USB to Serial Port Chip CH9101

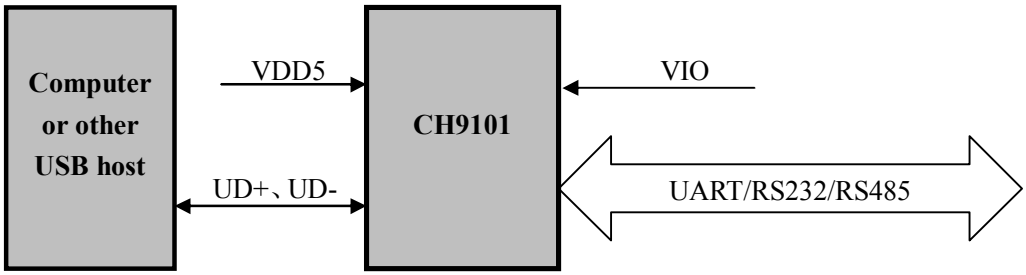
Datasheet

Version: 1C

http://wch.cn

1. Introduction

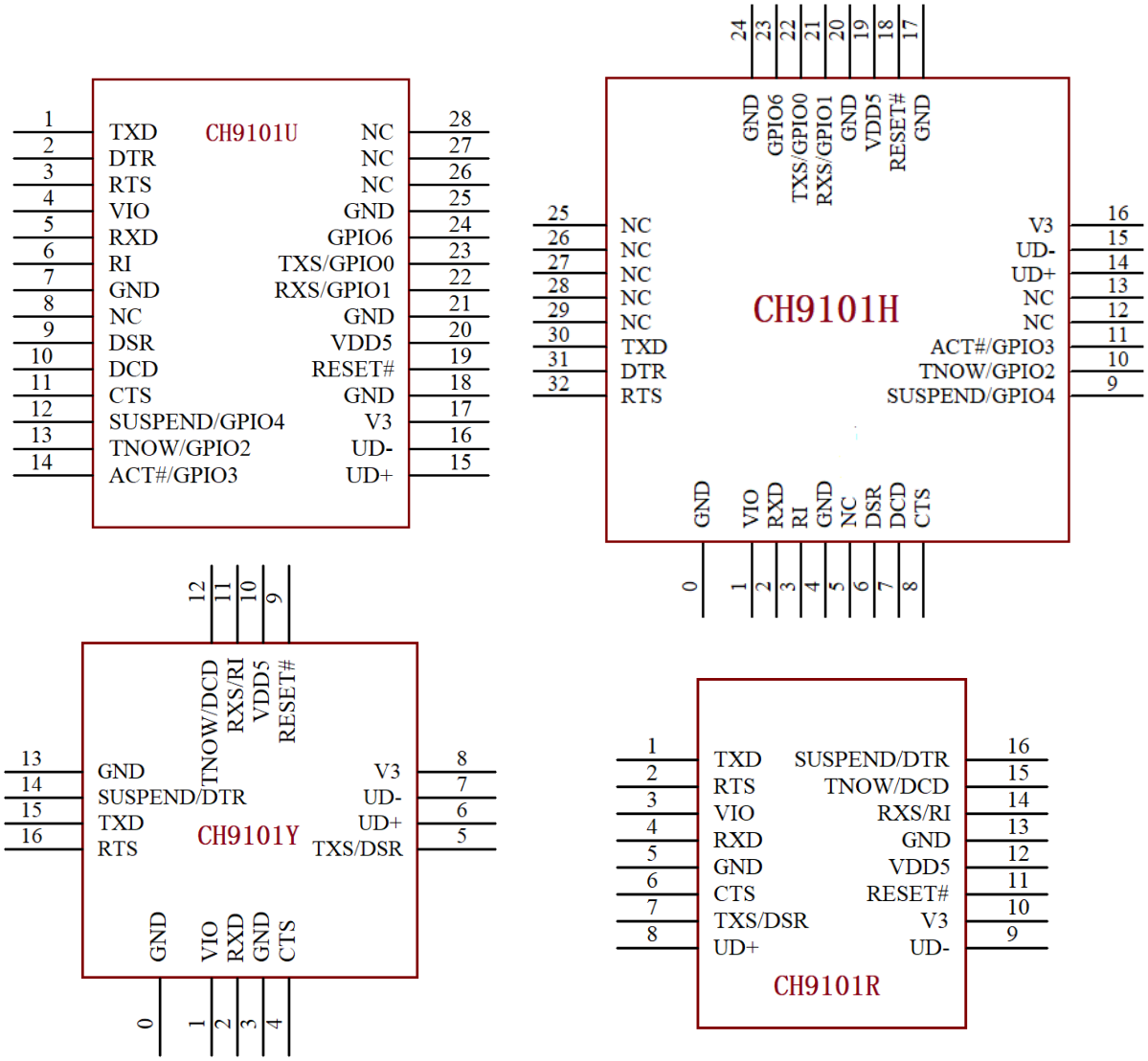
CH9101 is a USB bus converter chip, which converts USB to serial port. CH9101 provides standard MODEM signal, used to expand serial port for computer or upgrade directly from normal serial device or MCU to USB bus.



