*Application Report*

# *Optimizing Video Doorbell Designs with Common Logic Use Cases*

**ABSTRACT**

Logic and translation devices can be found in the majority of electronic systems. Video doorbells integrate numerous subsystems together that often require additional signal interfacing, such as when the system controller needs to operate at a different voltage than the wireless interface card, and translation must be used for the data, or when more LEDs must be controlled than there are pins available on the system controller. All of the use cases shown in the Block Diagram and Logic and Translation Use Cases sections of this document are commonly seen in video doorbell designs.

Logic gates, voltage translators, and other logic devices are used for many purposes throughout modern electronic systems. This document provides example solutions for common design challenges that can be solved using logic and translation. Not all of the solutions here appear in every system, however all solutions shown are commonly used and effective.

There are dozens of logic families available from Texas Instruments, and it can be difficult to select the correct one for the application. Video doorbells are generally very small, and prefer low power solutions, which makes it easier to identify an appropriate family for this application. See Recommended Logic and Translation Families for video doorbells in this document for help finding the correct logic family for your use case.

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## 1 Block Diagram

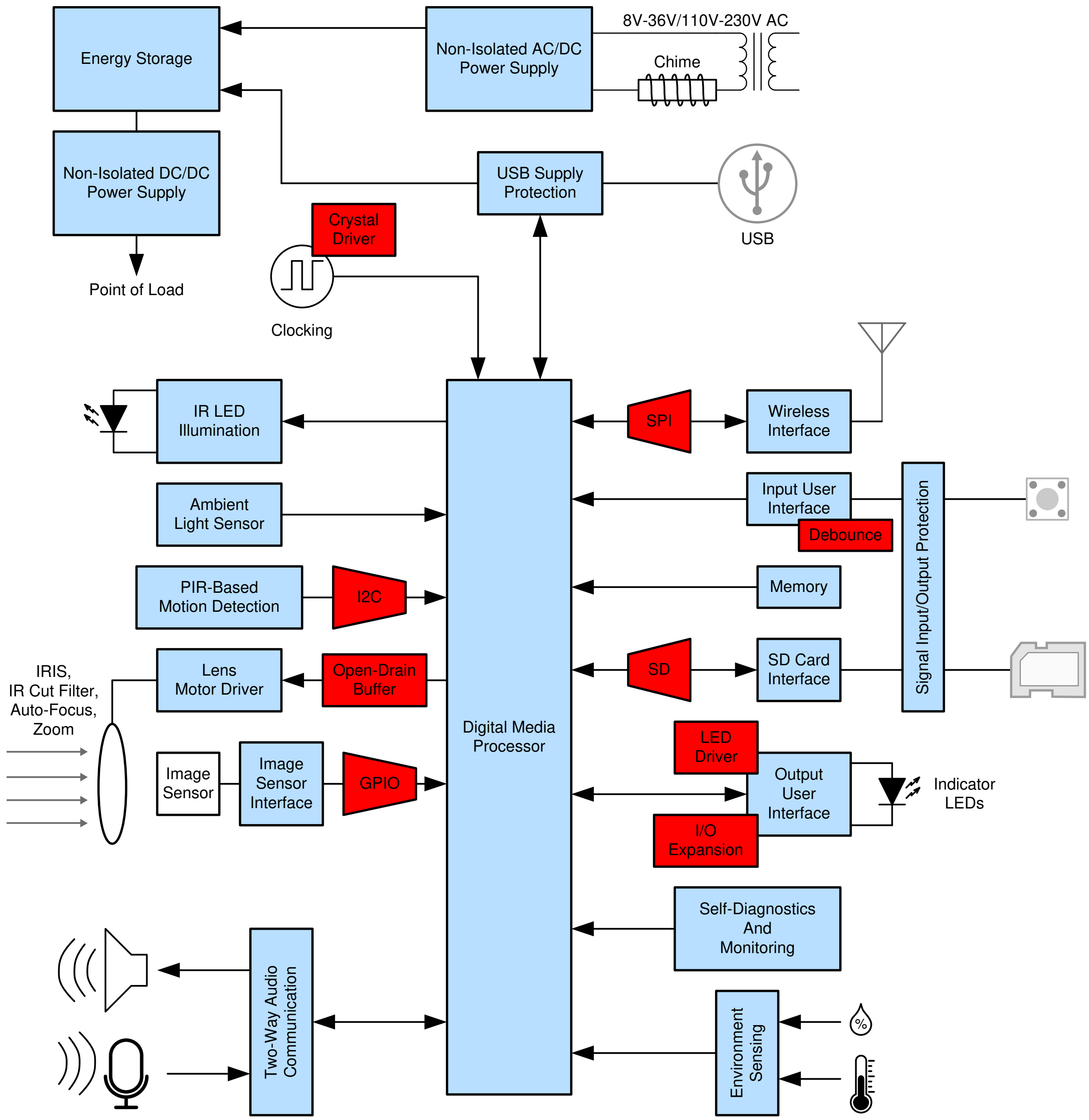


**Figure 1-1. Simplified Block Diagram for Video Doorbells**

See the interactive online *End Equipment Reference Diagram* for a more complete view.

## 2 Optimize System Controller to Wireless Module Interface

It is often desirable to have the system controller for a battery powered device such as a video doorbell to be as low voltage as possible. Reducing supply voltage reduces power consumption significantly; this reduction in voltage, however, also limits the peripherals that can be operated. It is very common for wireless interface modules to need at least 1.8 V supply and signal levels, sometimes requiring as much as 5 V for the supply.

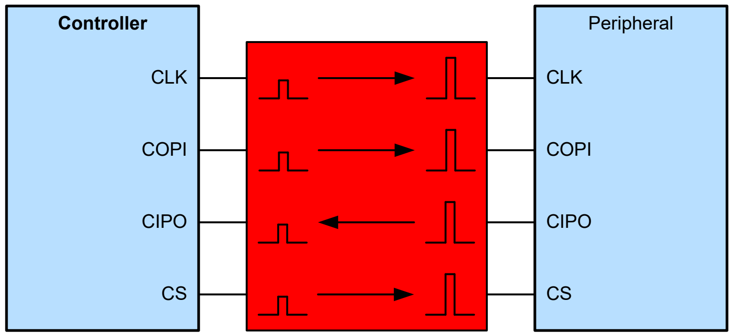


**Figure 2-1. SPI Translation for System Controller to Wi-Fi™ Module Interface**

Serial Peripheral Interface (SPI) provides up to 10 Mbps of data transfer and is typically used for this type of communication. There are two common solutions used for translating the voltage of this interface using either the TXB0104 or the SN74AXC4T774 voltage translators.

**TXB0104**

- Auto-bidirectional: No direction configuration required
- Works for 1.2 V to 5 V translation
- 20 Mbps per channel at 1.2 V operation

**SN74AXC4T774**

- 100 Mbps at 1.2 V operation
- Requires direction configuration; typically hard-configured to unidirectional translation
- 3.6 V maximum operating voltage

