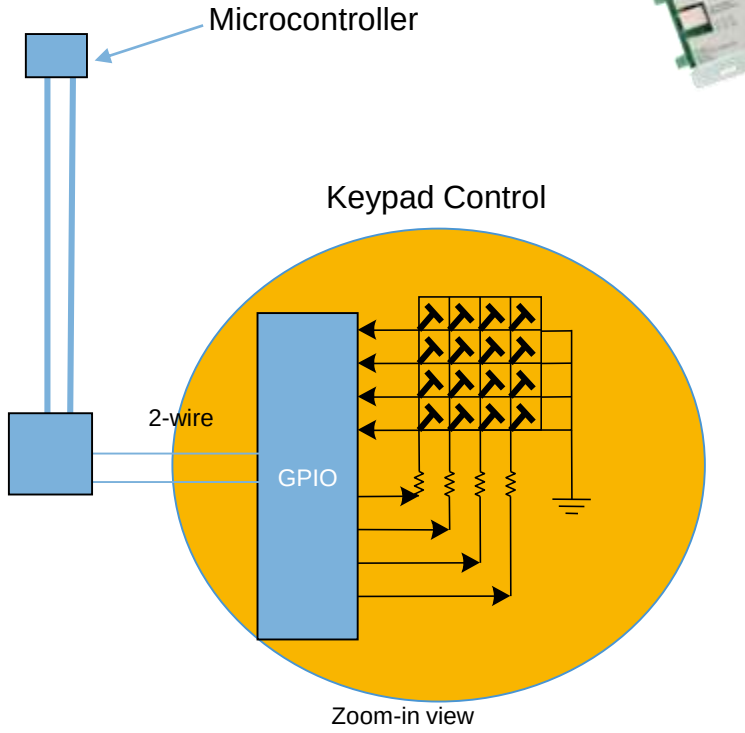
Summary: NTS030x vs. NTS010x vs. Competition

	NXP: NTS030x	NXP: NTS010x	Competitor T
Type	Pass-trough gate with one-shot accelerator for rising edge		
Typical IF	Open–drain <10Mbps	Open–drain <10Mbps, Push-pull with <=25Mbps	Open–drain < 2Mbps, Push-pull with <=100MHz
# Channels	1, 2, 4, 8	1, 2, 4	1, 2, 4, 8
$VccA_{min}$	0.9V	1.65V	1.65V (1.2V, ‘0108)
$VccB_{min}$	1.65V	2.3V	2.3V (1.65V, ‘0108)
ESD level on B-side	8kV IEC61000-4-2, class4	15kV HBM JESD22-A114E Class 3B	8kV IEC61000-4-2, class4 (4,8-ch)
Smart one-shot	Yes	No	No
One-shot duration	target 30ns, 50 ns max	~15 ns (spec <50 ns)	Measured to be ~30ns
Operating Temp.	-40 to +125 C	-40 to +125 C	-40 to +125 C

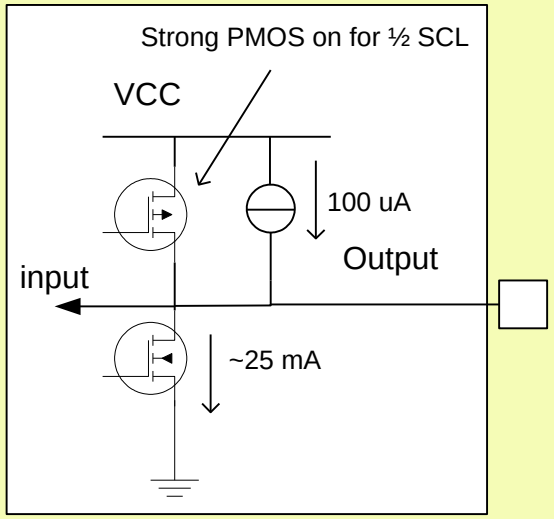
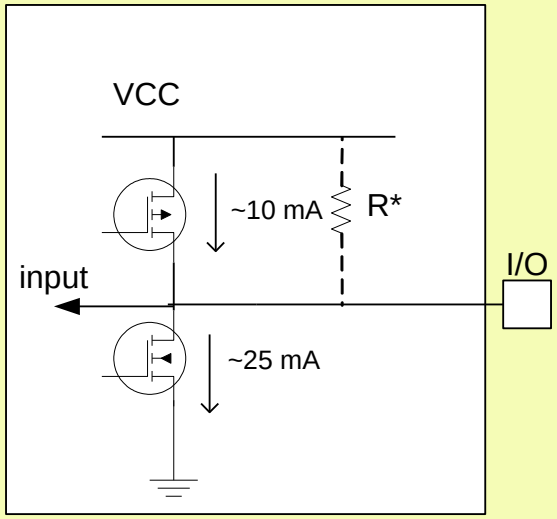
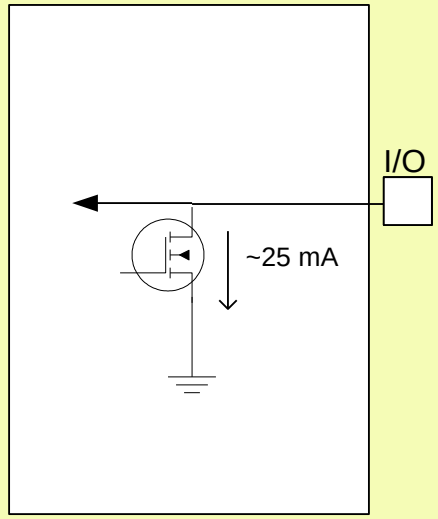
GPIO Expanders

