Logic Portfolio
Voltage translators / Level shifters
Welcome to NXP’s voltage translators training module. This module will explain the techniques and features of NXP’s voltage translators. The module will also help to select the right voltage translator for specific applications.
Voltage translation is required to ensure that devices operating at different supply voltages in a system are able to work with each other without any damaging current flow and signal loss.
Input switching threshold and output voltage levels for 5V/3V CMOS, mixed CMOS/TTL and BiCMOS logic families are shown here. High level output voltage (Voh) of driver device must be higher than high level input threshold voltage (Vih) of receiver device and the low level output voltage (Vol) of driver must be lower than low level input threshold voltage (Vil) of receiver for proper working of CMOS devices.
However, if $V_{OH}$ of driver is lower than $V_{IH}$ of receiver and/or $V_{OL}$ of driver is higher than $V_{IL}$ of receiver, the system behavior becomes unpredictable as shown in this slide. Therefore, it is necessary to match the input switching thresholds of receiver with output voltage levels of driver in a mixed voltage system.
If inputs of receiving device are over supply voltage tolerant, they can accept the input signals which are higher than the supply voltage. Since the outputs of such devices are referenced to Vcc, high to low voltage translation becomes possible. Use of current limiting resistors with CMOS devices which have diodes between inputs and Vcc is another technique for high to low voltage translation.
Open drain outputs and low input switching thresholds of CMOS devices are common techniques for low to high voltage translation.
Use of current limiting resistors in CMOS devices for high to low voltage translation is explained in this slide. Value of required current limiting resistor can be calculated by using Vcc values of driver and receiver devices and allowed input clamping current for receiver as shown here.
A pull up resister can be used with the open drain outputs of standard logic functions to implement the low to high voltage translation and drive the next device as shown in this slide.
NXP’s LVC, LVT, ALVT and AHC/T devices have over-voltage tolerant inputs up to 5.5V and can be used for HIGH to LOW voltage translation.

- Inputs of AUP and AVC devices are tolerant up to 3.6V only. They are suitable for 1.8V/3.3V mixed designs.
- LV, HC and HEF devices have input clamping diodes to VCC and can be used with current limiting resistors for HIGH to LOW voltage translation.

Examples:

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<th>Part Number</th>
<th>How</th>
<th>Description</th>
<th>Vcc Range</th>
</tr>
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<tr>
<td>74ALP2G157</td>
<td>Overvoltage tolerant inputs</td>
<td>Low Power 2 input Multiplexer</td>
<td>0.8V - 3.6V</td>
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<tr>
<td>74LV00</td>
<td>Current Limiting Resistor</td>
<td>Quad 2 Input NAND Gate</td>
<td>1V - 5.5V</td>
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<tr>
<td>74ALC18377</td>
<td>Overvoltage tolerant inputs</td>
<td>8 bits transparent D type latch</td>
<td>1.2V - 3.6V</td>
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<tr>
<td>74ALC34</td>
<td>Overvoltage tolerant inputs</td>
<td>Dual D Type Flip Flop with Set and Reset</td>
<td>1.65V - 3.6V</td>
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<tr>
<td>74LV32C34</td>
<td>Overvoltage tolerant inputs</td>
<td>Triple Buffer Gate</td>
<td>1.65V - 5.6V</td>
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<tr>
<td>74AMC1086</td>
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<td>2 Input Exclusive OR Gate</td>
<td>2V - 5.5V</td>
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<tr>
<td>74HC2082</td>
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<td>Dual 2 Input NOR Gate</td>
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<tr>
<td>74HC4084</td>
<td>Overvoltage tolerant inputs</td>
<td>Hex Inverting Hi-Low Level Translator</td>
<td>2V - 6V</td>
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<tr>
<td>74HC4090</td>
<td>Overvoltage tolerant inputs</td>
<td>Hex Inverting Hi-Low Level Translator</td>
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<tr>
<td>74ALVT162244</td>
<td>Overvoltage tolerant inputs</td>
<td>16 Bit Buffer Driver with 30 Ohm Termination Resistors</td>
<td>2.5V - 3.6V</td>
</tr>
<tr>
<td>74LV74A2</td>
<td>Overvoltage tolerant inputs</td>
<td>Octal Inverting Buffer</td>
<td>2.7V - 3.6V</td>
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<tr>
<td>HEF4040B</td>
<td>Overvoltage tolerant inputs</td>
<td>Hex Inverting Hi-Low Level Translator</td>
<td>8V - 16V</td>
</tr>
<tr>
<td>HEF4040B</td>
<td>Overvoltage tolerant inputs</td>
<td>Quad Hi-Lev level Translator with 3 State Outputs</td>
<td>8V - 16V</td>
</tr>
<tr>
<td>HEF450B</td>
<td>Overvoltage tolerant inputs</td>
<td>Hex Non-Inverting Hi-Lev Level Translator</td>
<td>8V - 16V</td>
</tr>
</tbody>
</table>

