Application Note

Schematic Checklist - A Guide to Designing With Fixed or Direction Control Translators

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ABSTRACT

This application note provides recommendations and a checklist to follow while creating or reviewing schematics for fixed-directional or direction-control level shifters. Examples of such devices are the TXU, TXV, LXC, LVC, AXC, AVC, AUP, LVxT devices.

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Trademarks

1 Introduction

TXU, TXV, LXC, LVC, AXC, AVC, AUP, LVxT device families are recommended for unidirectional applications where individual channels are used for a fixed directional signal. TXS, TXB and LSF families are recommended for applications that require auto-bidirection with individual channels. Section 1.2 shows examples of fixed directional signals and auto-bidirectional signals.

1.1 Device Applicability

This application note applies to the following devices:

- TXU, TXV, LXC, LVC, AXC, AVC, AUP, LVxT device families.

1.2 When to Use or Not Use Fixed Directional Devices

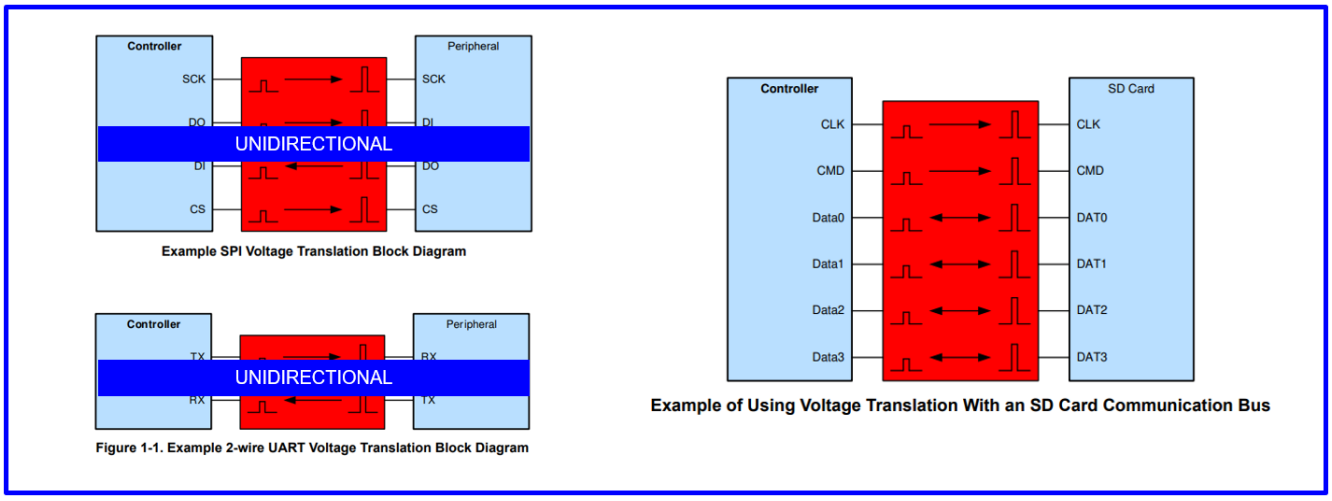

Figure 1-1. Differences Between Unidirectional and Auto-Bidirectional Signals

Each channel of unidirectional signals are directed towards a fixed direction while each channel of auto-bidirectional signals can be directed for both directions. Check for the direction of the application's signal or protocol and review this checklist with the latest data sheet documentation. Figure 1-2 and Figure 1-3 are examples showing fixed directional signals. See Section 2.7 for a full list of typical applications with their device recommendations.

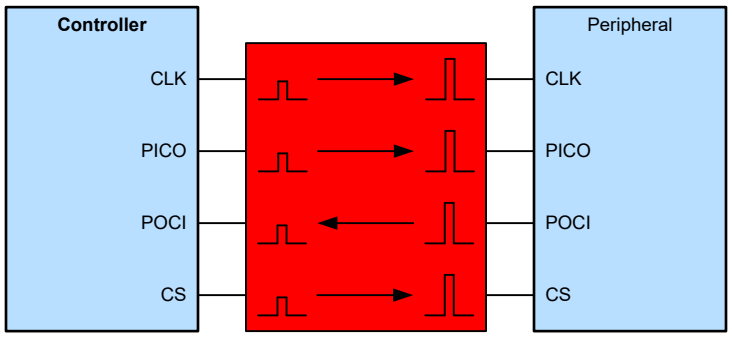

Figure 1-2. Example of Using Voltage Translation With an SPI Communication Bus

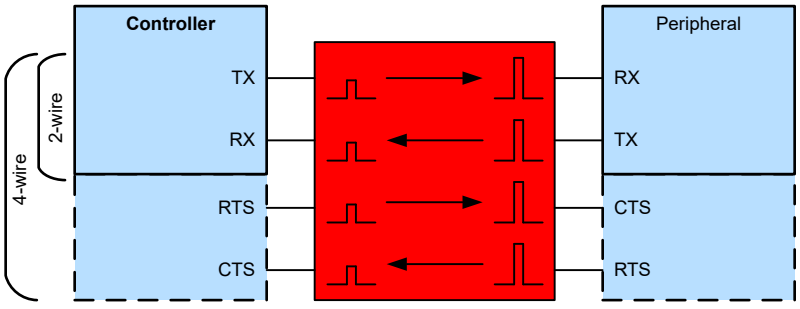

Figure 1-3. Example of Using Voltage Translation With UART

2 Recommendations Specific to Fixed Directional or Direction Control Level Shifters

2.1 Before You Begin

2.1.1 Documentation

Make sure you have the latest version of all documentation and data sheets.