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 & I^2C	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 I^2C 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 I^2C-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 I^2C 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 Open-Drain Output Structure

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

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

GPIO Expanders with Agile I/O (PCALxxxx)

- 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

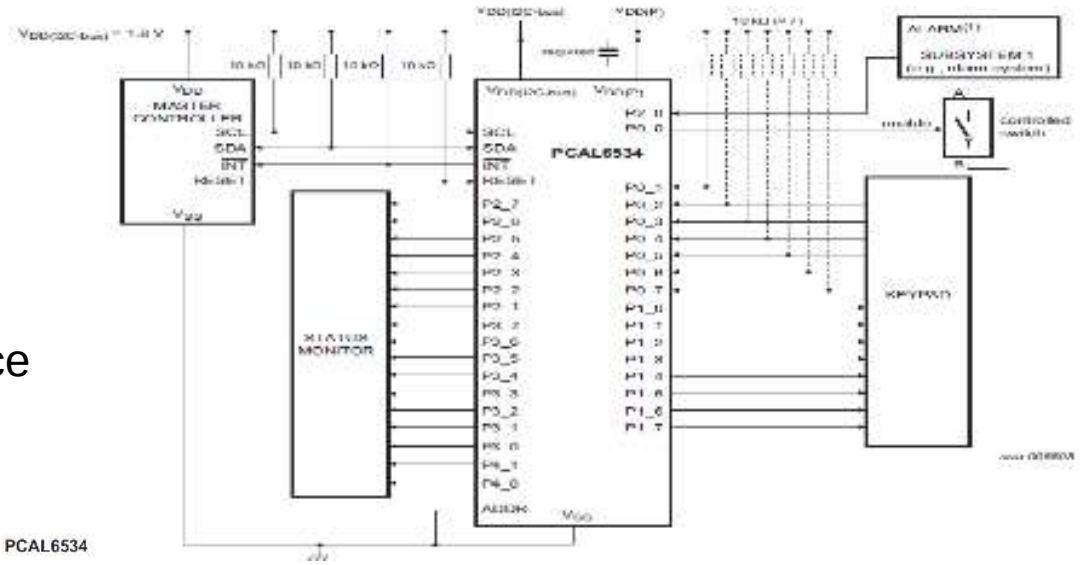
	BITS	V RANGE	BW	RESET	INT	I/O PULL-UP	NOTES	PACKAGE	PART#
	8	1.65 to 5.5V	400 kHz	Yes	Yes	Programmable	single V_{CC}	HVQFN16, TSSOP16	PCAL9554B PCAL9554C
				Yes	Yes	Programmable	single V_{CC}	HVQFN16, TSSOP16	PCAL9538A
				Yes	Yes	Programmable	dual V_{CC}	HVQFN16, TSSOP16, XQFN16, XFBGA16	PCAL6408A
	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
NEW	34	1.65 to 5.5V	1 MHz	Yes	Yes	Programmable	Additional Agile I/O Features	VFBGA-42	PCAL6534

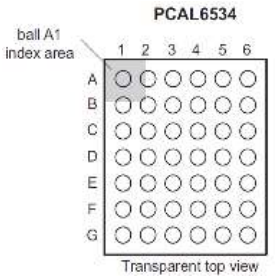
PCAL6534: 34-Bit GPIO Expander with Agile I/O Plus

- Simple interface and tiny solution for adding I/O's to sensors, push buttons, or keypads
- Level translating 1.65V to 5.5V range
- 1MHz Fast-Mode I^2C-bus down to 0.8V
- Tiny 2.6mm x 3mm BGA-42package with 0.4mm bump spacing

- Agile I/O plus Features
  - Output port: Programmable push-pull or open-drain
  - Interrupt status: read-only register identifies the source
  - I/O programmable features
    - Input latch: I/O's are kept until the Input Port register is read
    - Output drive strength: four strengths
    - Pull-up/pull-down enable
    - Pull-up/pull-down selection: 100kΩ

Key Applications
- Smartphones
- Game controllers
- IO Buttons
- Networking/communications systems
- Automotive button/window control



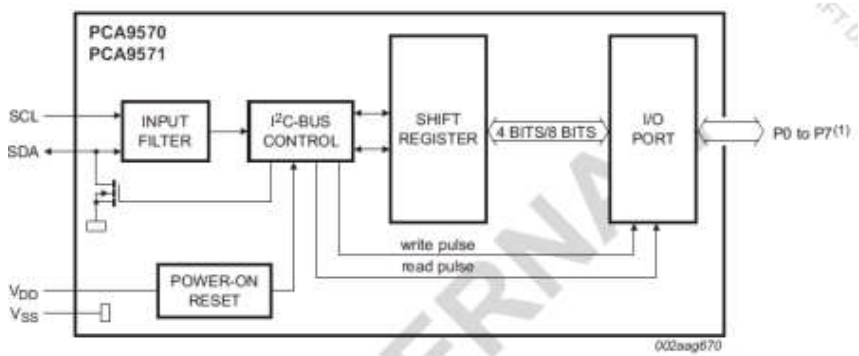


Evaluation Boards	OM13541

Small, Low-Cost, Low-Voltage GPO Expander

Features

- 1.1 V to 3.6 V operation with 4- or 8-bit, 4mA push-pull outputs
- 1 MHz I2C-bus interface with 6mA SDA sink capability for lightly loaded buses and improved power consumption
- Compliant with the I2C-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

