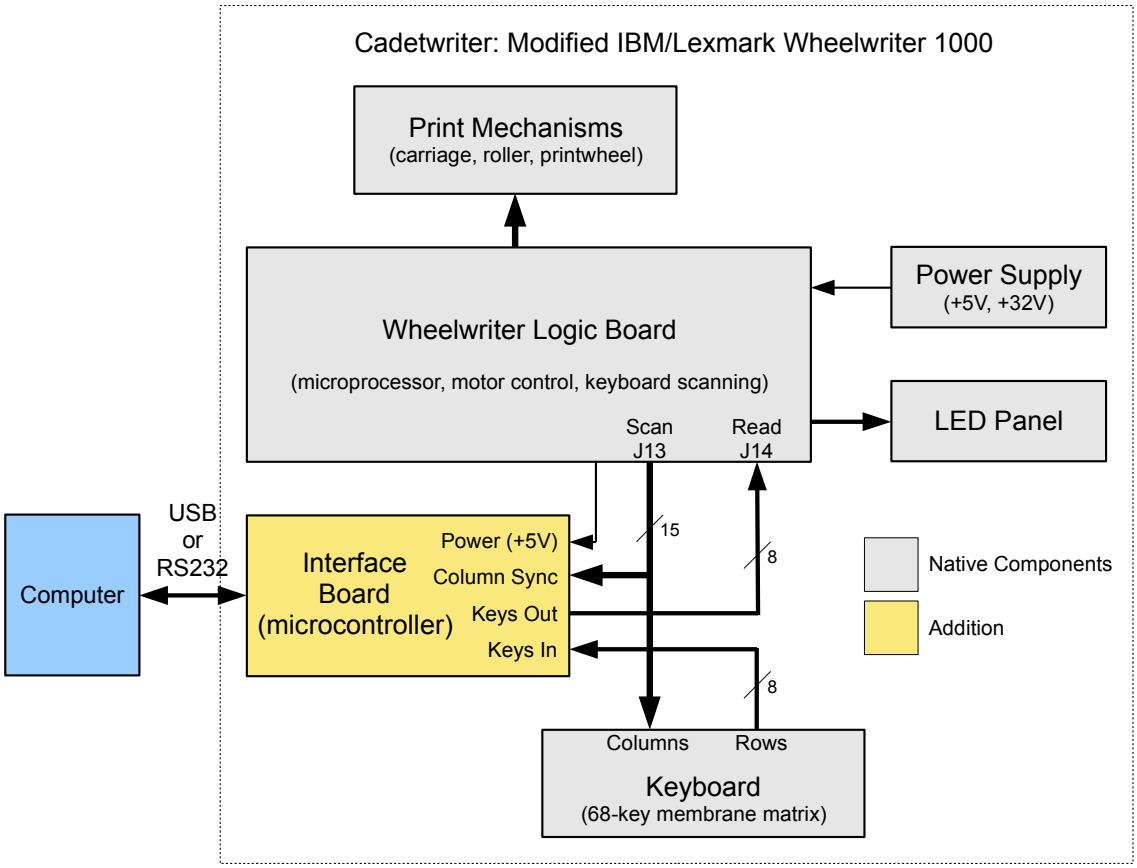
Cadetwriter: IBM/Lexmark Wheelwriter 1000 Teleprinter Adaptation

https://github.com/IBM-1620/Cadetwriter/raw/master/docs/adaptation_guide/wheelwriter-adaptation-instructions.pdf

The IBM 1620 Jr. project sponsored by the Computer History Museum is recreating the experience of running historic software on a 1960s-era computer by bringing a real IBM 1620 console to life with a cycle-accurate simulation running on a modern microcomputer. An integral part of the IBM 1620 console is the attached typewriter used to enter booting instructions and interact with programs. The typewriters used on the original machines were the IBM Model B and the IBM Selectric with nonstandard keyboard configurations, neither of which is practical to use for the recreation. Instead, a more recent IBM/Lexmark Wheelwriter 1000 typewriter has been adapted by interposing a microcontroller between the typewriter's keyboard and logic board and installing custom keycaps. This allows keys pressed on the keyboard to be captured and interpreted according to the IBM 1620 layout and then sent to the simulator over a USB serial link. Conversely, the simulator can send characters that are then printed by injecting virtual keypresses to the logic board.