# 3 Logic and Translation Use Cases

## 3.1 Logic Use Cases

### 3.1.1 Increase Number of Controller Outputs

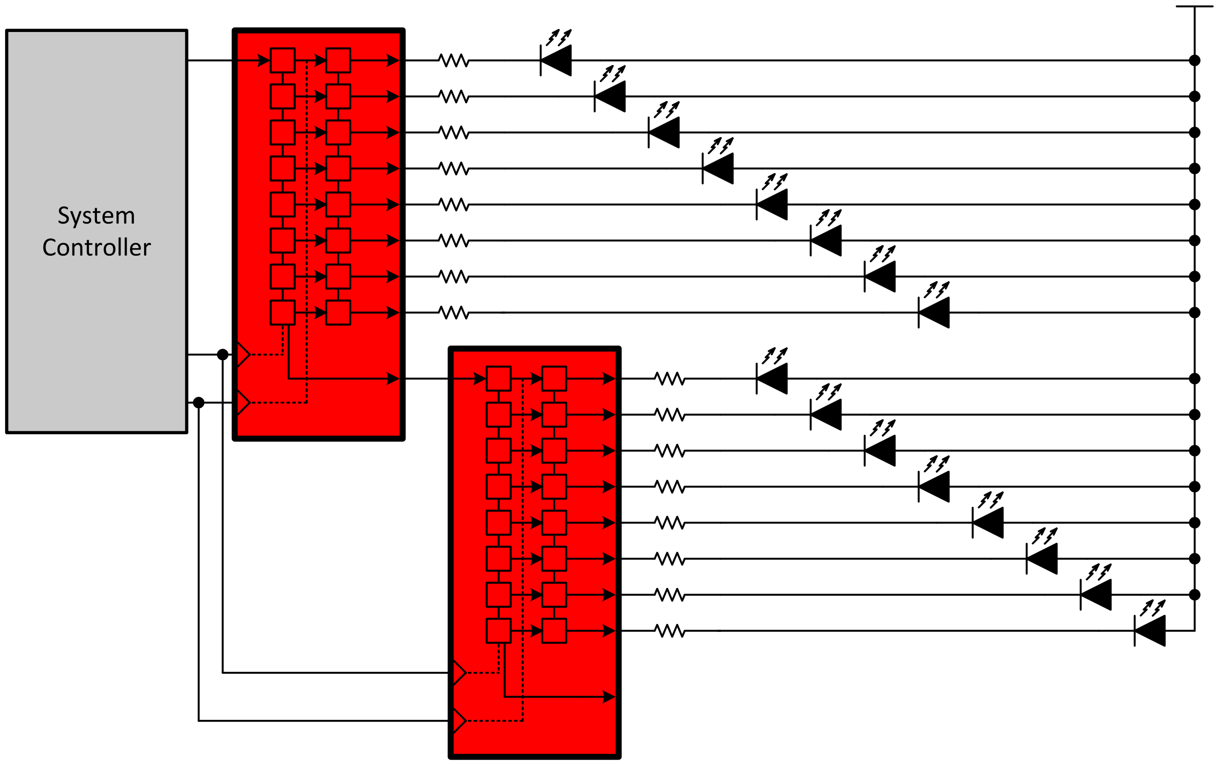


**Figure 3-1. Using Two Shift Registers to Control 16 LEDs with Three Signals (Data, Shift Clock, and Output Register Clock)**

- As few as two outputs can be turned into 8 outputs with one serial-in parallel-out shift register.
- Shift registers can be daisy chained for producing large numbers of outputs.
- Low current (< 8 mA) LEDs can be driven directly.

### 3.1.2 Drive Indicator LEDs

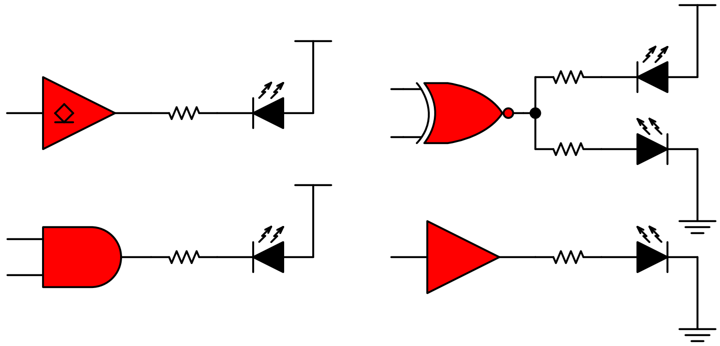

**Figure 3-2. Using Logic as Indicator LED Driver Application Examples**

- Add system indicators without controller interaction required.
- Most logic gates can drive low current indicator LEDs (1 mA to 25 mA).
- Logic functions add configurability.
- Disable indicator LEDs, as desired.

### 3.1.3 Open-Drain Buffer

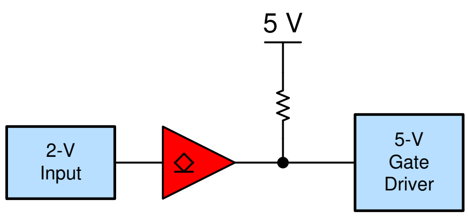


**Figure 3-3.**

- Control input thresholds with device supply voltage.
- Control output voltage with pullup supply voltage.
- Provides high-impedance output for discharge-only applications.
- See TI's *Translate Unidirectional Signals Using Open-Drain Outputs* video for more information about this use case.

