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.
Figure 1. Simplified Block Diagram for Video Doorbells

For a more complete view, see the interactive online *End Equipment Reference Diagram*.  

---

(1) All trademarks are the property of their respective owners.
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, however this reduction in voltage 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. SPI Translation for System Controller to WiFi Module Interface](image)

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 SN74AVC4T774 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

**SN74AVC4T774**
- 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. Using Two Shift Registers to Control 16 LEDs with Three Signals (Data, Shift Clock, 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

![Diagram of indicator LED application](image)

Figure 4. Using Logic as Indicator LED Driver Application Examples

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

3.1.3 Open-Drain Buffer

![Diagram of open-drain buffer](image)

Figure 5.

- 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 6. 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 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 7. 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

- 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

- 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

![I²C Communication Diagram](image)

**Figure 10. Using Voltage Translation with an I²C 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

![SD Card Communication Diagram](image)

**Figure 11. 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: SN74AUPxGxxxx
- 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, X2SON

Key Features: SN74AUPxTxxxx
- Low static-power and dynamic-power consumption
- 1.65-V to 3.6-V translation range
- Best in class for speed-power optimization
- $I_{off}$ spec 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 become 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, 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: SN74LVCxxxx
- 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: SN74LVCxGxxxx
- Put 1, 2, or 3 channels of any logic function exactly where you need them.
- 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, DSBGA

Key Features: SN74LVCxTxxxx
- 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](https://www.ti.com) to find the correct LVC family logic and voltage level translation devices.
IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI’s Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated