

Introduction to RS-232 and USB

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What is RS-232?

- ▶ (R)ecommended (S)tandard – Introduced in 1962. Sometimes known as EIA RS-232 or EIA-232. Oldest computer standard still in use today.
- ▶ Originally designed for serial communications between DTE (Data Terminal Equipment) and DCE. (Data Circuit Equipment)
- ▶ Originally designed for modem (Modulator / Demodulator) use.
- ▶ Commonly uses DE-9 or DB-25 connectors (No such thing as a DB-9!)



RS-232 Communication in 1963

DATA TERMINAL EQUIPMENT

TELETYPE ASR-33 (110 Baud ASCII – 10 CPS)



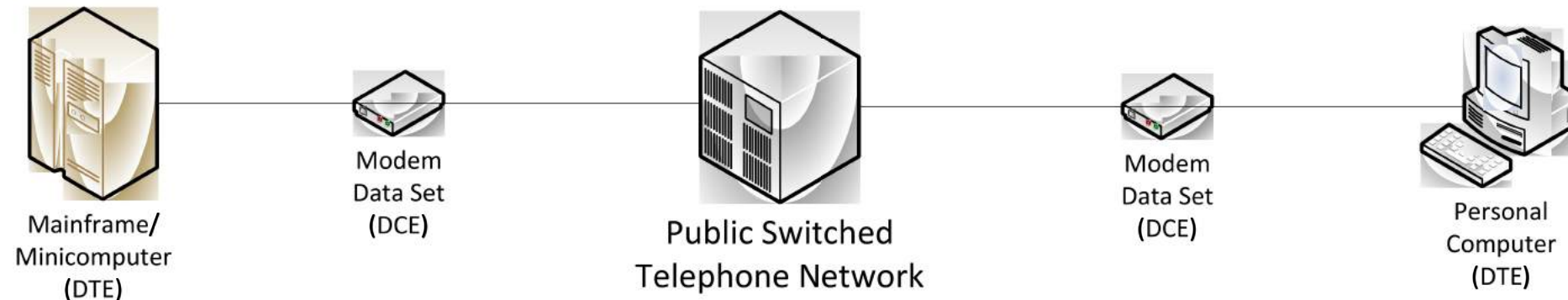
DATA COMMUNICATIONS EQUIPMENT

BELL 103A “DATA – phone” (300 Baud)

Used FSK over standard phone lines



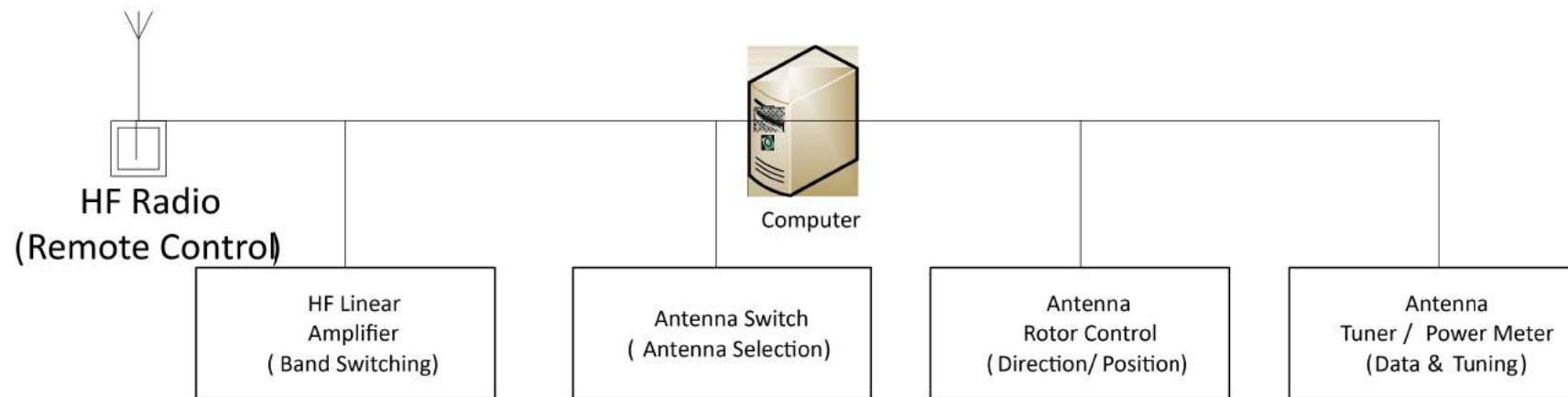
Interfacing RS-232



In a typical configuration we define:

- The mainframe / Minicomputer is considered to be “Data Terminal Equipment” or DTE.
- The modem is considered to be “Data Carrier Equipment” or DCE.
- Customers were not permitted to connect their own equipment up to the telephone network, so acoustic coupler modems were used to avoid a direct electrical connection.

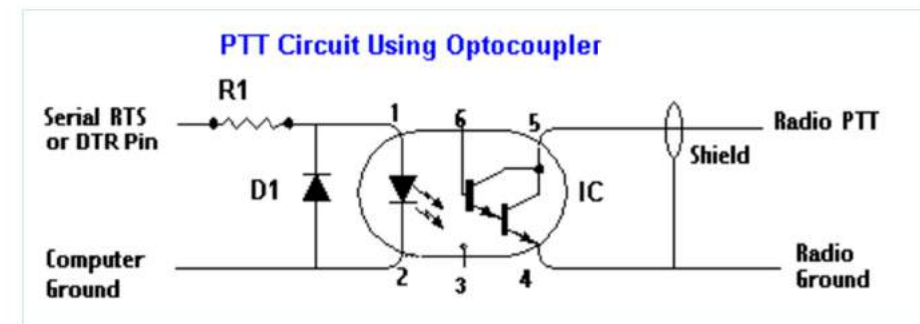
RS-232 In the shack



- ▶ HF Radio – CAT (Computer Aided Transceiver) control for mode, frequency, PTT control, etc.
- ▶ Logging programs – N1MM, Logger32, Ham Radio Deluxe, etc.
- ▶ Digital mode software – WSJT-X, MMTTY, etc.
- ▶ Antenna Switching and Rotor Control
- ▶ Band Switching – Antenna Tuner, Linear Amplifier, Power Meter
- ▶ TNC (Terminal Node Controller) – For those who prefer not to use a soundcard interface.

What is “CAT control”?

- ▶ Prior to 1984, microprocessor driven radios (e.g. IC-701) needed special interfacing circuitry between the computer and the radio's microprocessor. No standard was defined before then, so remote control was difficult to do.
- ▶ CAT (Computer Aided Transceiver) standardized the interface between the computer and the radio, via a level converter box.
- ▶ RS-232 can be used to drive PTT directly, or can be done via CAT command.



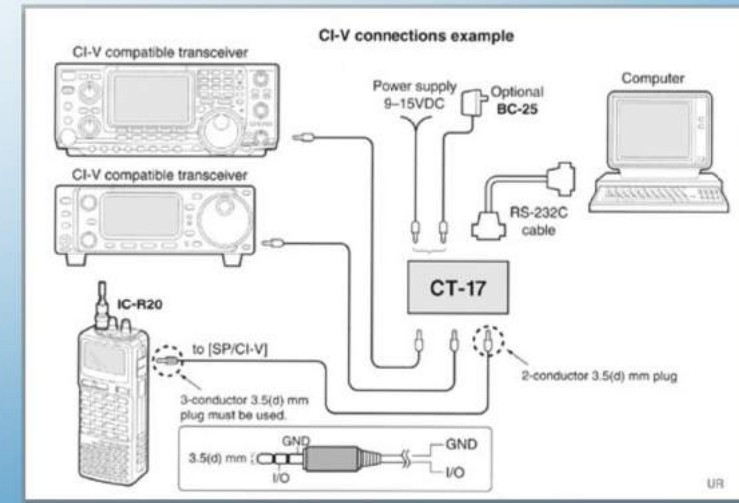
Pre-2000's RS-232 interfacing

- ▶ Pre-1984 HF Radios do not support CAT.
- ▶ All 1980's and 1990's radios require a proprietary level converter to convert to RS-232 levels!
- ▶ FIF-232C for Yaesu
CT-17 for Icom
IF-232C for Kenwood



Icom's CI-V system vs everyone else

- ▶ Icom's CI-V (Computer Interface 5) is a way to interface many different radios to a single RS-232 connection. No other manufacturer ever did this.
- ▶ Uses a standard 1 / 8" stereo audio cable between the radio and the CI-V Interface using simple TTL (5v/0v) levels.
- ▶ Icom radios still support CI-V even today, even through they now come with a built-in USB port. (e.g. IC-7300/IC-9700)
- ▶ 2000's vintage HF Radios (e.g. Kenwood TS-590, Yaesu FTDX-2000/5000) have "true" RS-232 compliant DB-9 connectors instead, no longer requiring converter boxes.