LED Controllers

LED Controller Portfolio

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
PCA9952 [1]	16	8MHz	5mA ~ 57mA	Yes	Fm+ I^2C; 8 Addresses
PCA9955 [1]	16	8MHz	5mA ~ 57mA		Fm+ I^2C; 16 Addresses
PCA9955B [1]	16	8MHz	225µA ~ 57mA	Yes	Fm+ I^2C; 125 Addresses
PCA9745B [1]	16	8MHz	225µA ~ 57mA	Yes	Serial-Shift; No Address
PCA9755B [1]	16	8MHz	225µA ~ 57mA	Yes	SPI; 25 Addresses
PCA9956B	24	8MHz	225µA ~ 57mA	Yes	Fm+ I^2C; 125 Addresses
PCA9957	24	8MHz	32mA	Yes	SPI; 10MHz

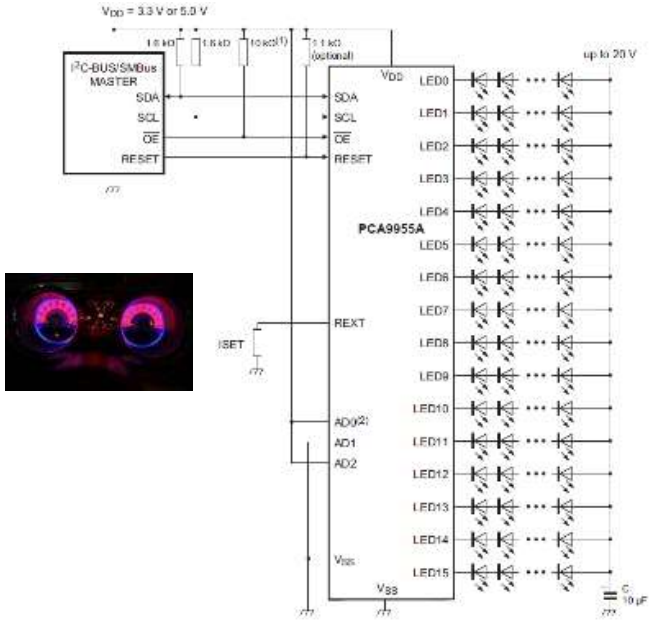
[1] AEC-Q100 Qualified

PCA9955B: 57mA 16-CH Constant-Current LED Controller

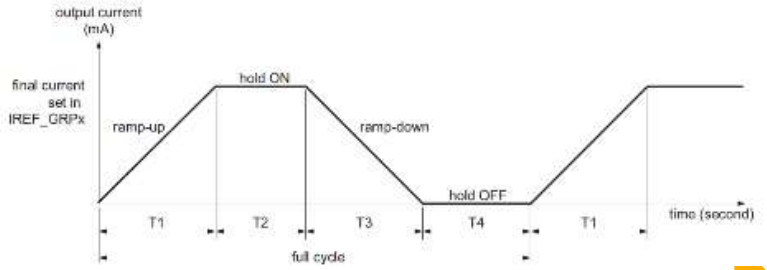
Features

- VCC = 3.0V to 5.5V
- Output
  - Constant current; Up to 57mA current drive/channel
  - 20V sustaining voltage
  - REXT sets ILED for all channels
  - ±4% channel-to-channel matching
  - ±6% IC-to-IC matching
  - 0.8V (typ) regulation voltage
  - 256:1 LED current peak adjustment
  - Gradation Control for all channels
    - Programmable step time from 0.5ms to 512ms
    - Programmable output current adjustment between linear and exponential curve
  - 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 to1.875us)
- Over-Temperature Protection (150 ˚C typ)
- HTSSOP28 Package with Thermal Relief Pad

Simplified Applications Diagram



Gradation Control Timing

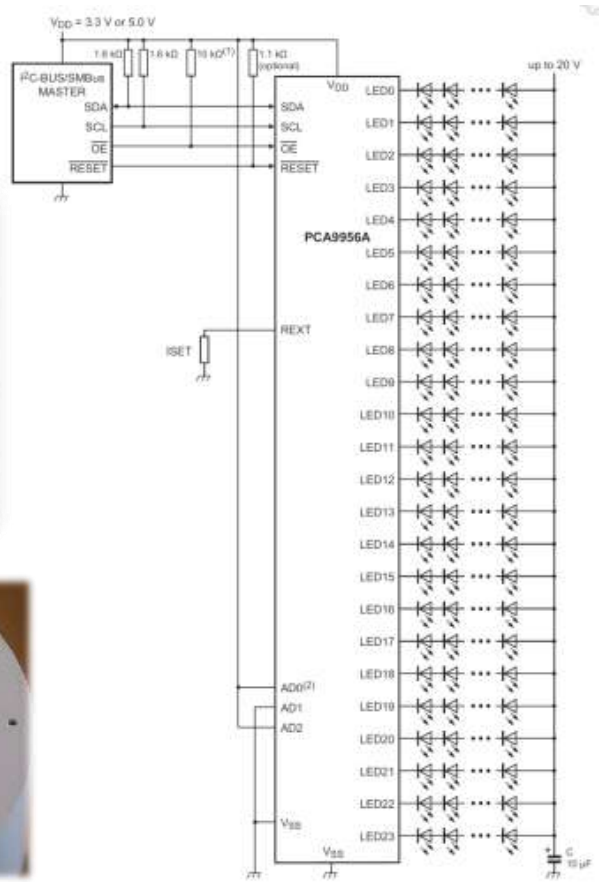


PCA9956B: 57mA 24-CH Constant-Current LED Controller

Features

- VCC = 3.0V to 5.5V
- Output
  - Constant current; Up to 57mA current drive/channel
  - 20V sustaining voltage
  - REXT sets ILED for all channels
  - ±4% channel-to-channel matching
  - ±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 (5 states) input address pins allow up to 125 devices to be connected on the same bus
  - Four software programmable I^2C-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 to1.875us)
- Over-Temperature Protection (150 ˚C typ)
- HTSSOP38 Package with Thermal Relief Pad