2. Features

- Full-speed USB device interface, USB 2.0 compatible.
- Built-in firmware, emulate standard UART interface, used to upgrade the original serial peripheral or expand additional UART via USB.
- Original serial applications are totally compatible without any modification in Windows operating systems.
- Supports free installation OS which built-in CDC driver or multi-functional high-speed VCP vendor driver.
- Hardware full duplex UART interface, integrated independent transmit-receive buffer, supports communication baud rate varies from 50bps to 3Mbps.
- UART supports 5, 6, 7 or 8 data bits, and supports odd, even, space, mark and none parity.
- Supports common MODEM interface signals RTS, DTR, DCD, RI, DSR and CTS.
- Supports CTS and RTS hardware automatic flow control.
- Supports half-duplex, provides sending status TNOW, used for controlling RS485 to transmit-receive switch.
- Supports RS232 interface, through external voltage conversion chip.
- Supports 5V and 3.3V power supply voltages.
- UART interface I/O powered independently, supports 5V, 3.3V, 2.5V, 1.8V power supply voltages.
- Integrated power-on reset, integrated clock, no external crystal required.
- Built-in EEPROM used to configure the chip of VID, PID, maximum current value, vendor and product information string, etc.
- Integrated Unique ID (USB Serial Number).
- RoHS compliant SSOP28, QFN32, QFN16 and QSOP16 lead-free package.

3. Packages



Package	Body size		Lead pitch		Description	Part No.
SSOP28	5.3mm	209mil	0.65mm	25mil	Ultra-small 28-pin patch	CH9101U
QFN32_5X5	5*5mm		0.5mm	19.7mil	Square leadless 32-pin patch	CH9101H
QFN16_4X4	4*4mm		0.65mm	25mil	Square leadless 16-pin patch	CH9101Y
QSOP16	3.9mm	150mil	0.635mm	25mil	1/4 size 16-pin patch	CH9101R

Note:

The backplane of CH9101H/CH9101Y is 0# pin GND, which is an optional but recommended connection; other GND are necessary connections.

The USB transceiver of CH9101 is designed according to the built-in design of USB2.0, and it is recommended that no external resistor is in series with UD+ and UD- pins.