What is great about RS-232

- ▶ Extremely simple to interface. Depending on hardware, three wires at minimum*.
- ▶ “Chewing gum and bailing wire” – Can work under the worst possible conditions at low data rates. Not finicky at all, it either works or it doesn’t.
- ▶ Under proper specifications, cables and connectors are all shielded, ideal for high RF and/or high noise environments. (As long as cables meet spec!)
- ▶ 50 ft (15m) maximum cable length at 9600 baud. No amplifiers or repeaters needed! Ethernet to RS-232 converters can extend this to 428 ft. (128m)
- ▶ Cables and connectors are very tolerant of “mistakes” made during assembly.

* Depends on the interfacing hardware of the DTE. (Will elaborate on this later)



What isn't so great about RS-232

- ▶ Low data rates. Maximum baud rate for most devices is usually 115,200 baud.* Older devices (Pre-1988) can only operate up to 9600 baud without errors.
- ▶ Most modern computer systems don't have any physical RS-232 ports unless an extra add-on card is installed.
- ▶ RS-232 to USB cables can be dicey to use. (Prolific PL-2303 chipset under Win10!)
- ▶ Not all RS-232 cables can be trusted. (Null modem? Unshielded? All conductors?)
- ▶ Not "Plug and Play" by any means! Always requires some manual configuration.
- ▶ 1:1 Device / Port relationship – Each device must have its own port.**

* Some virtual RS-232 "Megabaud" devices support baud rates up to 961,600 baud.

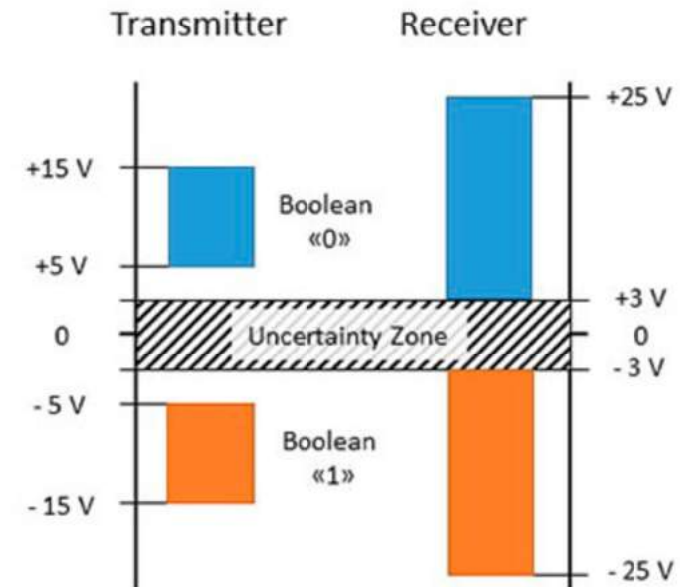
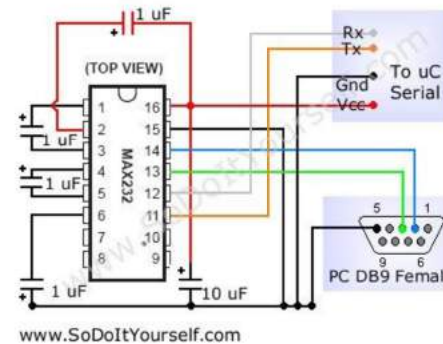
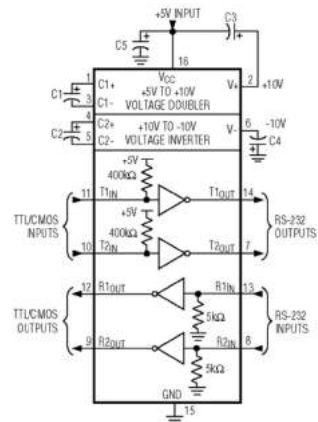
** Except for Icom's CI-V system.



RS-232 electrical information

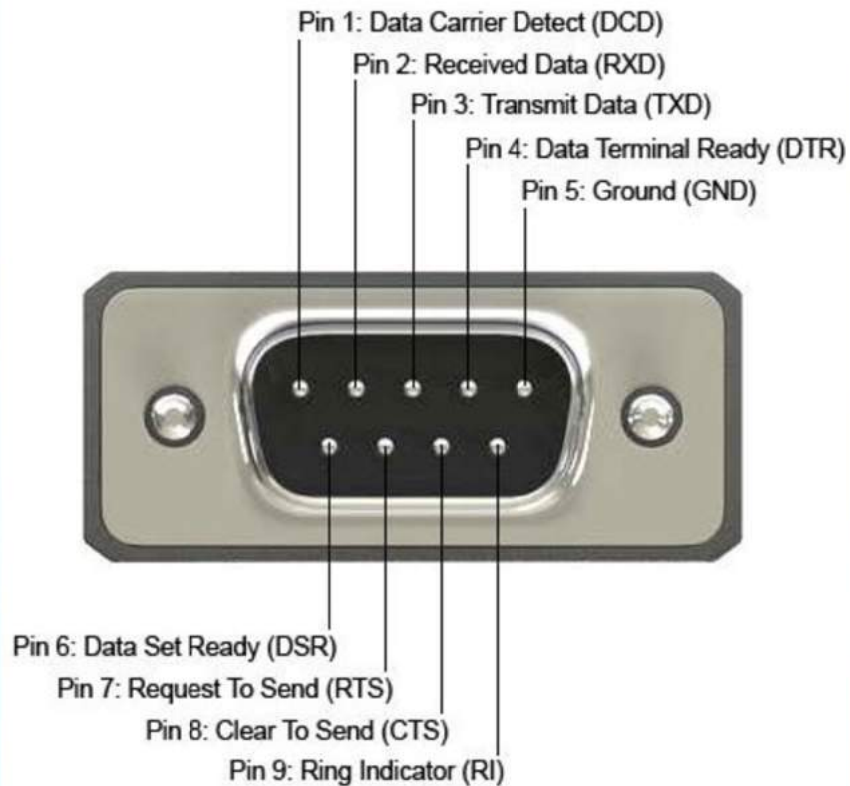
- Does not use TTL (0v/5v) logic levels!
- Logic “0” is +15 volts, Logic “1” is -15 volts
- Modern computers use 12v/-12v for logic levels.
- Can work with TTL levels in a pinch, but this isn't within specification and might be noisy.
- MAX232 converters in USB→RS232 cables convert from TTL to RS232 logic levels but won't have all control lines connected. (CI-V uses MAX232)

Source From pligoo.blogspot.com



RS-232 data and control lines

RS232 Pinout



Modem Cable - Straight Cable DB9 to DB9

DTE Device (Computer) DB9			DTE to DCE Connections		DCE Device (Modem) DB9		
Pin#	DB9	RS-232 Signal Names	Signal Direction		Pin#	DB9	RS-232 Signal Names
#1	Carrier Detector (DCD)	CD	←		#1	Carrier Detector (DCD)	CD
#2	Receive Data (Rx)	RD	←		#2	Receive Data (Rx)	RD
#3	Transmit Data (Tx)	TD	→		#3	Transmit Data (Tx)	TD
#4	Data Terminal Ready	DTR	→		#4	Data Terminal Ready	DTR
#5	Signal Ground/Common (SG)	GND	→		#5	Signal Ground/Common (SG)	GND
#6	Data Set Ready	DSR	←		#6	Data Set Ready	DSR
#7	Request to Send	RTS	→		#7	Request to Send	RTS
#8	Clear to Send	CTS	←		#8	Clear to Send	CTS
#9	Ring Indicator	RI	←		#9	Ring Indicator	RI
Soldered to DB9 Metal - Shield		FGND			Soldered to DB9 Metal - Shield		FGND

Data and control line functions

Signal (Pin)	Description
DCD (1)	DCE Asserts only when a DCE has carrier. Only is specific to modems.
RD (2)	Received data from DCE.
TD (3)	Transmitted data from DTE.
DTR (4)	DTE tells DCE that it is ready. Must be asserted for any data to flow!
GND (5)	Signal Ground (Not same as shield!)
DSR (6)	DCE tells DTE that it is ready. Must be asserted for any data to flow!
RTS (7)	DTE tells DCE that it is ready for data. DTE deasserts when terminal is too busy.
CTS (8)	DCE tells DTE that it is ready for data. DCE deasserts when DCE runs out of buffer.
RI (9)	DCE asserts when POTS line rings.