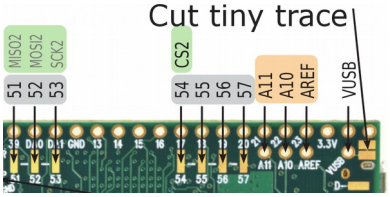
Some other historical computer projects have a similar need for a computer-interfaced typewriter or teletype and could use the same approach with the microcontroller firmware operating in ASCII mode. This document provides instructions for modifying an IBM/Lexmark Wheelwriter 1000 typewriter (Type 6781-024) to make a "Cadetwriter" as was done for the IBM 1620 Jr. project. These instructions may work with other model Wheelwriters, but that has not been verified. The tasks include building the USB & RS232 Interface Board Rev. 2.0 and RS232 cable; drilling and cutting holes in the typewriter case to mount the added interface board and the USB-B and RS232 cables; installing the interface board and cables connecting it to the logic board; and replacing the keycaps with the ASCII set. The following block diagram shows the adaptation.



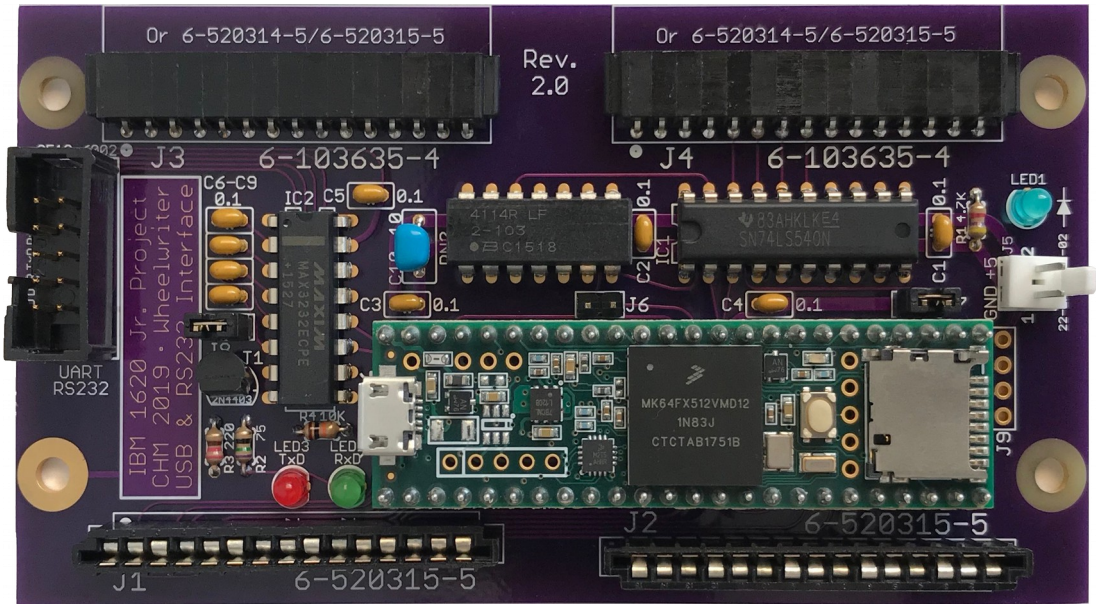
USB & RS232 Interface Board Rev. 2.0 Assembly

1. If no 6-520314-5 right-angle FFC connectors are available, two 6-520315-5 vertical FFC connectors can be modified for right-angle mounting instead. First use needle-nose pliers to flatten the alternating kinks in the pins, then use a hard surface to bend the pins 90° toward the ribbed side. Test easily dropping into place.

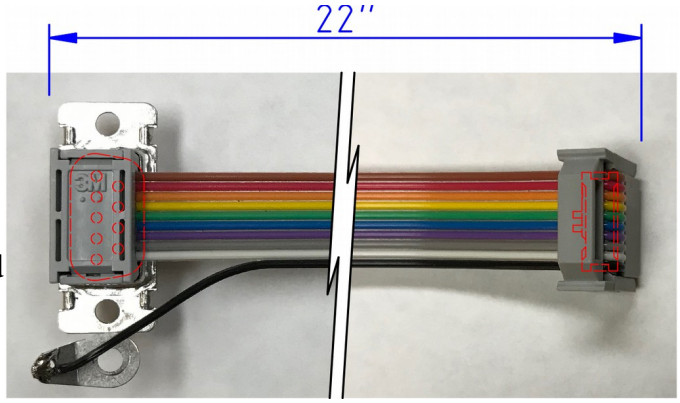
2. To hold the connectors in the right-angle orientation at J3 and J4, deposit a thin bead of epoxy in the bare area along the edge closer to the board edge, then set the connectors in place with the pins through the pads and let cure.
3. Insert two vertical 6-520315-5 FFC connectors in J1 and J2 in the orientation shown by the outline on the board, then solder all four FFC connectors.
4. Solder the 22-27-2021 2-pin connector in J5 with the latch side toward the edge of the board and the 2510-6002 10-pin connector in J10 with the notch side toward the edge of the board.
5. Insert and solder resistors, capacitors, blue LED1, green LED2 RxD, and red LED3 TxD.
6. Insert the three DIPs (74LS540 and MAX3232E ICs and the resistor array) using a pin-squeezing tool or by first bending the pins straight against a hard surface, then solder them.
7. Insert and solder the transistor (after the ICs so it's not in the way of the insertion tool).
8. Insert and solder the three 2-pin headers J6, J7 and J8 and install jumpers on J7 and J8 to configure for ASCII terminal mode and enable the RxD and TxD LEDs.
9. Cut the VIN - VUSB trace on the underside of the Teensy board.