4. Pin definitions

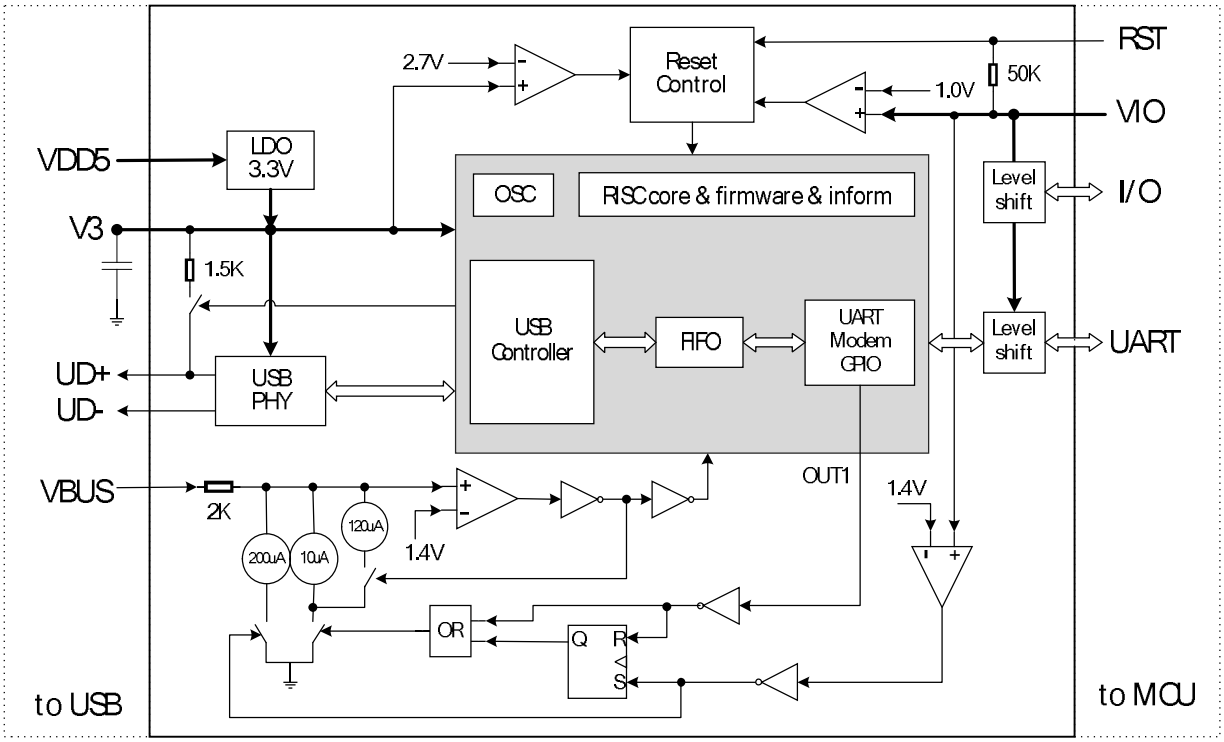
SSOP28 Pin No.	QFN32 Pin No.	QFN16 Pin No.	QSOP16 Pin No.	Pin Name	Pin Type	Pin Description
20	19	10	12	VDD5	POWER	Power supply voltage input, requires an external decoupling capacitor
4	1	1	3	VIO	POWER	I/O Power supply voltage input, requires an external decoupling capacitor
7,18, 21,25	0,4, 17,20, 24	0,3, 13	5,13	GND	POWER	Ground, connected to ground of USB bus directly
17	16	8	10	V3	POWER	Internal power regulator output and core and USB power input, When VDD5 voltage is less than 3.6V, connect VDD5 to input the external power supply, an external power decoupling capacitor is required to be connected when the VDD5 voltage is greater than 3.6V
19	18	9	11	RESET#	IN	Input of external reset, active low, built-in pull-up resistor
15	14	6	8	UD+	USB signal	Connect to USB D+ Signal directly, do not series resistors
16	15	7	9	UD-	USB signal	Connect to USB D- Signal directly, do not series resistors
1	30	15	1	TXD	OUT	Transmit asynchronous data output of UART, high when idle
5	2	2	4	RXD	IN	Receive asynchronous data input, built-in pull-up resistor
11	8	4	6	CTS	IN	MODEM input signal, clear to send, active low
9	6	5	7	DSR	IN	MODEM input signal, data set ready, active low; CH9101R/Y: the default function of this pin is the TXS function, which can be switched to the DSR function by configuring the parameters of the EEPROM
6	3	11	14	RI	IN	MODEM input signal, ring indicator , active low; CH9101R/Y: the default

						function of this pin is the RXS function, which can be switched to the RI function by configuring the parameters of the EEPROM
10	7	12	15	DCD	IN	MODEM input signal, data carrier detect, active low;CH9101R/Y: the default function of this pin is the TNOW function, which can be switched to the DCD function by configuring the parameters of the EEPROM
2	31	14	16	DTR	OUT	MODEM output signal, data terminal ready, active low;CH9101R/Y: the default function of this pin is the SUSPEND function, which can be switched to the DTR function by configuring the parameters of the EEPROM
3	32	16	2	RTS	OUT	MODEM output signal, request to send, active low If RTS pin has detected that an external pull-down resistor is connected during power-on, disable internal EEPROM configuration parameter, enable chip default parameter
23	22	-	-	TXS/ GPIO0	OUT/ (IN / OUT)	TXD pin transmit status output; General GPIO0, input or output controlled by driver software
22	21	-	-	RXS/ GPIO1	OUT/ (IN/ OUT)	RXD pin receive status output; General GPIO1, input or output controlled by driver software
13	10	-	-	TNOW/ GPIO2	OUT/ (IN/ OUT)	The serial port sends the status indication in progress, active high General GPIO2, input or output controlled by driver software
14	11	-	-	ACT# GPIO3	OUT/ (IN/ OUT)	USB configuration completed state output, active low, invalid when suspended; General GPIO3, input or output controlled by driver software
12	9	-	-	SUSPEND	OUT/	USB suspend state output, active low,