### 3.1.4 Debounce Switches and Buttons

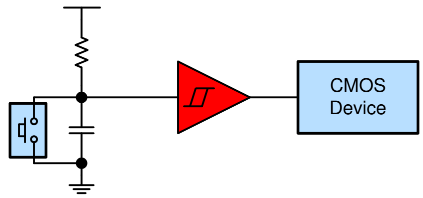


**Figure 3-4. Using Logic to Prevent Multiple Triggers of a CMOS Input Due to Switch Bounce**

- Prevents multiple triggers of CMOS inputs due to switch bounce.
- Works when the system controller is asleep.
- Works without a system controller.
- Reduces controller code complexity; no software debounce is required.
- See TI's *Debounce a Switch* video for more information about this use case.
- Visit TI's *Online parametric search tool* to find the correct Schmitt-trigger buffer.

### 3.1.5 Generate a Clock Signal from a Crystal Oscillator

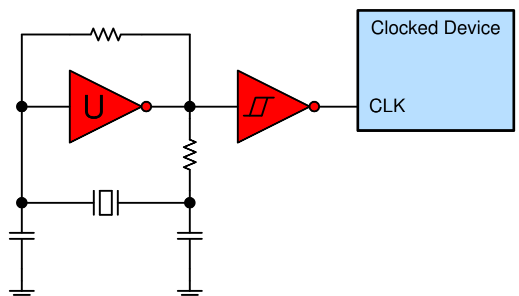


**Figure 3-5. Using an Unbuffered Inverter and Schmitt-Trigger Inverter to Generate a Clock Signal From a Crystal Oscillator**

- Drive crystal oscillators directly.
- Can be disabled with added logic.
- Allows for selectable system clocks with multiple crystals.
- Outputs a clean and reliable square wave.
- See *Use of the CMOS Unbuffered Inverter in Oscillator Circuits Application Report* for more information about this use case.
- Visit TI's *Online parametric search tool* to find the correct inverter.

## 3.2 Voltage Translation Use Cases

### 3.2.1 SPI Communication

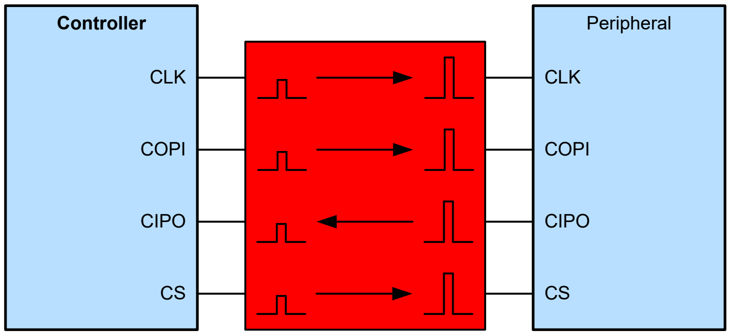


**Figure 3-6. Using Voltage Translation with a SPI-Communication Bus**

- Enable communication when devices have mismatched logic voltage levels.
- Prevent damage to devices that cannot support higher voltage inputs.
- Improve data rates over discrete translation solutions.
- Provides protection from disconnected peripherals
- Visit TI's *Online parametric search tool* to find the correct voltage level translator.