NXP’s LVC, LVT, ALVT and AHC/T devices have over-voltage tolerant inputs up to 5.5V and can be used for HIGH to LOW voltage translation in 5V/3.3V mixed supply voltage systems. Inputs of AUP and AVC devices are tolerant up to 3.6V only. They are suitable for 1.8V/3.3V mixed designs. LV, HC and HEF devices can be used with current limiting resistors for HIGH to LOW voltage translation for interfacing with voltages far in excess of typical logic families.
NXP’s AUPxT and HCT logic have lower than typical input switching thresholds and can be used for low to high voltage level translation. AUP1T57, AUP1T58, AUP1T97, AUP1T98 (1.8V to 3.6V) and HCT logic devices fall in this category. 03, 06, 07, 09, 11, 38, 7273, 9114, 9115 are the functions with open drain outputs in HC/T, LV, AHCT, AUP, LVC and FAST logic families.
Wide voltage translation range, low propagation delays, and different drive currents are available in AUP, LVC and AVC voltage translators from NXP. With the low Icc and Ioff in partial power down mode, these devices consume very low power in active and standby modes. Optional bus hold and integrated termination resistors can reduce the external components saving board space and cost. PicoGate is a very small 5, 6 or 8 pin TSSOP package with leads and MicroPak is the leadless smaller package. DQFN is the world’s smallest leadless package for full function logic devices.
For high to low voltage translation HC/T, AHC/T and HEF4000B logic families offer different logic functions with over supply voltage tolerant inputs and built in Schmitt trigger for slower inputs. With TTL compatible inputs, some level of low to high voltage translation can also be achieved. Wide operating temperature range of -55C to 150C makes these devices ideal for use in systems designed for harsh weather conditions as well.
ALVC logic is a high speed version of LVC logic with supply voltage range of 1.2V to 3.6V. LVT and ALVT are BiCMOS logic devices with drive currents as high as 64mA, suitable for high load applications. Outputs of LVT and ALVT devices can be tristated with output enable control and during power up and power down. Also the inputs of these devices are over voltage tolerant. These features provide an additional level of live insertion for LVT and ALVT voltage translators.
These are the devices with two supply voltages and different voltage ranges. These translators can be used for uni or bidirectional voltage level translation. Some bidirectional voltage translators have a ‘DIR’ pin to control the direction of data while others have ‘DIR” and ‘Output Enable’ pins for tristating the outputs and save power. Output enable control is available in 245 functions. Low to high as well as high to low voltage translation can be done with these devices.
Dual supply voltage translators with ‘DIR” pin are available from NXP in AVC, LVC, ALVC and AUP logic families. Output Enable feature is available in ‘245 functions offered in 4, 8, 16 and 20 bit devices. A wide voltage translation range of 0.8V to 5.5V can be addressed by using these devices.
### Dual Supply Translators

**Features and Benefits**

- Wide voltage translation range for mixed 5.0 V/3.3 V/2.5 V/1.8 V/1.2 V designs
- Direction control input for bidirectional data flow
- High speed and low power consumption for battery operated and handheld systems
- Live insertion and extraction for systems which are always powered on
- 3 state outputs for high impedance suspend mode
- Flow through pin out for PCB lay out flexibility
- Bus hold function for less external components and no floating inputs
- Innovative leadless MicroPak and DQFN packages for space saving

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Dual supply translators are available with various unique features that make them suitable for many different applications. Bidirectional data flow, flow through pin out, bus hold and live insertion are some of these features.
Standard SO, SSOP and TSSOP packages are offered in addition to innovative smaller leadless MicroPak and DQFN packages for voltage translators from NXP. Packages from NXP are RoHS compliant with no lead and are also dark green with no halogen and antimony oxides for better safer environment.
The slide provides helpful hints for selection of a right voltage translator in a system. Determination of number of channels, direction of data flow, translation voltage and current levels and required propagation delay are critical in selection of right voltage translator. With NXP's broad voltage translation portfolio, right voltage translator is always available for any application with specific operating requirements.
An 8 bit, dual supply voltage level translator is used to translate the voltage signal levels from 1.8V CPU bus to 3.3V memory and vice versa.
The slide explains the use of LVCH162245A as a bidirectional voltage level translator between 3.3V processor bus and 5V SRAM with TTL compatible input levels. By default, processor writes the data on memory. Whenever, processor tries to read the SRAM, it will generate Chip Select first. Since there is bus hold at inputs of LVCH162245, address will be passing through the transceiver into SRAM data lines. After sometime processor bus will be tristated and it'll generate RD signal. While /OE is still low, SRAM starts transmitting data. Data from SRAM appears at B port at the same time as the DIR input goes from HIGH to LOW and data starts flowing from B to A port. Data flows from processor to SRAM since inputs of SRAM are TTL compatible. Data flow from SRAM to processor due to high to low voltage translation by using over supply voltage translation at LVC inputs. Also, LVCH162245 is designed with 30 Ohm series termination resistors in both HIGH and LOW output stages to reduce line noise and ensure better signal integrity in design with no reflections, undershoots or overshoots.
NXP offers a broad portfolio of voltage translators in various logic families with different electrical specifications and package options. These voltage translators can be used for low to high or high to low voltage level translation between driver and receiver at high speed with very low power consumption. Various standard and leadless packages are available for these devices that can be used to save PCB space significantly. For a complete portfolio offering of voltage translators, please visit www.standardics.nxp.com/products/voltage.translation
Thank You!