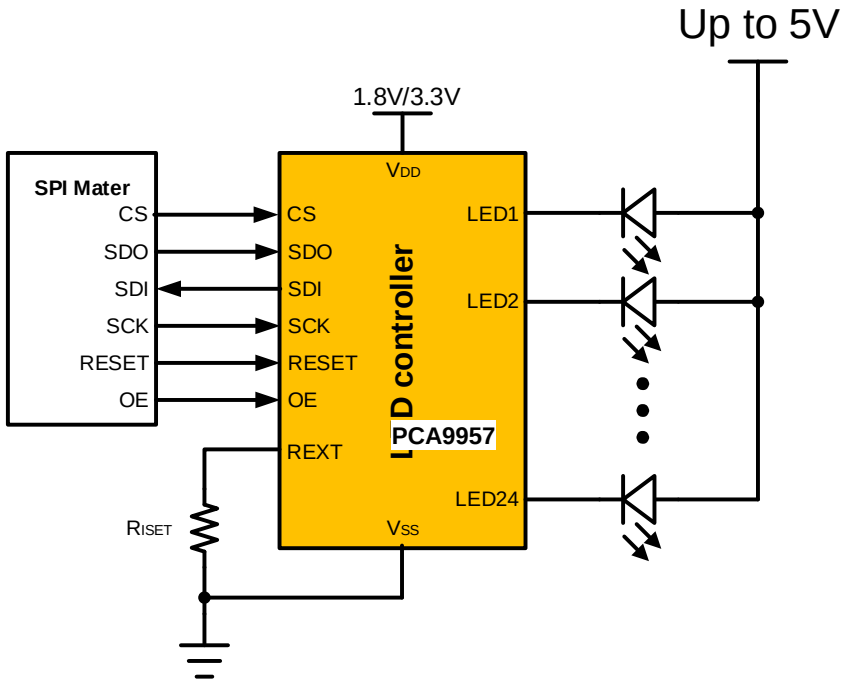
Simplified Applications Diagram



PCA9957: 32mA 24-CH Constant-Current LED Controller

Features

- 24 Channels constant current output
- VCC = 2.7V to 5.5V
- Output
  - Constant current; Up to 32mA current / channel
  - IREFx register to set current gain
  - Tolerant up to 5V
  - 0.4V (min) regulation voltage; drop at LED Output
  - Absolute accuracy: ±4% channel-to-channel matching
- Digital Interface
  - 4-Wire SPI-compatible serial-bus interface; up to 10MHz clock rate
  - Output Enable input pin allows for external hardware blinking and dimming of all LED's
- PWM Generator
  - 256-step group brightness and blinking control from 0% to 99.6%
- Hardware and Software Reset
- 8MHz internal oscillator requires no external component
- 140 ˚C Over-temperature protection
- Package: 40-Pin 5mm x 5mm QFN



Real Time Clock

The Role of RTC in System Power Consumption

Calculating the Battery Lifetime

- Power consumption determines the **system lifetime**
- $$\text{Lifetime} = \frac{\text{Battery Energy}}{\text{Average Power Consumption}} = \frac{\text{J}}{\text{W}} = \frac{\text{J}}{\text{J/s}} = \text{s}$$
- Battery typically expresses the charge as mAh instead of Coulomb

  Current*Time = Ampere*Seconds = A*s = (C/s) * s = C
- $$\text{Lifetime} = \frac{\text{Battery Charge}}{\text{Average Current Consumption}} = \frac{\text{C}}{\text{A}} = \frac{\text{C}}{\text{C/s}} = \text{s}$$

System Requirements Translation – Disposable Wearable

- If a system requires the following Lifetime:
  A. 104 weeks on the shelf
  B. 3 weeks in mission mode