Data and control line necessity

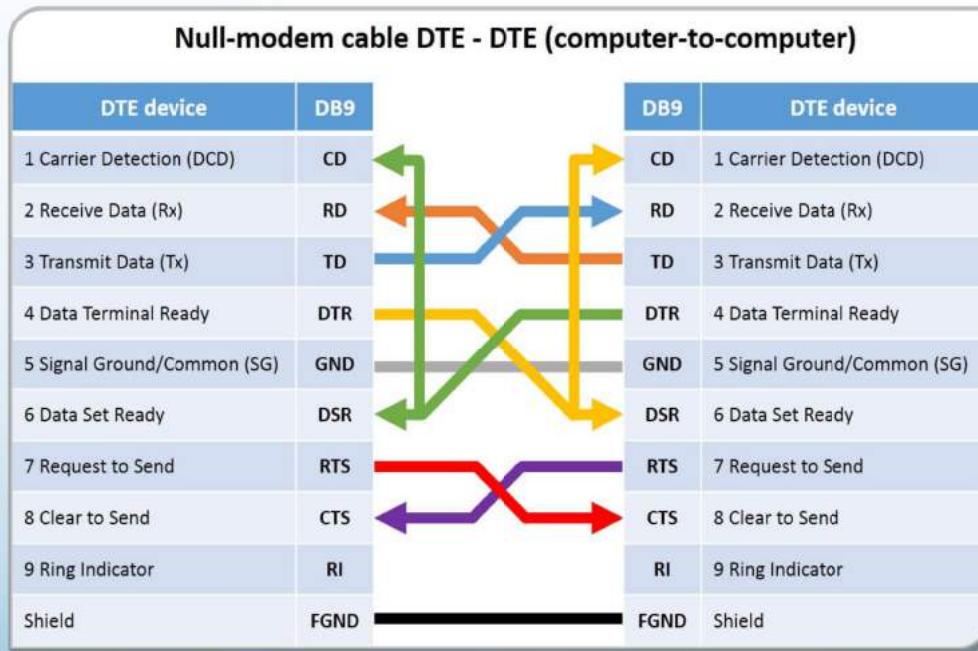
Signal (Pin)	Description
DCD (1)	Obsolete. (Except for modems) It must always be asserted in most applications.
RD (2)	Bare minimum required for a connection.
TD (3)	Bare minimum required for a connection.
DTR (4)	Is a hard “AND” gate with RD with many interfaces. Data won’t flow without this pin being asserted. (Excludes MAX232 converters, where this is ignored.)
GND (5)	Must never be omitted. If disconnected, nothing will work.
DSR (6)	Is a hard “AND” gate with TD with many interfaces. Data won’t flow without this pin being asserted. (Excludes MAX232 converters, where this is ignored.)
RTS (7)	Obsolete in some applications. Used for hardware flow control. Not necessary.
CTS (8)	Obsolete in some applications. Used for hardware flow control. Not necessary.
RI (9)	Obsolete.

A note about control lines

- ▶ DTR/DSR lines using a hard “AND” gate is only applicable to real RS-232 ports found on DTE. Although, some DTE may not even have these connected.
- ▶ Many USB → RS-232 converters do not have any of the control lines connected, so they are left floating or they are tied to signal ground, which isn't outside RS-232 specification, as many UART chips have pull-down resistors.
- ▶ RTS/CTS/DTR/DSR lines are sometimes not used to proper RS232 specification, they are repurposed for other things. (e.g. PTT, CW keying)
- ▶ Rigblasters use RTS for PTT and DTR for CW/FSK keying.
- ▶ As a result, Never use RTS/CTS flow control with ham radio software.
- ▶ Many software pins RTS high, can cause a key down condition!



“Null” MODEM cables – Computer to Computer



- ▶ Conventional RS-232 1:1 cables plugged in from computer-to-computer (DTE-to-DTE) won't work. No harm done, just nothing will happen.
- ▶ “Null” modems can be adapters or they can be cables that cross connections to emulate DCE.
- ▶ Using a “Null” modem cable from DTE to DCE doesn't work at all.



“Null” MODEM cables

- ▶ DTE Equipment always has male connectors. (Sometimes)
- ▶ DCE Equipment always has female connectors. (Sometimes)
- ▶ “Null” modem cables are female to female. (Sometimes)
Some radios require null modem cables to operate correctly.
- ▶ “Null” modem adapters are supposed to be female to female. Sometimes they can be any combination of genders including the wrong ones. (Male to Male)
- ▶ “Null” cables can be disguised as normal cables. If it doesn’t work at all, you may need a tester. Try another cable and hope it works. Again, no harm done, just wastes your time.
- ▶ ALWAYS label your null modem cables if you find one! It will save you from frustration!
- ▶ Very easy to confuse a null modem adapter with a gender changer



A note about cabling

- ▶ Not all RS-232 cables connect shield ground. Test with an ohm meter!
- ▶ Signal ground is not the same thing as shield ground, but they are sometimes tied together. (This is a bad thing in high RF environments! Can cause computer lockups, data corruption, etc.)
- ▶ A “modem” cable (i.e. DTE to DCE) has a 1:1 pin out. E.g. RTS <-> RTS
- ▶ DCE is wired differently than DTE, so that certain pins are meant to receive signals while other pins send signals. This makes cabling easier.
- ▶ RS-232 is robust enough to handle shorts, miswired pins, etc.
- ▶ Null modem cables won't work with conventional DTE <-> DCE connections.
- ▶ BEWARE OF CABLES WITH PARTIALLY WIRED PINOUTS



RS-232 “Handshaking”

- ▶ The DCE needs a way to tell the DTE when it is ready for data and vice versa. Without this, data is lost.
- ▶ With V.92, highest modem speeds were 56 Kbps, but the baud rate of the DTE is usually 115,200 baud. Handshaking is necessary to tell the DTE when to wait for when it can send more data.
- ▶ When the DCE isn't ready for data because the DTE is sending too fast, it de-asserts CTS line temporarily until the DCE has had enough time to empty its buffer enough to accept more data.
- ▶ When DTE isn't ready for data, it temporarily de-asserts RTS line. This doesn't happen too often.
- ▶ When the DTE is offline, it de-asserts DTR. (Data Terminal Ready)
 - On a PC, DTR will be low if no terminal program is running.
- ▶ When the DCE is offline, it de-asserts DSR. (Data Set Ready)
 - DSR is low for a second or two while the modem is booting up.