### 3.2.2 GPIO Communication

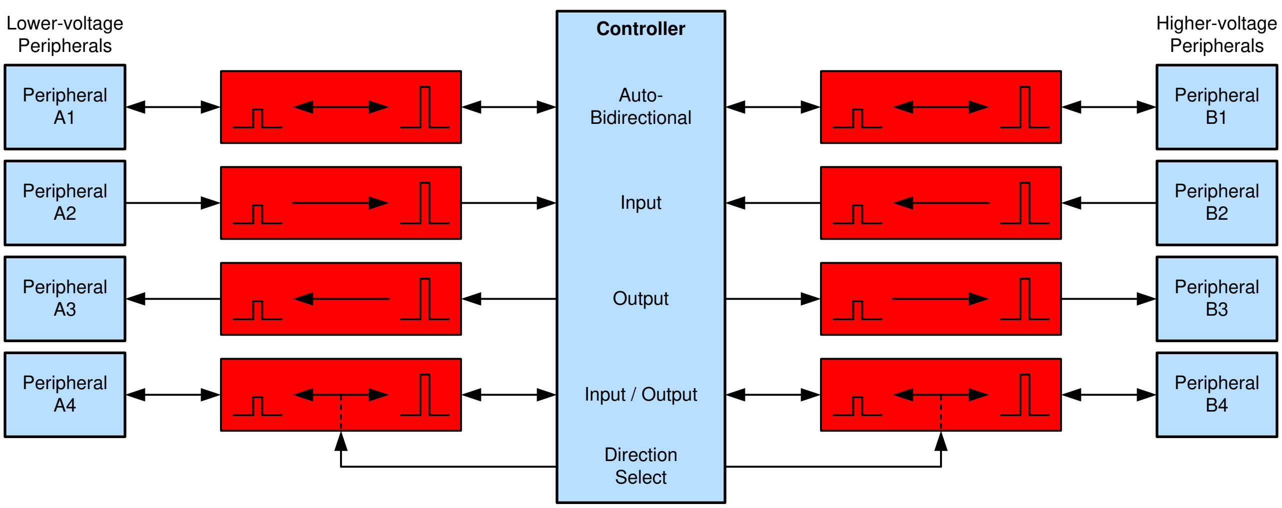


**Figure 3-7. Using Voltage Translation with GPIO Communications**

- Enable communication when devices have mismatched logic voltage levels.
- Prevent damage to devices that cannot support higher voltage inputs.
- Improve data rates over discrete translation solutions.
- Provides protection from disconnected peripherals
- Visit TI's *Online parametric search tool* to find the correct voltage level translator.

### 3.2.3 I2C Communication

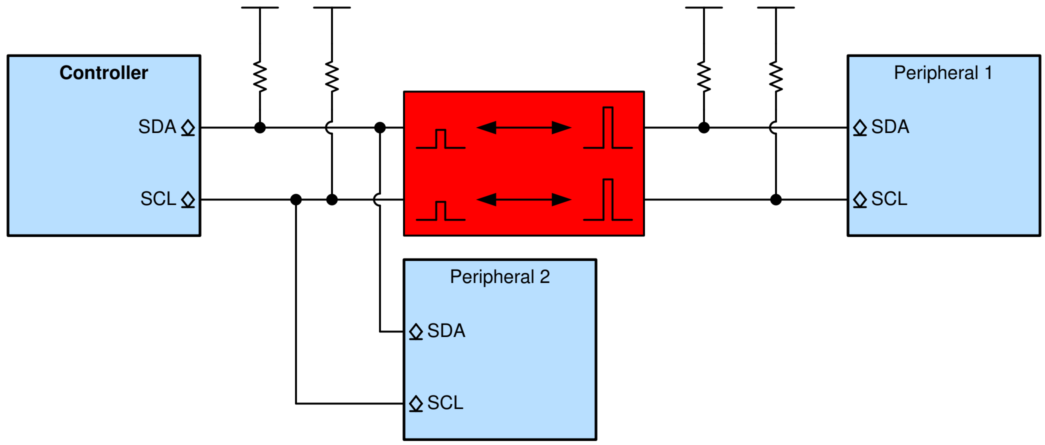


**Figure 3-8. Using Voltage Translation with an I2 Communication Bus**

- Enable communication when devices have mismatched logic voltage levels.
- Prevent damage to devices that cannot support higher voltage inputs.
- Improve data rates over discrete translation solutions.
- Visit TI's *Online parametric search tool* to find the correct voltage level translator.