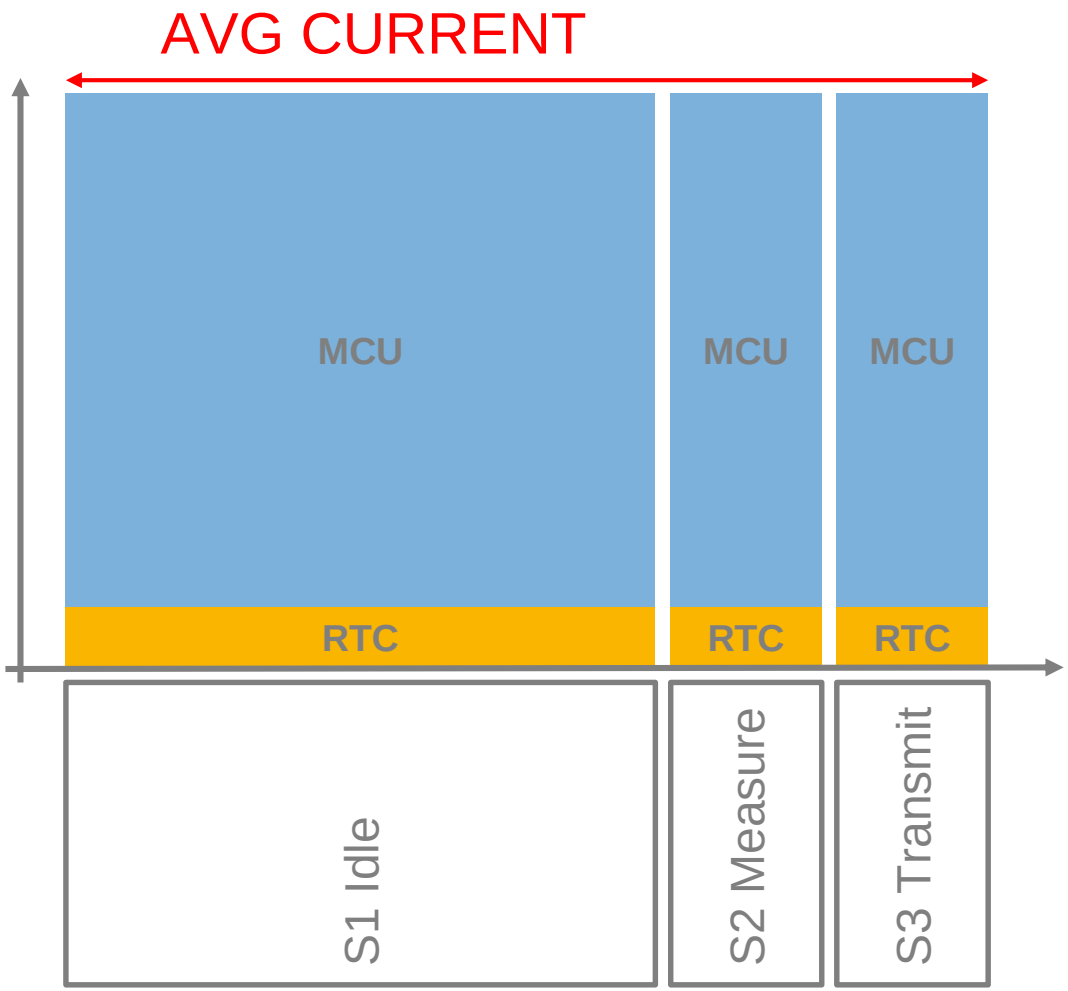
- What is the average current consumption required in the sleep mode and active mode given:
  - 2 mAh Battery Charge
  - 50% charge used on the shelf
  - 50% charge used on mission mode

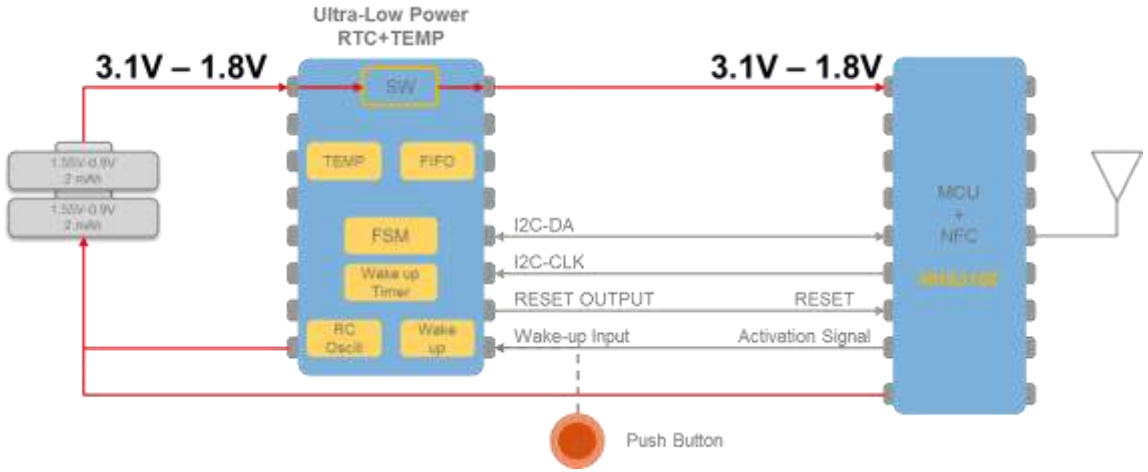
- Average Current Consumption Specification:
  - 60nA consumption on the shelf
  - 2µA consumption on a mission

State	Parameter	Value	Unit
Initial status	Battery charge nominal	2.00	mAh
Initial status	Battery charge use-factor	1.00	
Initial status	**Battery charge effective**	**2.00**	**mAh**
On the shelf	Assigned charge	50%	
On the shelf	Lifetime	104.00	week
On the shelf	**Lifetime**	**17,472.00**	**h**
On the shelf	**Average current consumption**	**0.06**	**uA**
On a mission	Assigned charge	50%	
On a mission	Lifetime	3.00	week
On a mission	**Lifetime**	**504.00**	**h**
On a mission	**Average current consumption**	**1.98**	**uA**