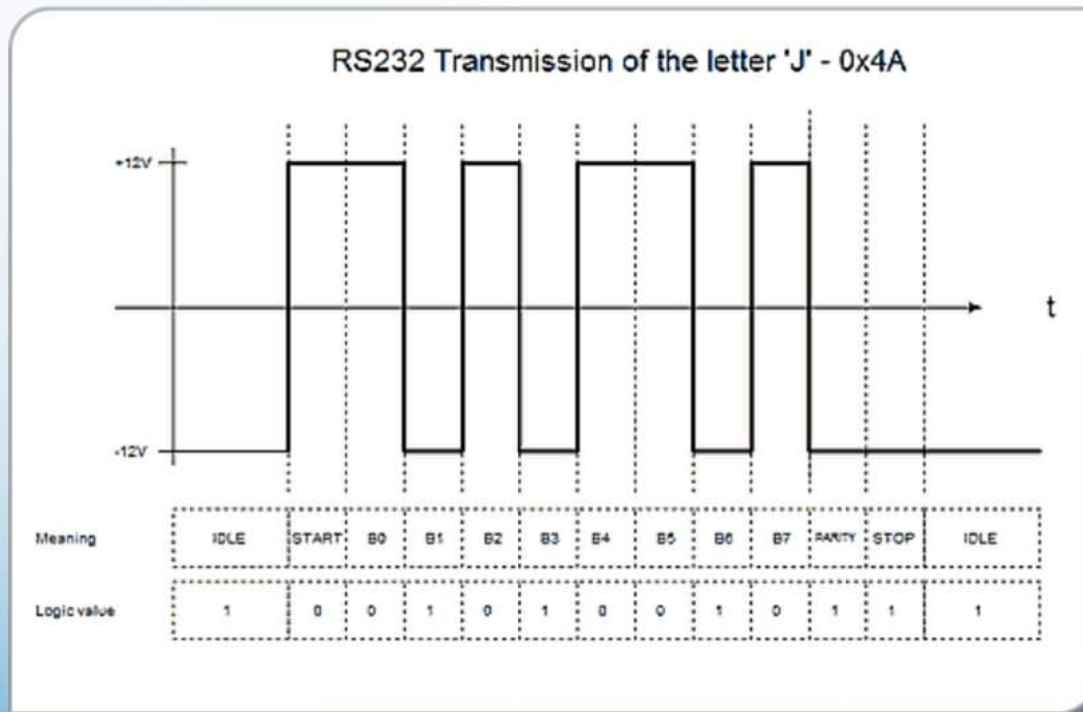


Types of Handshaking

- ▶ There are three types of handshaking aka flow control:
 - **RTS/CTS** – Sometimes called “Hardware” flow control. Most used by external modems and with null modem cables. If these signals are physically disconnected, no data will flow when this is enabled. MAX232-based devices do not support this type of flow control and ignore it.
 - **XON/XOFF** – Sometimes called “Software” flow control. CTRL-S sends XOFF to pause transmission of data, CTRL-Q sends XON to resume transmission of data. Usually sent by the DCE when it needs to use it. Not everything supports it.
 - **OFF** – Use no flow control at all. “Drink from the firehose”. Only needed when the RS232 device is a virtual one or a USB converter, where even the highest baud rate can be handled!



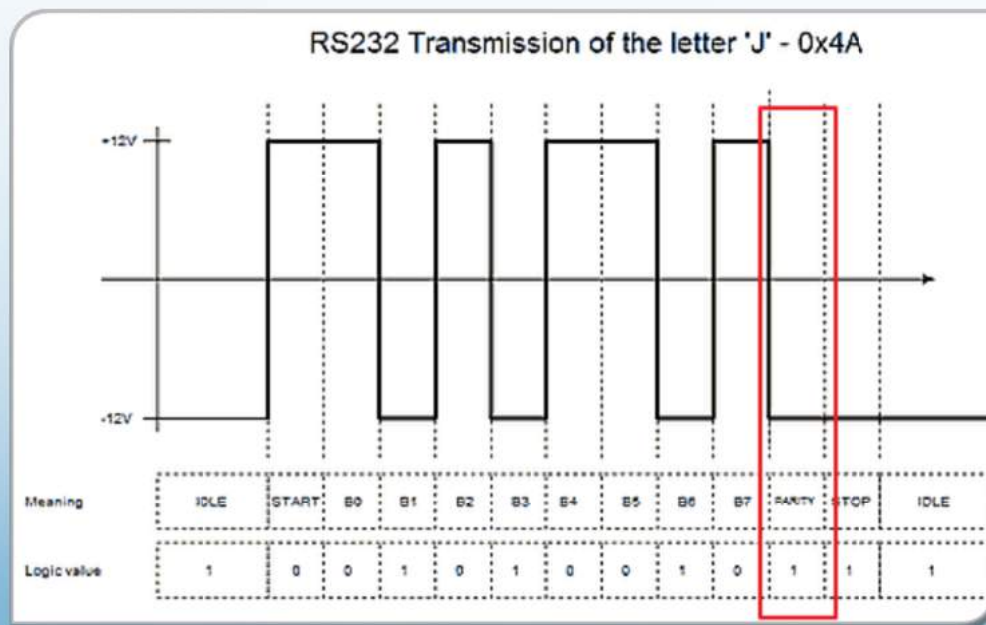
RS-232 protocol information



- ▶ The duration of the bit and of the character is determined by baud rate.
- ▶ Logic “0” (12v) is called a “Space”
- ▶ Logic “1” (–12v) is called a “Mark”
- ▶ (Mark and Space are from Teletype days)
- ▶ Data lines always idle in an “1” state. (–12v)
- ▶ Characters always have a “Start” bit which is always a logic 0. (e.g. +12v)
- ▶ 7 or 8 data bits – Most equipment today use 8 bits. The example here has 7 data bits.
- ▶ Parity bit, which can be 0 or a 1 depending if odd or even. Parity bit is optional.
- ▶ 1, “1.5” or 2 stop bits, which are always a logic 1. 1.5 stop bits are unique, not used.

What is parity?

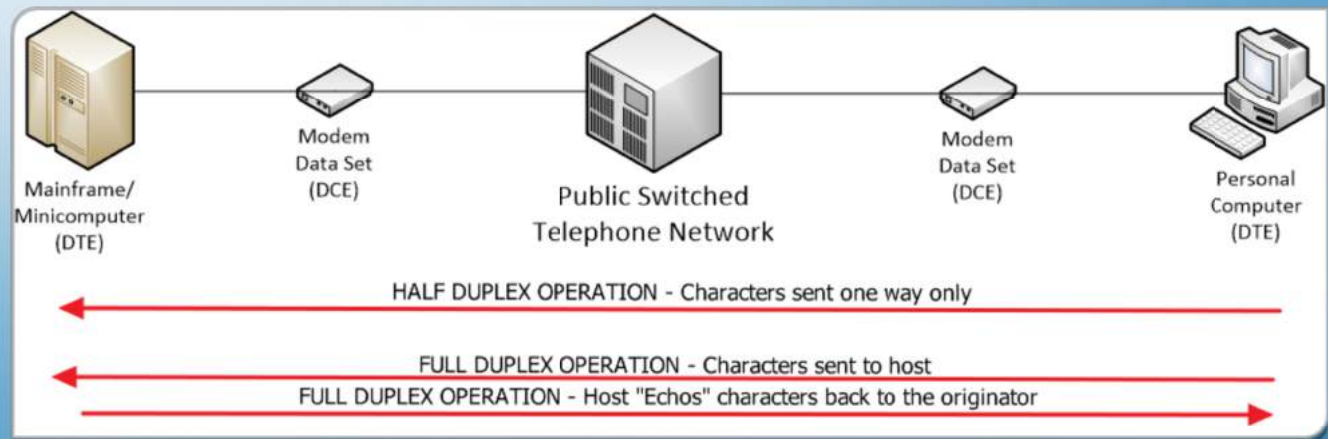
Used as a crude form of error correction. Largely useless because of dual bit flip. If the parity bit mismatches, the character will be ignored by the receiver and needs to be resent. This should always be set to “None”.



- ▶ When parity is “none”, this bit is omitted from the character.
- ▶ When parity is “odd”, the data bits + parity bit must add up to an odd number.
- ▶ When parity is “even”, the data bits + party bit must add up to an even number. (As in this example)
- ▶ Some applications can force parity bit always high or always low. Don't do this!
- ▶ Enabling parity bit when it isn't needed can cause the terminal to fill up with garbage characters or can prevent any data from passing at all!