				/ GPIO4	(IN/ OUT)	normal working state output high level, output low level after suspension; General GPIO4, input or output controlled by driver software
24	23	-	-	GPIO6	IN/ OUT	General GPIO6, input or output controlled by driver software
8,26, 27,28	5,12, 13,25, 26,27, 28,29	-	-	NC	NONE	No connection, must be suspended

5. Function descriptions

5.1. Internal structure



5.2. Power and power consumption

CH9101 has 3 power supplies and a built-in voltage regulator which generates 3.3V. VDD5 is the input of the power regulator, V3 is the output of the voltage regulator and USB transceiver and core power supply input, and VIO is the I/O pin power supply.

CH9101 supports 5V or 3.3V power supply voltages, and the V3 pin should be externally connected to a power decoupling capacitor with a capacity of about 0.1uF. When using 5V power supply (greater than 3.8V), VDD5 inputs external 5V power supply (for example, the USB bus power supply), the internal voltage regulator generates 3.3V on V3 which used by USB transceivers. When using 3.3V or lower operating voltage (less than 3.6V), V3 should be connected to VDD5, while input external 3.3V power supply. V3 still

requires an external decoupling capacitor.

VIO pin of CH9101 provides I/O power for serial port I/O and RESET pin. It supports 1.8V～5V power supply. VIO should use the same power supply as MCU and other peripherals. UD+ and UD- pins use V3 power supply, not VIO power supply.

CH9101 automatically supports USB device suspend to save power consumption. In the USB suspend state, if there is no external load on the I/O output pins, and the I/O input pins are in a floating (internal pull-up) or high state, then the VIO power supply will consume no current. In addition, when V3 and VDD5 lose power supply and are at 0V voltage, the current consumption of VIO is the same as above, and VIO will not sink current to VDD5 or V3.

Several power supply connection schemes for reference here:

<table>
<tr><td rowspan="2">Power supply scheme</td><td rowspan="2">UART signals voltage
MCU operating voltage</td><td>VDD5</td><td>V3</td><td>VIO</td><td>MCU or peripheral power supply</td></tr>
<tr><td>Not less than V3 voltage</td><td>Rated around 3.3V</td><td colspan="2">Both use the same power supply, 1.8V～5V</td></tr>
<tr><td rowspan="4">All USB power supply</td><td>5V</td><td>USB powered 5V</td><td>Connects to capacitor only</td><td colspan="2">USB powered 5V</td></tr>
<tr><td>3.3V</td><td>USB powered 5V</td><td>Connects to capacitor</td><td colspan="2">Powered by V3 for 3.3V, up to 10mA</td></tr>
<tr><td>3.3V</td><td colspan="4">USB 5V power stepped down to 3.3V via external LDO power regulator, V3 connects to external capacitor</td></tr>
<tr><td>1.8V～4V</td><td>USB powered 5V</td><td>Connects to capacitor only</td><td colspan="2">USB powered by external LDO regulator</td></tr>
<tr><td>USB+ self-powered Dual power supply</td><td>1.8V～5V</td><td>USB powered 5V</td><td>Connects to capacitor only</td><td colspan="2">Self-powered 1.8V～5V
(1.8V,2.5V,3.3V,5V)</td></tr>
<tr><td rowspan="2">All self-powered</td><td>4V～5V</td><td>Self-powered 4V～5V</td><td>Connects to capacitor only</td><td colspan="2">Self-powered 4V～5V</td></tr>
<tr><td>1.8V～5V</td><td colspan="2">Self-powered, rated 3.3V, connects to external capacitor</td><td colspan="2">Self-powered 1.8V～5V</td></tr>
</table>

Recommended dual power supplies scheme, only VIO and MCU use the same power supply, low-current consumption VIO current is only 2uA when USB suspend or sleep.

5.3. UART description

In UART mode, CH9101 contains: data transfer pins, MODEM interface signals and assistant pins.

Data transfer pins contain: TXD and RXD. RXD should be high when UART input is idle. When UART output is idle, TXD is high level.