All Functional Blocks Always Turn On

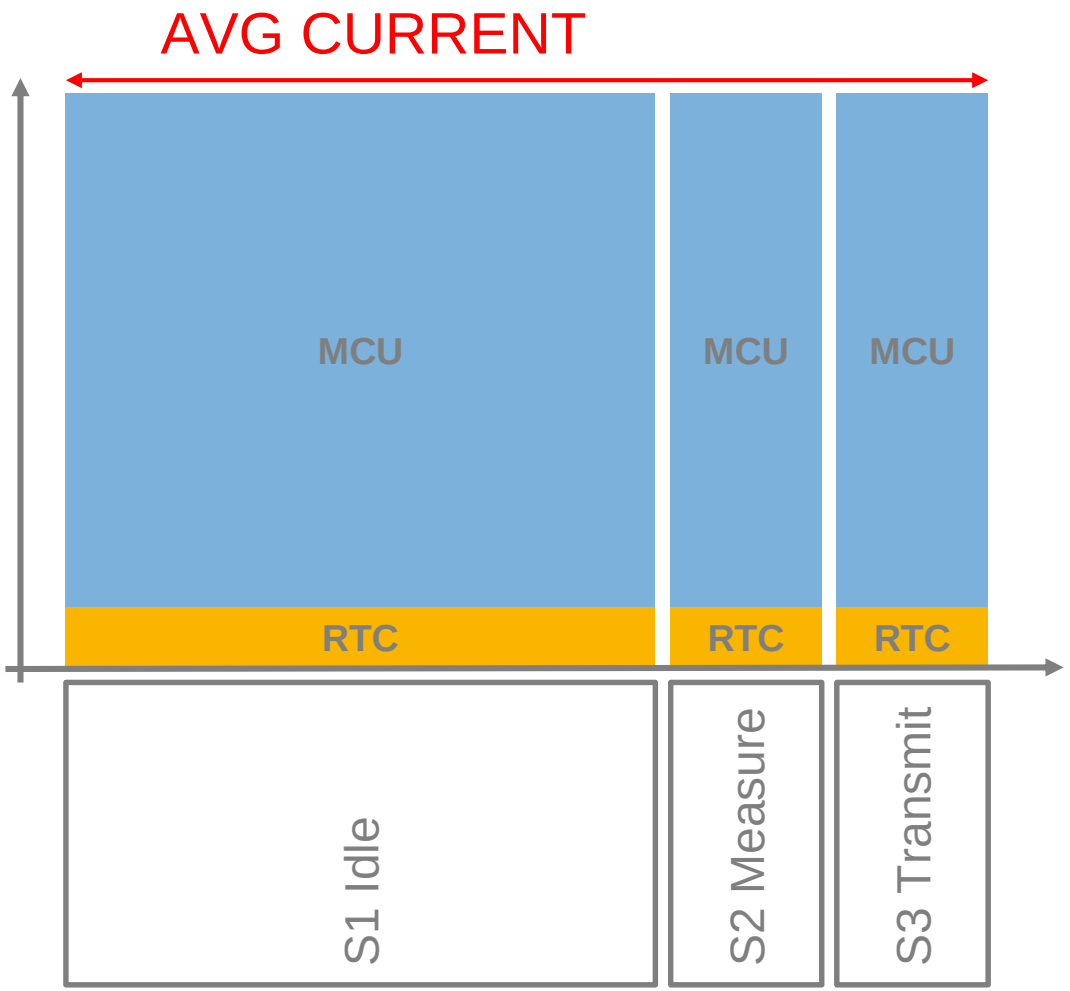
Lifetime = Battery Charge / **Average** Current Consumption