Note

There is a Notifications button on each ti.com device product folder. Registration here enables proactive automatic notification of device errata.

2.2 Power Supplies

2.2.1 Biasing Requirements

- Make sure supply voltages match data sheet recommendations.

2.2.2 Decoupling Capacitors

During transitions, level-shifters can draw large transient currents from the power supply. Decoupling capacitors prevents voltage droops on the power rails by bypassing the power supply and creating a low-impedance path for high-frequency signals. This makes sure the level-shifter is provided a clean and stable supply voltage.

A typical recommendation is 0.1 µF, to help mitigate noise from power supplies. Place decoupling capacitors as close as possible to V_{CC} pins on the printed circuit board layout.

2.2.3 Power Sequencing

- The recommendation is to make sure the OE pin is configured to keep the device disabled until both supplies are stable.
- Devices such as AXC | LXC | TXU are equipped for robust power sequencing and do not recommend any specific power sequence requirement.

2.3 Output Enable and DIR Pins

- Never leave floating.
- Connect directly to V_{CC} or GND (or drive HIGH or LOW with a control signal).
  - Can use pull-ups or pull-downs when driven by a control signal. 10 kΩ is typical.

2.4 Input or Output Pins

Make sure your input or output pins meet the data sheet recommendations. For example:

- Data rate frequency.
- Load capacitance.
- Double check proper voltage levels for inputs (follow the device-specific VIH / VIL specification in the data sheet). Devices are over-voltage tolerant and inputs can be ≥ V_{CC} within the data sheet's recommended operating conditions.
- Series resistors used should be sufficient with the device's output impedance and transmission line used. For more information, see [FAQ] Can I estimate appropriate dampening resistor value for level-shifter outputs?
- Not recommended to have delay (RC) circuitry tied to input pins to avoid violating the data sheet's input transition spec, where applicable. Violations can result to shoot-through currents and oscillations. For more information, see Implications of Slow or Floating CMOS inputs.

2.5 Unused Pins

AXC | LXC | TXU devices are equipped with internal pull-downs to prevent floating. Their unused pins can be left disconnected (with the exception of the OE | DIR pins).

Devices not equipped with internal pull-downs can never have unused floating inputs. The recommendation is to tie unused pins to GND.

2.6 Pull-Ups and Pull-Downs

- External pull-up (or pull-down) resistors can be used with devices that do not have internal pull-downs (or pull-ups).
- If a device includes internal pull-downs (or pull-ups), external pull-ups (or pull-downs) can be sized properly avoid voltage divider networks.
  - The general rule is to size external pull-ups no larger than 10% of the value of the internal pull-down resistor used. See respective data sheet recommendations for AXC | LXC | TXU.

2.7 Recommended Translator by Interface

Table 2-1. Recommended Translator by Interface

	Translation Level	
Interface	**Up to 3.6V**	**Up to 5.5V**
FET Replacement	2N7001T	SN74LXC1T45 / TXU0101
1 Bit GPIO / Clock Signal	SN74AXC1T45	SN74LXC1T45 / TXU0101
2 Bit GPIO	SN74AXC2T245	SN74LXC2T45 / TXU0102
2-Pin JTAG / UART	SN74AXC2T45	SN74LXC2T45 / TXU0202
I2C / MDIO / SMBus	TXS0102 / LSF0102	TXS0102 / LSF0102
IC-USB	SN74AVC2T872 / TXS0202	N/A
4 Bit GPIO	SN74AXC4T245	TXB0104 / TXU0104
UART	SN74AXC4T245	TXB0104 / TXU0204
SPI	SN74AXC4T774	TXU0304
Quad-SPI	TXB0106	TXB0106
JTAG	SN74AXC4T774 / TXB0104	TXB0104 / TXU0304
I2S / PCM	SN74AXC4T774 / TXB0104	TXB0104 / TXU0204
SDIO / SD / MMC	TXS0206 / TWL1200	N/A
6 Bit RGMII	TXV0106	N/A
8 Bit GPIO / RGMII	TXV0108	SN74LXC8T245

For more information on specific interfaces, see *Voltage Translation Application Quick Reference*.

3 Summary

Step	Checklist	Comments
1	Verify the interface	See Section 2.7 Fixed directional or direction control devices are used with push-Pull interfaces
2	Verify power supplies are biased correctly	Data sheet guarantees V_{CC} within the respective data sheet's recommended operating conditions **AXC** 0.65V - 3.6V | **AVC** 1.2V - 3.6V | **TXV** 1.14V - 3.6V | **TXU** 1.08V - 5.5V| **LXC** 1.08V - 5.5V | **LVC** 1.65V - 5.5V
3	Verify decoupling capacitors are used with all power supplies	0.1µF is recommended. Recommended to place cap as close as possible to the V_{CC} supply pin(s).
4	Verify the schematic pinout matches the data sheet pinout.	Unused I/Os can be left floating only if there is a pull-down internal to the device in cases such as AXC | LXC | TXU Without an internal pull-down, tie all unused pins to GND or use bus-hold alternatives such as AVC**H** | LVC**H**.
5	Verify output capacitive load is minimal	Typically, up to 70pF unless specified in data sheets.
6	Verify that external pull-up (or pull-down) resistors are consistent with data sheet.	Pull-ups are not recommended for AXC | LXC | TXU. If used, make sure the pull-up used is not larger than 10 % of the internal pull-down. Pull-ups are not recommended with bus-hold devices. Pull ups can be used with all other devices without internal pull-downs.

4 References

- Texas Instruments, *Implications of Slow or Floating CMOS inputs*, application note.
- Texas Instruments, *Voltage Translation Application Quick Reference*, product overview.

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