### 3.2.4 SD Card Communication

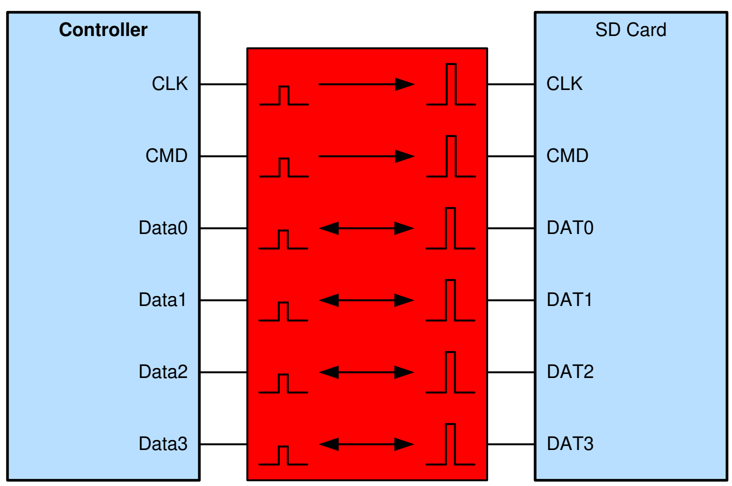


**Figure 3-9. Using Voltage Translation with an SD Card Communication Bus**

- Enable communication when devices have mismatched logic voltage levels.
- Prevent damage to devices that cannot support higher voltage inputs.
- Improve data rates over discrete translation solutions.
- Protect controller while SD Card is not connected.
- Visit TI's *Online parametric search tool* to find the correct voltage level translator.

# 4 Recommended Logic and Translation Families for Video Doorbells

## 4.1 AUP: Advanced Ultra-Low-Power CMOS Logic and Translation

Key Features: SN74**AUPxG**xxxx

- Low static-power and dynamic-power consumption.
- Wide $V_{CC}$ operating range: 0.8 V to 3.6 V.
- Input hysteresis allows for slow input transition rate.
- Best in class for speed-power optimization.
- $I_{off}$ spec for partial-power-down support.
- Packaging Options: DSBGA, SC70, SM8, SON, SOT-23, SOT, UQFN, US8, and X2SON.

Key Features: SN74**AUPxT**xxxx

- Low static-power and dynamic-power consumption.
- 1.65 V to 3.6 V translation range.
- Best in class for speed-power optimization.
- $I_{off}$ specification for partial-power-down support.

Visit TI's *Online parametric search tool* to find the correct AUP family logic and voltage level translation devices.

## 4.2 AXC: Advanced Extremely Low-Voltage CMOS Translation

Key Features

- Up and down translation across 0.65 V to 3.6 V.
- Designed with glitch suppression circuitry to improve power sequencing performance.
- Maximum quiescent current ($I_{CCA}$ + $I_{CCB}$) of 6 µA (85°C maximum) and 14 µA (125°C maximum).
- Up to 500-Mbps support when translating from 1.8 V to 3.3 V.
- $V_{CC}$ Isolation Feature: If either $V_{CC}$ input is below 100 mV, all I/Os outputs are disabled and becomes high impedance.
- $I_{off}$ supports partial-power-down mode operation.
- Operating Temperature: –40°C to + 125°C
- Packaging Options: DSBGA, SC70, SM8, SON, SOT-23, SOT, UQFN, US8, and X2SON

Visit TI's *Online parametric search tool* to find the correct AXC family voltage level translation devices.

### 4.3 LVC: Low-Voltage CMOS Logic and Translation

Key Features: SN74**LVC**xxxx

- Huge portfolio of logic functions
- LVC: 4+ channels per package
- Over-voltage tolerant inputs allow unidirectional down-translation with any function.
- High-drive outputs (up to 32 mA)
- Up to 250-Mbps operation
- $I_{off}$ supports partial-power-down mode operation.
- Packaging Options: SOIC, TSSOP, VQFN, SOP, SSOP

Key Features: SN74**LVCxG**xxxx

- Put 1, 2, or 3 channels of any logic function exactly where you need them.
- Configurable gates available ('57, '58, '97, '98, and '99 functions)
- Over-voltage tolerant inputs allow unidirectional down-translation with any gate or buffer.
- High-drive outputs (up to 32 mA)
- Up to 250 Mbps operation
- $I_{off}$ supports partial-power-down mode operation.
- Packaging Options: SOT-23, SC70, X2SON, SOT-5X3, SON, and DSBGA

Key Features: SN74**LVCxT**xxxx

- LVCxT: Up and down translation across 1.65 V to 5.5 V
- 1, 2, 8, or 16 channels per device
- High-drive outputs (up to 32 mA)
- Up to 250 Mbps operation
- $I_{off}$ supports partial-power-down mode operation.

Visit TI's *Online parametric search tool* to find the correct LVC family logic and voltage level translation devices.

## 5 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

**Changes from Revision * (April 2019) to Revision A (April 2021)** **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document..................2
- Updated the *SPI Translation for System Controller to Wi-Fi Module Interface* figure for inclusive SPI terms.... 3
- Updated the *Using Voltage Translation with a SPI-Communication Bus* figure for inclusive SPI terms............. 7