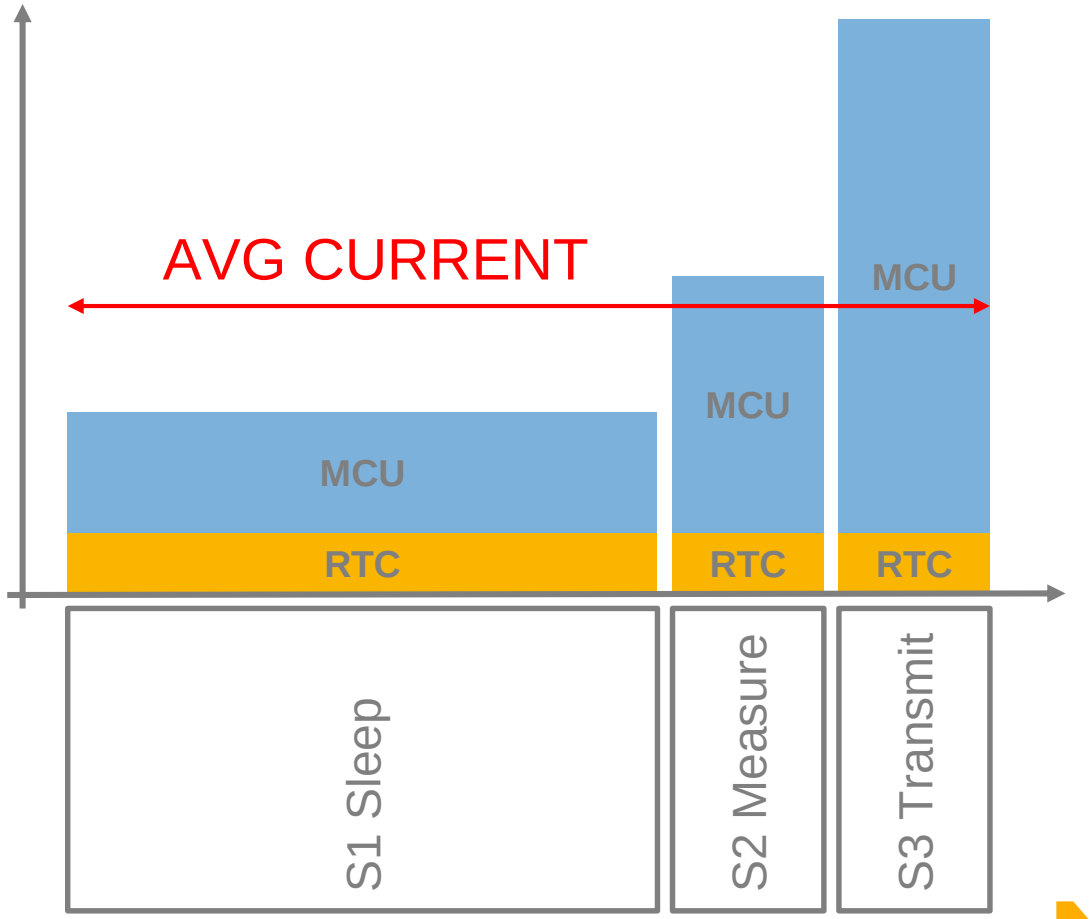




Functional Blocks Turn On When Needed: Duty Cycle Mode

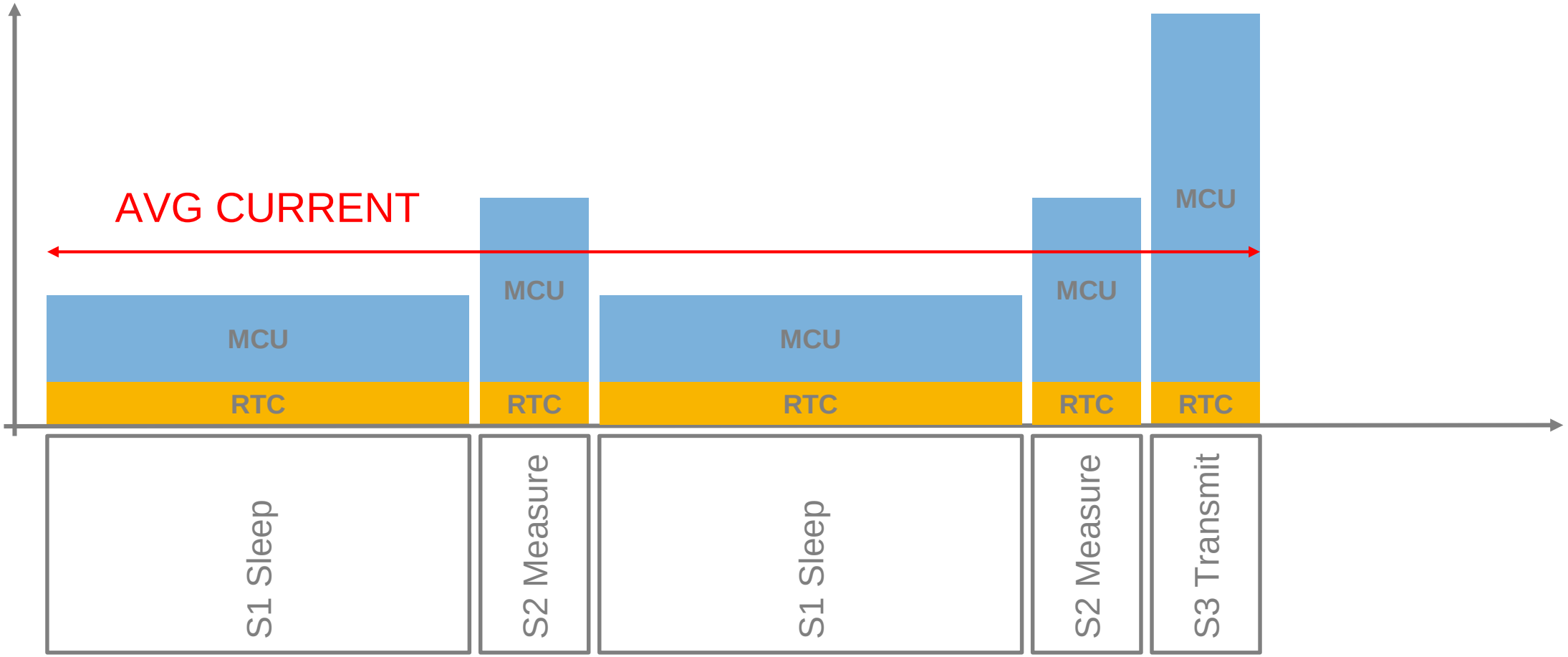
Lifetime = Battery Charge / **Average** Current Consumption





Average Current Consumption

Lifetime = Battery Charge / **Average** Current Consumption



Portfolio Overview

	Type	Interface	Package	Status	Key features
	PCF8563	I²C-Bus	SO8, TSSOP8, HVSON8	Production	Industry standard
Tiny	PCF85063 PCF85063A	I²C-Bus	HWSON8, SO8 HXSON10	Production	Tiny footprint, best cost *(PCF85063A with alarm)*
	PCF85063B	SPI Bus	HXSON10	Production	Tiny footprint, best cost, alarm
Latest Generation	PCF85263A PCF85363A	I²C-Bus	SO8, TSSOP8/10 HXSON10	Production	Two alarms, watchdog, electronic tuning, battery management, time stamp *(PCF85363A features also 64byte of RAM)*
	PCF85263B PCF85363B	SPI-Bus	SO8, TSSOP10, HXSON10	Development	Two alarms, watchdog, electronic tuning, battery management, time stamp *(PCF85363B features also 64byte of RAM)*
Lowest Power	PCF2123	SPI Bus	TSSOP14, HVQFN16	Production	Lowest power (100nA), electronic tuning
	PCF8523	I²C-Bus	SO8, TSSOP14 HVSON8,	Production	Low power (100nA), electronic tuning Battery management
Precise	PCF2129A, PCF2127A	I²C-Bus/ SPI Bus	SO20	Production	High accuracy ±3ppm, -25°...+65°C Battery management, Time stamp, metal can quartz *(PCF2127A features also 512byte RAM)*
	PCF2129 PCF2127	I²C-Bus/ SPI Bus	SO16	Production	High accuracy ±3ppm, -40°..+85°C Battery management, Time stamp, ceramic quartz (PCF2127 features also 512byte RAM)
Automotive	PCA8565	I²C-Bus	TSSOP8, HVSON10	Production	Robustness: up to 125°C HVSON10 package variant is not automotive grade
	PCA21125	SPI Bus	TSSOP14	Production	Robustness: up to 125°C
	PCA2129	I²C-Bus/ SPI Bus	SO16	Production	High accuracy ±3ppm, Battery management, Time stamp, ceramic quartz for automotive
	PCA85063A	I²C-Bus	TSSOP8=TT	Production	Like PCF85063A, Tiny footprint, alarm, up to 105°C