MODEM interface signals contain: CTS, DSR, RI, DCD, DTR and RTS. All these MODEM interface signals are controlled and function defined by computer applications.

Assistant pins contain: TNOW, SUSPEND, RXS, TXS, ACT#, etc.

TNOW is the status indication pin that the serial port is transmitting data, which can be used to control the RS485 transceiver switching. When TNOW outputs low or high level, UART sending and receiving can be performed at the same time.

SUSPEND are the output signals to indicate suspend states of the chip. When the chip is in the normal working state, the SUSPEND pin outputs a low level; when the chip is in a suspend state, SUSPEND pin outputs high level.

RXS is the output pin of UART receiving data status, TXS is the output pin of UART sending data status.

ACT# is USB device configuration complete status output, which can be used to notify the MCU or drive the LED which connects to the VIO through the current limiting resistor.

CH9101 supports CTS and RTS hardware automatic flow control, which can be enabled by software. If enabled, UART will continue to send the next data only when CTS is valid (active low), otherwise the UART transmission will be suspended; when the receiving buffer is empty, UART will automatically set RTS to be valid (active low), it will automatically invalidate RTS until the data in the receiving buffer is nearly full, and RTS will be valid again when the buffer is empty. While using hardware automatic flow control, CTS of CH9101 should connect to RTS of the other side, and RTS of CH9101 should connect to CTS of the other side.

CH9101 has integrated separate transmit-receive buffer and supports simplex, half-duplex and full duplex UART communication. UART data contains one low-level start bit, 5, 6, 7 or 8 data bits and 1 or 2 high-level stop bits, supports odd/even/mark/space parity. CH9101 supports common baud rate: 50, 75, 100, 110, 134.5, 150, 300, 600, 900, 1200, 1800, 2400, 3600, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 56000, 57600, 76800, 115200, 128000, 153600, 230400, 256000, 307200, 460800, 921600, 1M, 1.5M, 2M, 3M etc.

In applications with high communication baud rate, it is recommended to enable hardware automatic flow control. Full-speed USB is only 12Mbps, considering the protocol overhead and other factors, the serial port should be avoided in a continuous or full-duplex high-speed communication state of 3Mbps and above in applications.

The allowable baud rate error of CH9101 UART reception is not more than 2%, the baud rate error of UART transmission is less than 1.5%.

On operating systems, CH9101 supports CDC class driver that comes with system, and VCP manufacturer driver could be installed to support high speed communication and other functions. It can simulate the standard serial port, so most serial port applications are fully compatible, usually without any modification.

CH9101 can be used to upgrade the UART peripherals, or expand extra serial ports for computers via USB bus, provides further RS232, RS485, RS422 interface, etc. through external voltage conversion chip.

5.4. Clock and reset and others

CH9101 has a built-in USB pull-up resistor, and the UD+ and UD- pins should be directly connected to the USB bus.

CH9101 has built-in power-on reset circuit.

CH9101 has a built-in low-voltage reset circuit, and monitors the voltage of the V3 pin and VIO pin at the same time. When the voltage of V3 is lower than VRV3 or the voltage of VIO is lower than VRVIO, the chip will automatically reset by hardware.

CH9101 has built-in clock generator, without external crystal and oscillation capacitor.

5.5. Parameter configuration

In larger batch applications, the vendor identification code (VID) and product identification code (PID) of CH9101 and product information can be customized.

In less batch applications, parameters can be configured by built-in EEPROM. After installs VCP vendor driver, through configuration tool CH34xSerCfg.exe provided by chip manufacturer, it can be flexibly configured the identification code (VID), product identification code (PID), maximum current value, BCD version number, manufacturer information and product information string and other descriptor, etc.

6. Parameters

6.1. Absolute maximum ratings

(Operating in critical ratings or exceeding the absolute maximum ratings may cause chip to not work or even be damaged)

Name	Parameter Description	Min.	Max.	Unit
TA	Operating Ambient Temperature	-40	85	℃
TS	Storage Temperature	-55	125	℃
VDD5	USB power supply voltage (VDD5 connects to power, GND connects to ground)	-0.5	6.0	V
VIO	Serial port I/O power supply voltage (VIO connects to power, GND to ground)	-0.5	6.0	V
VUSB	USB signal voltage	-0.5	V3+0.5	V
VUART	Voltage on UART and other pins	-0.5	VIO+0.5	V