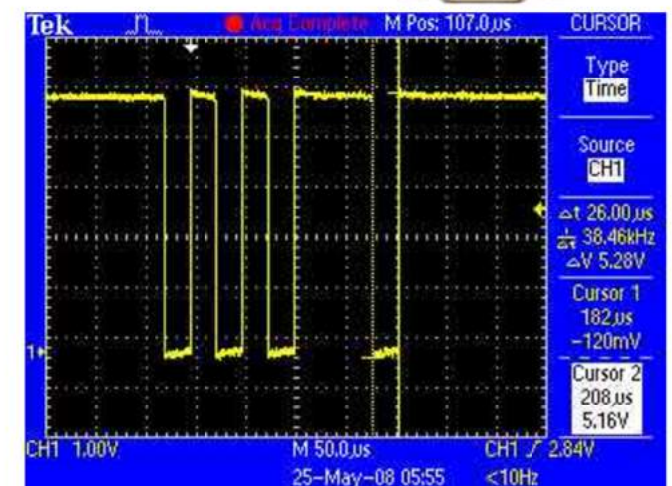
Duplex / Local echo

- ▶ Duplex refers to how the characters are echoed back to the user when typed in.
- ▶ In Full Duplex operation, the answering DTE echoes back the characters being sent by the originating DTE. This is normal operation. This is done purely for the convenience of the user, so they can see what they are sending.
- ▶ In Half Duplex operation, the answering DTE does not echo back the characters being sent by the originating DTE. This is common with CAT for example. If you can't see what you are typing, it might already be working!
- ▶ When the connection is in half-duplex, "Local Echo" must be enabled in the terminal program to show typed characters being sent by the originating DTE. Double characters are typed when local echo should be off.



TROUBLESHOOTING

- In a scenario of “no data” at all, check:
 - May be caused by a large mismatch of baud rate. Default for most devices is 9600 baud. Check configuration of both the DTE/DCE.
 - Null modem cable instead of regular cable? Determine by using a breakout box and see if levels look like what they’re supposed to.
 - COM port not selected in terminal program.
 - Whack enter a few times and see if auto-baud picks it up.
 - Wrong flow control type. Try setting to XON/XOFF or off.
 - Are DTR and DSR asserted? (N/A to CI-V)
- In a scenario of the screen filling up with garbage characters:
 - Smaller mismatch of baud rate. Try different ones until it works.
 - Try using default of 9600 baud, 8 data bits, 1 stop bit, no parity.
 - Try different combinations of data bits, stop bits and parity.
 - Use an oscilloscope to determine baud rate, data bits & parity.
 - Check the width of the shortest pulse.
 - In this example, pulse width is 26 μ s.
 $1/26 \mu\text{s} * 10^6 = 38461$
... Or about 38,400 baud.

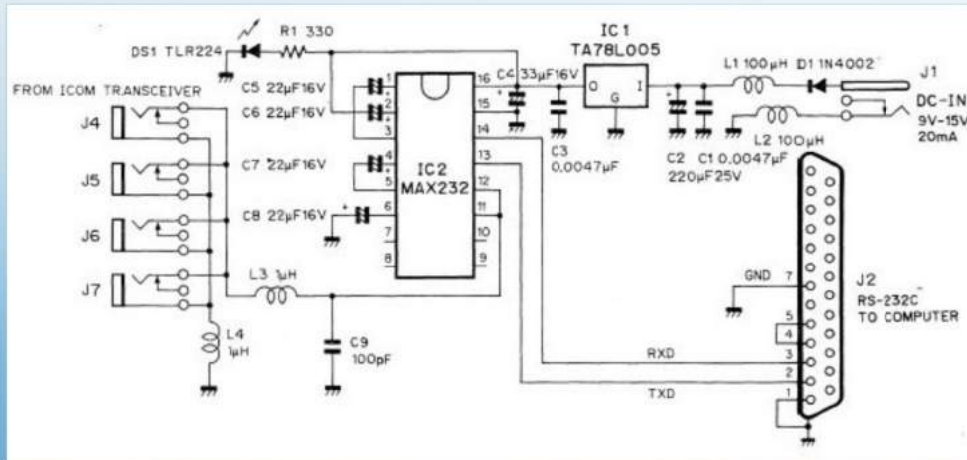


Troubleshooting YAESU CAT

- ▶ Yaesu FTDX-2000/5000 transceivers utilise two stop bits.
- ▶ Check CAT transceiver speed. Default is 9600 baud, can be set to 38400 baud.
- ▶ Start PuTTY and see if you can send CAT commands to the radio. Note: Yaesu radios use half-duplex echo, so characters typed won't be seen.
 - FA; – Lists frequency of VFO A
 - FB; – Lists frequency of VFO B
- ▶ Is RTS TX enabled in the menu if no TX?
- ▶ RTS/CTS flow control turned off! RTS is used to engage PTT! Key down warning!



Model	Address number	Model	Address number
IC-781	26	IC-R9000	2A
IC-775	46	IC-R7100	34
IC-765	2C	IC-R7000	08
IC-761	1E	IC-R72	32
IC-738	44	IC-1275A/E	18
IC-737/A	3C	IC-970A/E/H	2E
IC-736	40	IC-820H	42
IC-735	04	IC-575A/H	16
IC-729	3A	IC-475A/E/H	14
IC-728	38	IC-375A	12
IC-726	30	IC-275A/E/H	10
IC-725	28		
IC-707	3E	Controller	E0



Troubleshooting ICOM CI-V

- ▶ Some Icom radios use jumpers to determine Baud Rate, CI-V address and CI-V transceive enable.
- ▶ Try default baud rate of 9600 baud, 8 bits, no parity and 1 stop bit.
- ▶ Null modem adapter being used?
- ▶ Many Icom radios have a specific CI-V address. Check the manual. It may have been changed from the default address.
- ▶ Regulated 12v being supplied to the interface?
- ▶ CI-V Transceive must be turned on! (Switch, Jumper or setting in the menus.)
- ▶ RTS/CTS flow control is not used. Neither are DTR/DSR. (CI-V interfaces use a MAX232 chip)

PORT CONTENTION

THE BANE OF ALL AMATEURS AND I.T PEOPLE

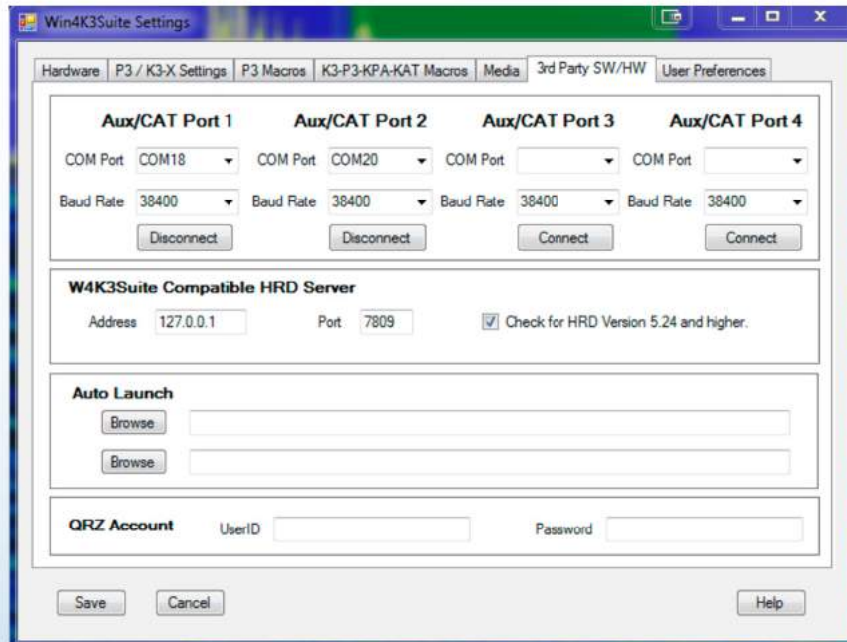
- ▶ RS-232 devices were never meant to be used by multiple devices at the same time. Thereby, an RS-232 port must be dedicated to one single application.
- ▶ Trying to use an RS-232 port while it is in use by another application will cause errors within the application. Common bane of most amateurs.
- ▶ To get around these issues, we emulate virtual serial ports which act as a way of presenting multiple serial ports to many different programs.
- ▶ Corrupted hamlib libraries can also cause similar issues. Reinstalling fixes it.
- ▶ Fastest way to clear port contention is to reboot.



