# RS-232 vs. TTL Serial Communication

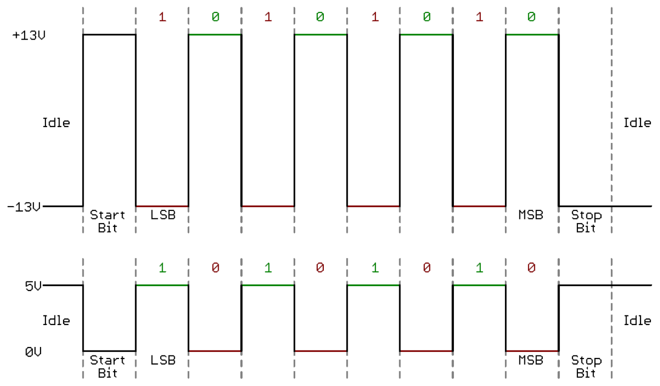
by Jimb0 | November 23, 2010 | 11 comments Skill Level: ★ Beginner

One of the tools we use most when debugging our projects is serial input/output. Serial is very easy to implement, and it allows you to send/receive any data you need from your microcontroller to a computer's serial port so it can be viewed using a terminal emulator. These two devices are compatible from a software perspective, however you can't just hook a microcontroller up to a computer because the hardware interfaces are not compatible.

Most microcontrollers these days have built in UARTs (universally asynchronous receiver/transmitter) that can be used to receive and transmit data serially. UARTs transmit one bit at a time at a specified data rate (i.e. 9600bps, 115200bps, etc.). This method of serial communication is sometimes referred to as **TTL serial** (transistor-transistor logic). Serial communication at a TTL level will always remain between the limits of **0V and Vcc**, which is often 5V or 3.3V. A logic high ('1') is represented by Vcc, while a logic low ('0') is 0V.

The serial port on your computer (if it's lucky enough to have one, they're quickly becoming a relic) complies with the **RS-232** (Recommended Standard 232) telecommunications standard. RS-232 signals are similar to your microcontroller's serial signals in that they transmit one bit at a time, at a specific baud rate, with or without parity and/or stop bits. The two differ solely at a hardware level. By the RS-232 standard a logic high ('1') is represented by a negative voltage – anywhere from -3 to -25V – while a logic low ('0') transmits a positive voltage that can be anywhere from +3 to +25V. On most PCs these signals swing from **-13 to +13V**.

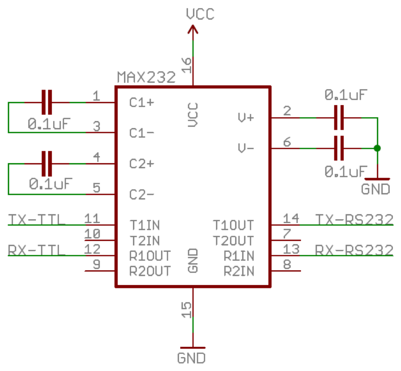
The more extreme voltages of an RS-232 signal help to make it less susceptible to noise, interference, and degradation. This means that an RS-232 signal can generally travel longer physical distances than their TTL counterparts, while still providing a reliable data transmission.



This timing diagram shows both a TTL (bottom) and RS-232 signal sending 0b01010101

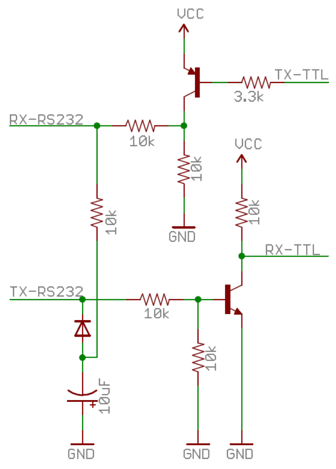
## Solutions

So, you may see where the problem lies in interfacing these two signals. To connect these two ports you not only have to **invert** the signals, but you also have to deal with regulating the potentially harmful RS-232 voltages to something that won't destroy a microcontroller's serial pins. There are a handful of solutions to this problem of voltage converting and inverting. The most common, and easiest solution is just plugging a MAX-232 in between the two devices:



There are many generic derivatives of the MAX-232. Maxim IC just happened to be the first to market with this neato device (decades ago!) so out of habit, we call all ICs that do similar jobs 'MAX-232s'.

Less expensive solutions, like our RS-232 Shifter, use transistors or inverters to flip the signals, and charge pumps to get the voltages high enough to be RS-232 compliant:



## Sample Question

With the above information at hand, here's a quick quiz to test your shiny new knowledge:

1. What are the two main differences between RS-232 and TTL signals?

2. True or false: Data is sent from a PC's RS-232 port at 9600 bits-per-second (bps), it's converted to TTL by a MAX232 before reaching a microcontroller. The voltages of the signals look different on each end, but the speed (bps) does not change.

**Answers:**

Spoiler Alert! Highlight from here...

1. The '1's and '0's are inverted from each other. The minimum and maximum voltages of RS-232 signals is +/-13V, and only 0 to 3.3V/5V for TTL signals.

2. True. The data rate will always remain the same, even if the voltages of the RS-232 and TTL signals are different.

...to here to reveal the answers. Because, you know, they're so super-secret.

## Comments 11 comments

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George Hawkins / about 6 months ago / ★ 1

Why do you call the RS-232 Shifter a less expensive solution? Your MAX3232 - transceiver Breakout is currently $5.95 while your corresponding RS232 shifter is $9.95 (and the one with a DB9 is $13.95). In what situation would one choose the RS232 shifter over the MAX3232 transceiver? It looks like the shifter can go as low as 2.8V TTL while the transceiver can only go down to 3.3V so that might be one reason. Are there then reasons, other than price, for choosing the other way around, i.e. transceiver over shifter?

Member #737236 / about 2 years ago / ★ 1

Hi,

I' ve a rs232-4/20 mA converter but I need to invert the signal logic level on the rs232 side because the current loop circuit uses the following rule: 4mA = low logic level - 20 mA High logic level. By my understanding your rs232shifter invert the logic signal levels but move to a voltage between 0 to Vdc. My curent loop link speed is 9600 bps but i could decrease a little bit, could you please suggest to me a circuit (integrated or not) with the components to be used to invert the logic level using rs232 signal voltage level in such way put that circuit between my pc and the rs232/currentLoop converter ?

Thanks :-)

> Member #436268 / about 2 years ago * / ★ 1
>
> You don't need logic to invert. Use the inverse_logic argument for SoftwareSerial(). This will give you inverted data bits which will result in uninverted bits from the level shifter.

johnxzhao / about 2 years ago / ★ 1

Great info. Thanks.

exdwh / about 3 years ago / ★ 1

The cheapest and easiest solution is to buy a < $2 USB to TTL serial cable.

Member #386933 / about 5 years ago / ★ 1

I wanted to try out your circuit for a tll to rs 232 converter. What voltage do you use for Vcc? I'm using arduino uno, so would I use the 5V to power the bjt?

Mr. Patrick / about 5 years ago / ★ 1

Nice little chunk of info! Thanks, Sparkfun!

pkonrad37 / about 7 years ago / ★ 1

It doesn’t really understand the mcu’s language, you are just sending bits across, so a terminal would interpret them 8 at a time as chars/bytes.

Chris20 / about 7 years ago / ★ 1

How does the computer understand the MCU’s language? Do you have to write a driver?

MK1888 / about 6 years ago / ★ 1

The computer has a UART of its own to turn the bits into bytes.

MrMark / about 7 years ago / ★ 1

the text is in——-for the answers, so you have to ——— the text to get it to show up for the answers, good luck!!<br />