6.2. Electrical characteristics

(Test conditions: TA=25℃, VDD=5V OR VDD5=V3=3.3V, VIO=1.8～5V, exclude USB pin)

Name	Parameter Description		Min.	Typ.	Max.	Unit
VDD5	USB supply voltage	V3 doesn't connect to VDD5, V3 connected to capacitor	4.0	5	5.3	V
		V3 connected to VDD5, VDD5=V3	3.0	3.3	3.6	
VIO	Serial port I/O power supply voltage		1.7	5	5.5	V
IVDD	Operating VDD5 or V3 power supply current			3	15	mA
IVIO	Operating VIO Supply current			0	(10)	mA
ISLP	The supply current when USB is suspended	VDD5 power supply =5V		0.09	0.16	mA
		VDD5=V3 power supply =3.3V		0.085	0.15	mA
		VIO power supply, no I/O load/pull up		0.002	0.05	mA

ILDO	External load capacity of internal power regulator				10	mA
VIL	Input high voltage	VIO=5V	0		1.5	V
		VIO=3.3V	0		0.9	V
		VIO=1.8V	0		0.5	V
VIH	Input high voltage	VIO=5V	2.5		VIO	V
		VIO=3.3V	1.9		VIO	V
		VIO=1.8V	1.2		VIO	V
VOL	Output low voltage	VIO=5V, 15mA draw current		0.4	0.5	V
		VIO=3.3V, 8mA draw current		0.3	0.4	V
		VIO=1.8V, 3mA draw current		0.3	0.4	V
VOH	Output high voltage non-reset status	VIO=5V, 10mA output current	VIO-0.5	VIO-0.4		V
		VIO=3.3V, 5mA output current	VIO-0.4	VIO-0.3		V
		VIO=1.8V, 2mA output current	VIO-0.4	VIO-0.3		V
IPUP	Pull-up current of serial port and RST pin (pull up to VIO voltage)	VIO=5V	35	150	220	uA
		VIO=3.3V	15	60	90	uA
		VIO=1.8V	3	14	21	uA
VRV3	V3 Power-on reset/low voltage reset voltage threshold		2.5	2.7	2.9	V
VRVIO	VIO power supply low voltage reset voltage threshold		0.8	1.0	1.15	V
VESD	HBM ESD withstand voltage on USB or I/O pins		5	6		KV

6.3. Timing parameters

(Test conditions: TA=25℃, VDD5=5V or VDD5=V3=3.3V, VIO=1.8V～5V)

Name	Parameter Description		Min.	Typ.	Max.	Unit
FD	Error of internal clock (influence baud rate comparatively)	TA=-15℃～60℃	-1.0	±0.5	+1.0	%
		TA=-40℃～85℃	-1.5	±0.8	+1.5	%
TRSTD	Reset delay after power on or external reset input		9	15	25	mS
TRI	Effective signal width of RESET external reset input		100			nS
TSUSP	Detect USB automatic suspend time		3	5	9	mS
TWAKE	Wake-up completion time after chip sleep		1.2	1.5	5	uS

7. Applications

7.1. USB to 9-line TTL UART (Figure below)

The figure below is the USB to TTL converter realized by CH9101U. Only RXD, TXD and public ground

are necessary connection, while the others are optional.

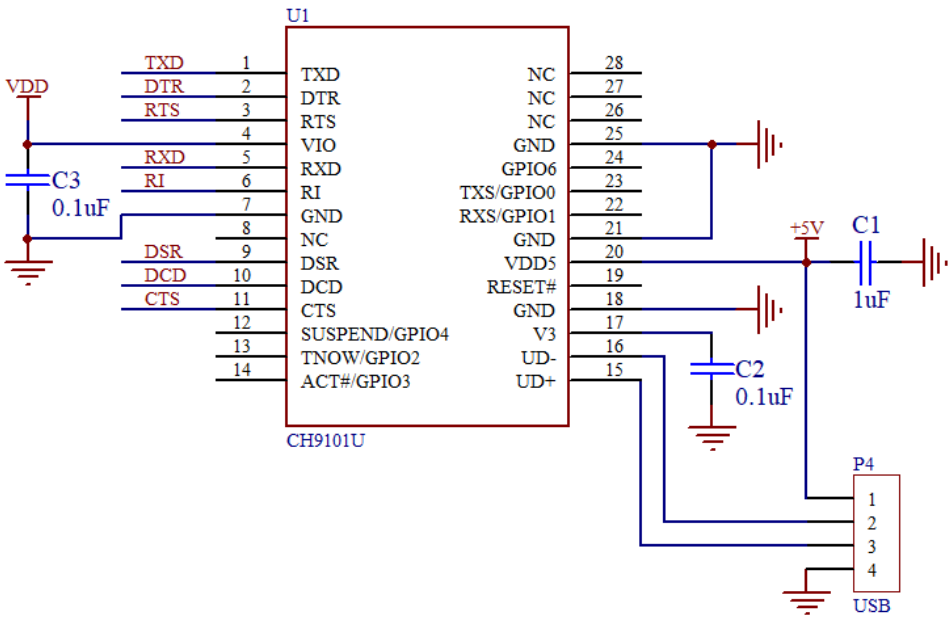
P4 is USB port, USB bus contains a pair of 5V power lines and a pair of data signals. Usually, the color of +5V power line is red, the black one is ground. D+ signal line is green and the D- signal line is white. The max supply current of USB bus is up to 500mA.