RS232 Port Emulation software

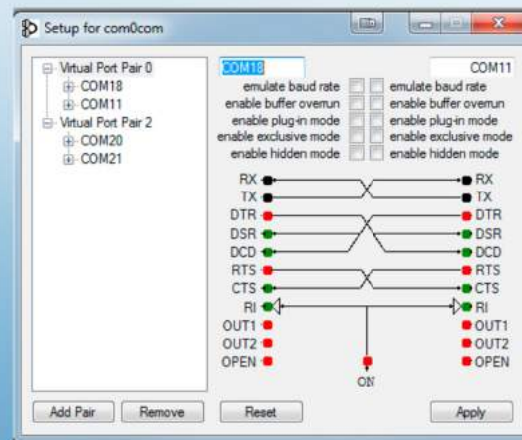
- ▶ For ultimate flexibility with what an amateur can do with serial ports, “Virtual Serial Port Driver” is software that allows for complete flexibility for when multiple RS-232 devices are being used.
- ▶ Win4YaesuSuite and Win4IcomSuite also allow for multiple virtual serial ports to have access to multiple programs at once, to allow for logger program and rig access at the same time.
- ▶ Com0com is a freeware virtual serial port driver that enables emulation of serial communication devices and can create virtual “Null MODEMs” and virtual “passthrough” RS-232 cables from port to port.





RS232 Port Emulation example

- Win4Yaesu Suite is set up to exchange traffic to COM18 and COM20. These ports are in use by this software.
- Com0com sets up a virtual “null modem” cable between:
 - COM18 <—> COM11 and
 - COM20 <—> COM21
- WSJT-X reads/writes COM11.
- Logging software reads/writes COM21.
- No port conflicts.



A complex example of using virtual ports

- ▶ My GPSDO (GPS disciplined oscillator) has a physical RS232 port.
- ▶ NMEATime can be used to read GPS data to synchronise computer clock.
- ▶ Icom IC-9700 can use GPS data for D-STAR operation.
- ▶ How do we get GPS data from the GPSDO to the IC-9700?



CHALLENGES

- GPSDO is RS232 only. Can't connect directly to the Icom IC-9700 directly because it has no "real" RS232.
- I want to use NMEATime to sync the computer clock, while also providing data to the radio.
- IMPOSSIBLE 20 years ago. Is it possible now?

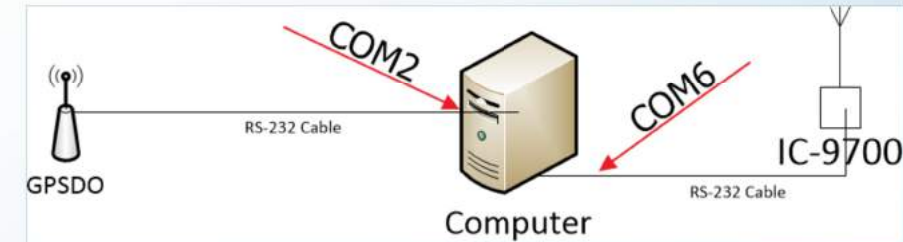
Using Virtual Serial Port Driver

PHYSICAL RS232 PORTS

- ▶ GPSDO connected to computer physically to COM2 via Standard RS-232 cable.
- ▶ Icom IC-9700 connected to computer physically to COM6 via OPC-2350LU data cable. (USB to CI-V converter)

VIRTUAL COM PORT CONFIGURATION

- ▶ Virtual Serial Port Driver configured with input of COM2, outputting to Virtual COM9 and Real COM6.
- ▶ NMEATIME configured to use virtual COM9.
- ▶ COM2 is only allowed to write data to COM9/6.



The screenshot shows the VSPD configuration window for a complex named "GPSDO to IC-9700". The window is divided into two main sections: a left sidebar and a right main area.

Left Sidebar: Shows a list of COM ports. "COM2" is selected and highlighted with a star icon. Below it are "COM9" and "COM6".

Right Main Area: Displays the configuration for the selected COM2 port. It is divided into "Input side" and "Output side".

Input side: Shows "COM2 (Real, Main)" with the following details:

- Port status: Opened
- Current settings: Dynamic
- Sent / Received: 219.1 KB / 0 bytes

Output side: Shows two output ports:

- COM9 (Virtual):**
 - Port status: Opened
 - Opened by: ...usualGPS\NMEATime2\NMEATimeService.exe
 - Current settings: 9600,N,8,1
 - Sent / Received: 10 bytes / 219.1 KB
- COM6 (Real):**
 - Port status: Opened
 - Current settings: 9600,N,8,1
 - Sent / Received: 0 bytes / 219.1 KB

A footnote on 25 pin DB-25

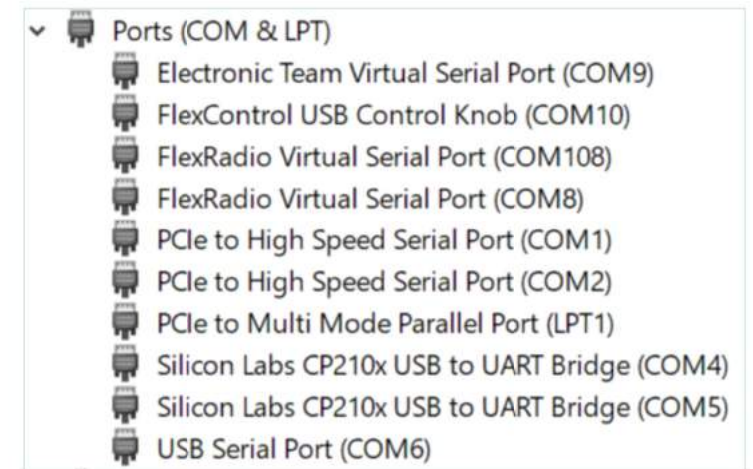
- ▶ Largely obsolete. Found mostly on older modems and TNC's. The picture to the right is a typical modem cable.
- ▶ The extra signals that the DB-25 connector used are obsolete and were never used with personal computers.
- ▶ 9 pin to 25 pin adapters are still available. They leave the extra pins disconnected as they're not necessary.
- ▶ Stopped being used in PC's by the mid-1980's.
- ▶ Extra pins were used for secondary data, synchronous clock, local and remote loopback, (for testing) data rate detect and test mode.
- ▶ Synchronous RS-232 is obsolete. Was replaced by RS-422/RS-485 or USB.
- ▶ **WARNING FOR OLDER COMPUTERS:**
Female DB-25 could be SCSI or a Printer Port!



RS-232 under Windows

- ▶ All serial ports are listed as COM*. Windows supports the first four physical serial ports from COM1 to COM4. Anything higher is virtual.
- ▶ Serial ports listed in device manager don't always have a name that indicates the device. Look for "UART"*.
 - "PCIe to High Speed Serial Port" is a physical add-on card.
 - "Silicon Labs CP210x USB to UART..." are my IC-9700.
 - "USB Serial Port" is the GPS serial port for the IC-9700.
 - "FlexRadio Virtual..." is the CAT control port for my Flex.
 - ▢ COM108 isn't actually a real port I can chat with.
- ▶ Best terminal program (IMHO) to use is PuTTY.

*UART– Universal Asynchronous Receiver–Transmitter



RS-232 under Linux

- ▶ Linux sees serial ports as `/dev/tty*` – Short for “Teletype”
 - `sudo dmesg | egrep --color 'serial|FTDI|ttyS|ttyUSB'`
 - FTDI stands for “Future Technology Devices International”. They are a company that specializes in USB technology. USB → RS232 converters will show up as `/dev/ttyUSB*`
 - Physical serial ports show up as `/dev/ttyS*`
 - `sudo apt install setserial` or `sudo yum install setserial`
 - `sudo setserial -g /dev/ttyS[0123]` to get a list of the first four serial devices.
- ▶ Minicom is the best (IMHO) terminal program under Linux. Clone of TELIX.