PCF85063: Small Footprint Low-Power RTC

- Available Versions:
  - PCF85063TP: I2C-bus, Limited feature set, 8-pin package
  - PCF85063A: I2C-bus, Full feature set, 8-pin package
  - PCF85063B: SPI-bus, Full feature set + CLKOUT, 10-pin package
  - PCA85063A: Automotive Qualified

- Features
  - Cost optimized
  - Low-power consumption; At VDD=2.0V, TAMB=25 °C, no bus activity and CLKOUT active, IDD=260 nA (typ)
  - Very small footprint packages
    - HWSON8 (2 x 3 x 0.8mm)
    - HXSON10 (2.6 x 2.6 x 0.5mm)
    - SO8
    - TSSOP8
  - Two interfaces supported; I2C and SPI
  - Two integrated programmable oscillator capacitors
    - For 7-pF load
    - For 12-pF load
  - Electronic Tuning
- Target Applications
  - Printers
  - Copy Machines
  - Digital Still Cameras
  - Digital Video Cameras

Function	PCF85063TP	PCF85063A	PCF85063B
Electronic tuning	Yes	Yes	Yes
I^2C-bus SPI interface	✓	✓	 ✓
1 min interrupt	No	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
Package SOT number	HWSON-8 [1] SOT1052	SO8, TSSOP8, HXSON-10 [1] SOT1052	HXSON-10 [1] SOT1197

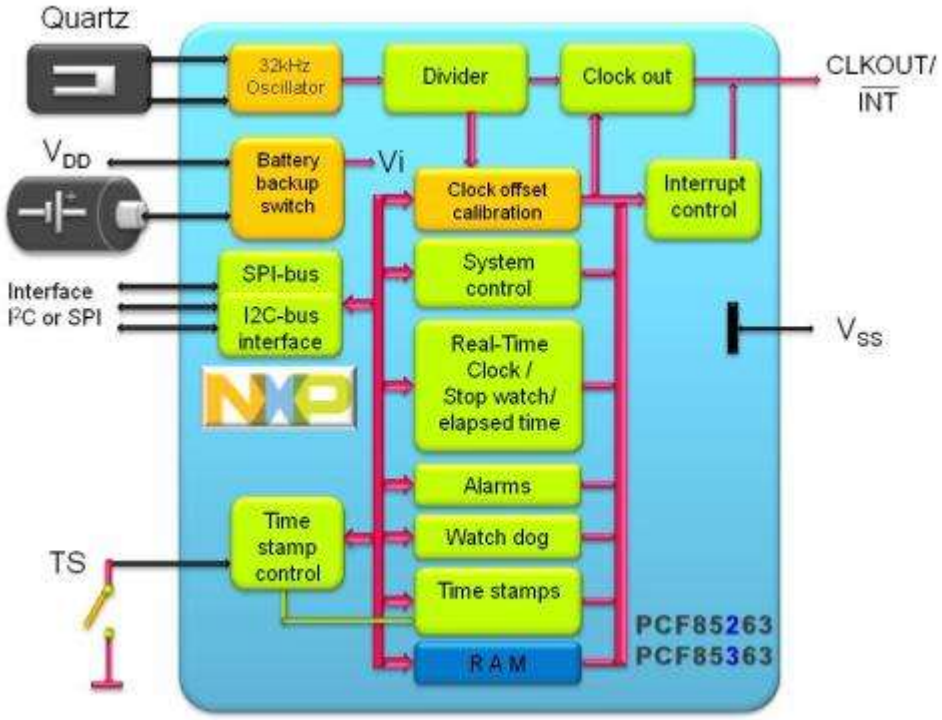
[1] 0.5-mm pitch

PCF85263 & PCA85363: Tiny RTC Family

- Available Versions:
  - PCF85263A: I2C-bus (1-Byte RAM)
  - PCF85363A: I2C-bus + 64-Byte RAM
- Features
  - Low-power consumption; At VDD=3.0V, TAMB=25 °C, No bus activity and CLKOUT inactive, IDD<300nA (typ)
  - Additional integrated features
    - 1/100 s resolution RTC, stop-watch or elapsed time counter
    - Battery backup input
    - Time Stamps for tamper detection and battery switchover
    - UL Recognized Component
    - Watchdog
    - Elapsed time counter
    - Battery backed-up RAM (PCF85363)
- Target Applications
  - Telecom and Networking Equipment
  - Servers
  - Medical Equipment
  - Power Supplies

Packages:

Leadless Tiny Package: HXSON10
Leaded Package: TSSOP8, TSSOP10
Leaded Package: SO8 (PCF85x63A with I²C-bus)



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