The capacitor C2 on V3 is 0.1uF, used to CH9101 internal power decoupling. C1 and C3 are used for external power decoupling.

In the case of VIO=V3=VDD5, all self-powered 3.3V, capacitors C2 and C3 can be omitted.

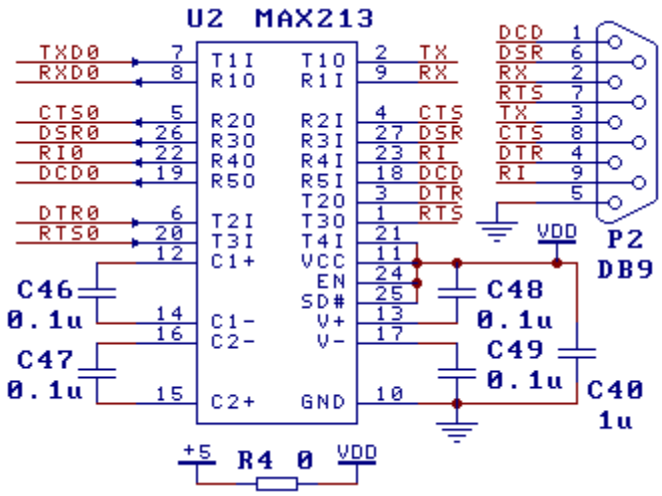
Three power supply schemes: One is all USB power supply, CH9101 and USB products directly use the 5V power supply provided by the USB bus, that is, VDD5=VBUS=USB 5V power, VIO=VMCU=USB 5V or 1.8V~4V after step-down; The second is separate and independent power supply. The VIO of CH9101 and the MCU of the product use self-supplied standing power VDD, while CH9101 uses USB power, and its VDD5 is connected to the USB power, that is, VDD5=USB 5V power, VIO=VMCU=VDD= self-supply 1.8V~5V; The third is all self-powered, only detecting but not using USB power, USB products provide power VDD through self-powered mode, mainly VDD5=VIO=VMCU=VDD=self-supplied 5V or VDD5=V3=VIO=VMCU=VDD=self-supplied 3.3 V two kinds.

When designing the PCB, pay attention to: the decoupling capacitors C1, C2 and C3 should be as close as possible to the connected pins of CH9101; The D+ and D- signal lines are placed close to the parallel wiring, and ground or copper should be provided on both sides to reduce signal interference from the other parts.

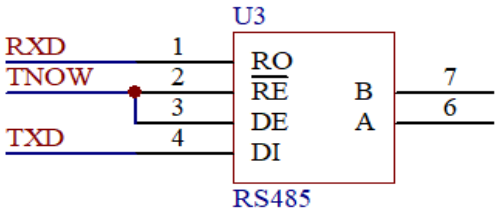


7.2. USB to 9-line RS232 UART (Figure below)

CH9101 provides common UART and MODEM signals, converts TTL to RS232 through level conversion chip U2. Port P2 is DB9 connector, the pins and their functions are the same as common PC DB9 connector, the chips similar with U2 have MAX213/ADM213/SP213/MAX211 etc.U2 in the image is uniformly powered by the USB bus through R4.



7.3. USB to RS485 UART (Figure below)



In the figure, TNOW is the switch pin, the TNOW pin can be used to control DE (send enable, high active) and RE# (receive enable, low active) pin of RS485 transceiver. RS485 transceiver should use the same power supply as VIO.