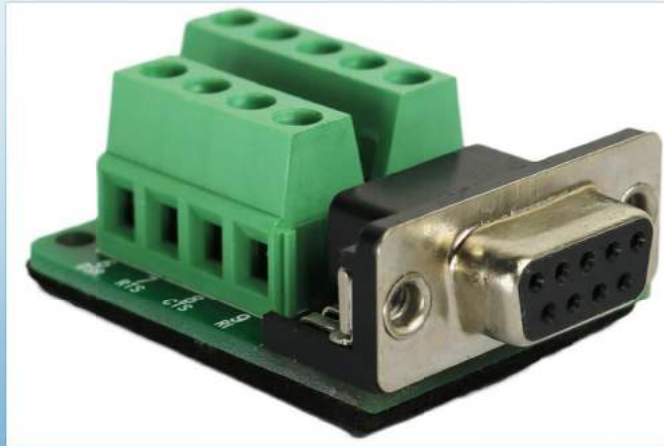
Quick note about Legacy RS-232

If you want to use a “period correct” computer in the shack

- ▶ Original IBM PC/XT/AT had limited interrupts (IRQ) for things. COM1 /COM3 used interrupt 4 and COM2 /COM4 interrupt 3. Sharing interrupts causes unpredictable operation, so we'd only use COM1 /COM2 or COM3 /COM4 at one time.
- ▶ Not an issue today with plug n' play operating systems.
- ▶ UART (Universal Asynchronous Receiver/Transmitter) chips are what do the hard work. Anything older than a 16550 UART isn't worth using, unless the baud rate is kept at 9600 baud or slower.



Tips and tricks



- ▶ Always label null modem cables.
- ▶ Write with pen on the connector which COM (Or TTY) port each connector goes to. Makes it handy to reconnect everything else up later.
- ▶ Don't overtighten the screws on the connector. Finger tighten the screws onto the connector, don't use a screwdriver if the screw head has a slot!
- ▶ Keep a supply of hex head 7mmx5 screws handy. If you overtighten the connector, these may come off the connector. Use a socket screwdriver to re-install them. Use needle nose pliers in a pinch if one isn't available.
- ▶ Connector doesn't want to go in? Check for bent pins. Use a small jewellers flathead screwdriver or fine needle nose pliers to straighten them out again.
- ▶ Label or discard partially wired RS-232 cables. (e.g. 3/4 pin) Identified by being thin.



Scaling RS-232 in the shack

- ▶ A device that takes multiple RS-232 ports and converts them to Ethernet is called a “Terminal Server”. Used in the 1990’s to connect thousands of modems.
- ▶ Using more than 2 physical serial ports in the shack on one computer can be done with RS-232 to Ethernet converters.
- ▶ Multiple serial ports are represented by multiple TCP Port numbers to the same IP address. Already supported by some software.
- ▶ Do you notice something wrong here?

Computer Interfacing

OLD WAY



NEW WAY



- Old way required two RS-232 ports. One for CAT control and one for TNC Communication
- TNC did all of the “heavy lifting” for signal processing and generation.
- Interface was done through simple terminal program
- New way has the computer do all of the “heavy lifting” for signal processing and generation.
- Much easier to interface.
- Microphone passthrough, switches out when in TX.
Caveat: Can be heard on-air if TX switch is off!

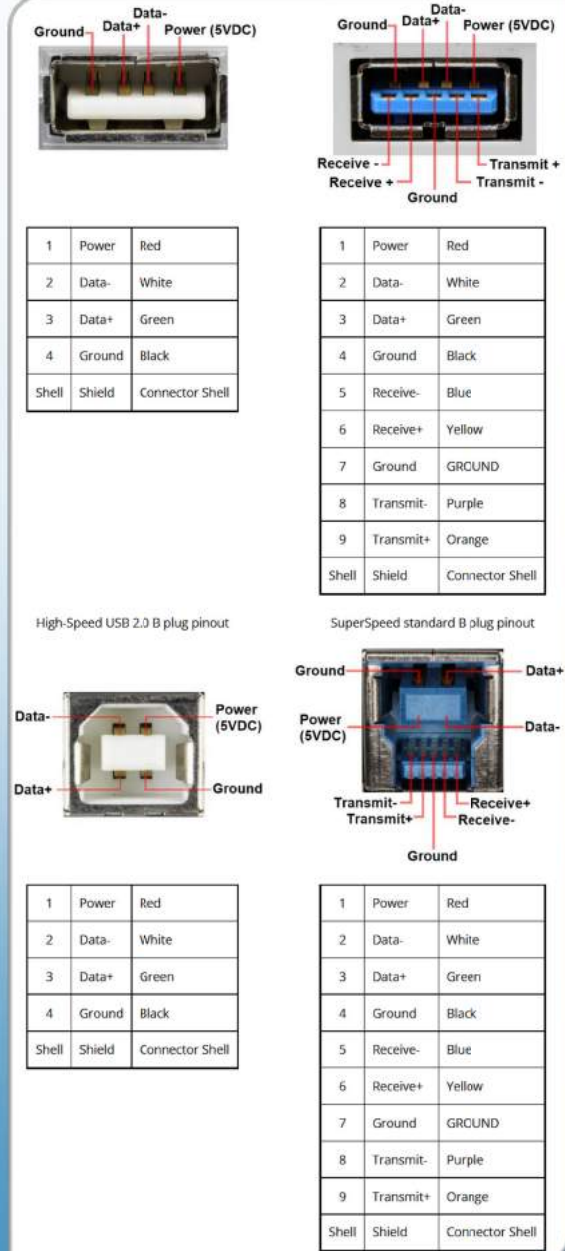
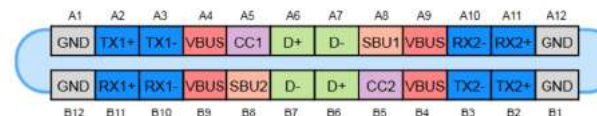
USB – Universal Serial Bus

- ▶ PC's built prior to 1997 had a multitude of ports of different types and different functions that all did different things. There had to be an answer!
- ▶ RS232 ports for modems, Centronics Parallel for Printers, SCSI for scanners and external hard drives, PS/2 ports for keyboards and mice, strange parallel port passthrough dongles for MP3 players and external CD-ROM drives. Too many different ports, too many problems.
- ▶ USB 1.0 wasn't used. USB 1.1 released in 1998 and was the first standard used.
- ▶ USB is a packet based protocol – This is a presentation on its own!



Identifying USB

- ▶ Type A USB Connectors supply power. Are host devices. No such thing as USB Type A-A cables and there shouldn't be!
- ▶ Type B USB connectors receive power. Are peripheral devices.
- ▶ Type C USB connectors are completely universal.
- ▶ USB "On the Go" blurs the lines and allows a peripheral device (Such as a smartphone) to become a host device for other peripherals. Requires a special adapter or type-C cable.
- ▶ Mini A and Mini B USB is mostly obsolete.
- ▶ Micro A is rare. Micro B is more common, found on any mobile device, batteries etc



USB TYPES AND SPEEDS

- ▶ USB 1.1 jacks are white.
- ▶ USB 2.0 jacks are black.
- ▶ Type-A USB 3.0 jacks are dark blue.
- ▶ Type-A USB 3.1 jacks are light blue or teal.
- ▶ Type-C USB 3.0/3.1 jacks don't have a colour.
- ▶ "Sleep and Charge" are USB ports that can provide power from the laptop battery while a laptop is sleeping.



Type A or Type B



Type A or Type B
SuperSpeed



Type A or Type B
SuperSpeed+



Type A or USB C
Huawei Supercharge



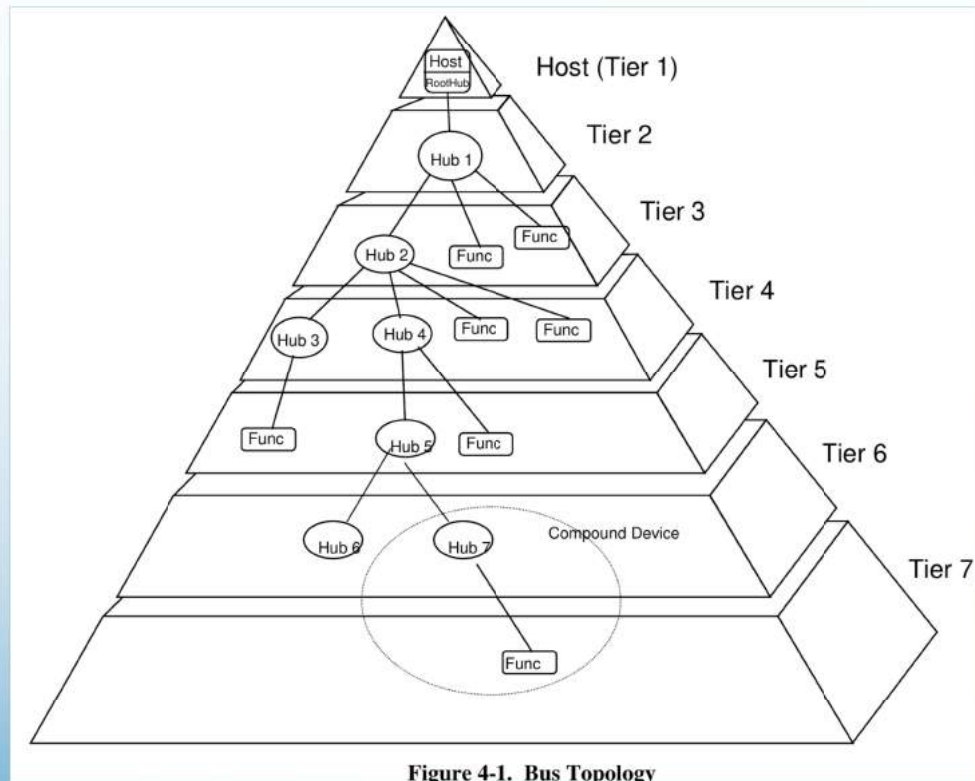
Type A or Type B
Qualcomm Quick
Charge



High-current or Sleep-and-Charge

USB Version	Name	Speed (Mb/Sec)	Used for
1.0 (1996)	Low Speed	1.5 (187.5 KB/s)	Keyboards, Mice (Obsolete)
1.1 (1998)	Full Speed	12 (1.5 MB/s)	Keyboards, Mice, Printers (Mostly obsolete)
2.0 (2000)	High Speed	480 (60 MB/s)	Scanners, Hard Disks, Audio (Still in use)
3.0 (2008)	Super Speed	5,000 (625 MB/s)	SSD Disks, Monitors
3.1 (2013)	Super Speed+	10,000 (1.25 GB/s)	NAS Bays, Monitors, Laptop docking stations
3.2 (2017)	Super Speed USB 20	20,000 (2.5 GB/s)	Laptop docking stations, Monitors, NAS bays
4.0 (2019)	USB4 aka Thunderbolt 3	40,000 (5 GB/s)	Multiple monitors, Multiple NAS Bays, etc.

USB Topology and Limitations



- ▶ The computer is considered the host and the USB ports on the computer are considered part of the "Root Hub". So the limits apply per root hub.
- ▶ No more than 5 daisy-chained USB hubs in the topology. No limit on the number of ports that can be in a single hub. Devices are 7 tiers deep max.
- ▶ Maximum of 127 devices across all ports including any USB hubs. (Root hubs do not count as a device.)
- ▶ Maximum current is 500 mA with USB 2.0 and 900 mA with USB 3.0, both at 5 volts.
- ▶ USB 1 & 2 maximum cable length is 16' 5" (5m)
- ▶ USB 3 maximum cable length is 9' 10" (3m)
- ▶ USB 2.0 cable length can be extended with the use of Active (Repeater) extension cables to a maximum of 98' 5" (30m) or 59' (18m) with USB 3.0.

Notes on USB Power Draw

- ▶ Max. current draw for “dumb” devices is 100 mA with USB 2.0. Only once the host has negotiated with the peripheral, is the peripheral allowed to draw more than this limit.
- ▶ The 500 mA USB 2.0 and 900 mA limit for USB 3.0 apply to all current drawn from a root hub USB port using unpowered USB hubs.
- ▶ Using powered USB hubs means that the 500 mA/900 mA limit can apply per USB device off a single USB hub instead of drawing power from the root hub.
- ▶ USB uses a “soft” circuit breaker that kills all power to any circuit that exceeds maximum current draw limits on a root hub. A full power cycle may reset it.
- ▶ USB jacks can supply up to 1.5 A @ 5 V if they support battery charging mode.



Notes on USB wear and tear

- ▶ USB Type-A connectors are rated for 1,500 cycles of insertion and removal.
- ▶ USB Mini-B connectors are rated for 5,000 cycles of insertion and removal.
- ▶ USB Micro-B connectors and USB Type-C connectors are rated for 10,000 cycles of insertion and removal.
- ▶ USB Type-C connectors were redesigned so that the wear and tear happens to the plug and not to the jack. The former being significantly easier to replace!
- ▶ About at about roughly 60% wear you can expect to see these things happen:
 - Connectors will get loose and wobbly, may easily come out.
 - Intermittent connections. Devices will pop “in and out” of the device manager.
 - Windows may pop up errors about a malfunctioning USB device.
- ▶ Keep all USB ports clear of dirt and debris, they can kill USB ports and devices.
 - Dirt in a Micro USB-B port set my XYL's phone on fire!



Notes on USB CHARGING

Name or Type	Max. Power	Notes
USB Battery Charging 1.0	5 V @ 1.5 A (7.5w)	Used with ordinary USB 2.0
USB Battery Charging 1.1	5 V @ 1.8 A (9w)	Used with USB 2.0 – Not common
USB Battery Charging 1.2	5 V @ 5 A (25w)	Used with USB 2.0 mostly.
USB Power Delivery 1.0 (USB-PD) / Active	20 V @ 5 A (100w)	Used by Qualcomm Quick Charge
USB Power Delivery 3.1 (USB-PD) / Active	48 V @ 5 A (240w)	Rarely seen in the wild (EPR)
USB Power Delivery 1.0 (USB-PD) Micro-USB / Passive	20 V @ 3 A (60w)	Typically found on phone chargers
USB Type-C 1.0	5 V @ 3 A (15w)	Common for all USB 3.0 Type-C

- ▶ To recognize battery charging mode, 0–200 ohm resistance is placed across D+ and D– terminals.
- ▶ Passive Power Delivery cables are limited to 20 V @ 3 A maximum.
- ▶ Active Power Delivery cables that can support charging rates of 60 watts or higher contain active components.
- ▶ If your device takes an extremely long time to charge off of a USB port, check port type, check cable, try a different charger, try a different USB cable. Troubleshoot through elimination.





USB IN THE SHACK



- ▶ Ensure that you use high quality name brand cables.
- ▶ Load drivers and software for the device you are plugging in before you plug it into the computer. This is especially true of SDRPlay radios.
- ▶ High RF levels in the shack can cause USB devices to disappear and reappear. Try using shorter cables and avoid using long coiled up cables whenever possible.
- ▶ Put ferrite chokes on all USB cables connected to the radio and to the computer.
- ▶ Don't chain USB 2.0 and USB 3.0 hubs as speed degrades to the slowest.
- ▶ Try not to cascade hubs whenever possible. Always plug off the root hub.
- ▶ Always used powered hubs whenever possible. Switched hubs are even better!
- ▶ Always connect transceivers up to a powered hub, never directly to a root hub.



Troubleshooting USB

- ▶ USB Cables without ferrite chokes can destroy chip inputs from the USB jack.
- ▶ Inspect the connector and/or the cable for damage. Try another cable?
- ▶ USB jack may be worn out. Try using another one?
- ▶ Suspect faulty USB hubs, take them out and plug directly into root hub.
- ▶ Is power to the USB hub connected if it is an active hub?
- ▶ Loose connectors or worn connectors?
- ▶ Examine Device manager to see if any devices disappear/reappear.
- ▶ Not much can go wrong otherwise. USB is “Plug and Play”.
- ▶ Virtual COM ports under USB still require configuration to work properly.
- ▶ “Hi-Speed USB device is plugged into non-hi-speed USB hub”. Can be caused by using cheap passive USB hubs with faster devices. White USB ports?



Comparing standards

Type	RS-232	USB 3	Gigabit Ethernet
Maximum Speed	115,200 bps	4,800,000,000 bps	1,000,000,000 bps
Max number of devices per computer	Physical – 2 ports Virtual – 256 ports	127 physical devices per host controller	2,147,483,648 (If using a 10.x.x.x IP)
Ease of setting up	Moderate	Easy	Moderate
Max. Cable length	Depends – 50 ft	Depends – 9 feet	328 feet
Ease of cabling	Moderate	Easy	Easy
Ease of making cables	Moderate	Difficult (Due to tolerances)	Easy
Year of release	1962	2019	1999
Cabling topology	Point-To-Point	Star (7-levels) – hubs required.	Star (No-limit) – switches required.

QUESTIONS?