10. If using SIL header pins with the Teensy, cut them to 24 pins long and insert them into the 48-pin socket, then set the Teensy board over the pins to solder, noting pin 1. If using a Teensy with preinstalled pins, attach the 24x1 sockets onto the Teensy pins.
11. Insert the Teensy socket with the Teensy in place, noting the right orientation, and solder.
12. Clip all component leads on the back side of the board to avoid damaging FFC cables.
13. (optional) Clean with solvent to remove flux.



Build RS232 Cable



The following instructions tell how to build an RS232 serial cable using the ribbon cable and connectors in the parts list to go between the USB & RS232 Interface Board and a DE-9 connector mounted on the knockout panel at the back of the Wheelwriter. A male DE-9 connector was selected since it is standard for Data Terminal Equipment (DTE). If you want to use a female DE-9 connector in the standard Data Communications Equipment (DCE) configuration with data transmitted by the typewriter coming out of pin 2, then you will need to split the wires of the ribbon cable to swap the 3rd and 5th wires and the 4th and 6th wires. With a rainbow cable as shown in the photo, that would be brown, red, green, blue, orange, yellow, violet, gray, white. The cable included in the parts list has all gray wires with a red stripe for pin 1 (which is the brown wire in the photo).

1. Select a 24" piece of ribbon cable. The wiring shown here uses a 10-wire ribbon cable where the 10th wire is connected to a solder lug for grounding the DE-9 shell. If the Wheelwriter is one that does not have an aluminum shield on the inside of the base, or if this grounding is not desired, a 9-wire ribbon cable can be used instead in which case the result would be as in the photo but with the black wire removed.
2. Place the ribbon cable onto the pins of the 2x5 IDC ribbon cable socket with about an inch extending on the side with the index bumps. The rest would be extending to the right with the socket oriented as in the photo. Snap the cover on over the cable and clamp in a vise or with water pump pliers while holding the cable square to the connector. After clamping use diagonal cutters to remove the extra inch of ribbon cable on the side with the index bumps. Fold the ribbon cable back over the top of the cover (so it heads left as in the photo) and snap on the strain relief.
3. Place the other end of the ribbon cable onto the pins of the DE-9 connector in the orientation shown in the photo with about 1" extending past the connector. Snap on the adhesive cover and clamp, then trim the excess.

Note 1: The RS232 DSR signal is looped back to DTR in a labelled trace on the bottom side of the USB & RS232 Interface Board. Cut the trace if that loopback is not desired.

Note 2: Some desktop PCs use a similarly wired cable to connect from a 10-pin IDC connector on the motherboard to a male DE-9 connector on the back panel, so it might be possible to use a pre-made cable. However, there are some considerations:

1. There are two industry standard pinout conventions in use, the *AT/Everex* and the *DTK/Intel*. This cable corresponds to the *DTK/Intel* convention; an *AT/Everex* cable would put the signals on the wrong pins. See http://www.bodenzord.com/archives/117 for an explanation of the differences.
2. Most cables available as standard products are only 12" long. That length would reach the back panel if routed directly, but then it would be under the carriage FFC cable that flexes back and forth as the carriage moves which might cause wear or interference.
3. These cables use a DE-9 connector intended for mounting behind a metal panel. The plastic knockout panel in the Wheelwriter case is too thick to leave enough depth for jackscrews on the outside of the panel if the connector is mounted behind the panel.

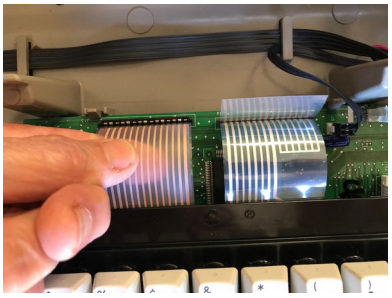
Wheelwriter Case Modifications

1. Pull the paper release and paper bail load levers forward.

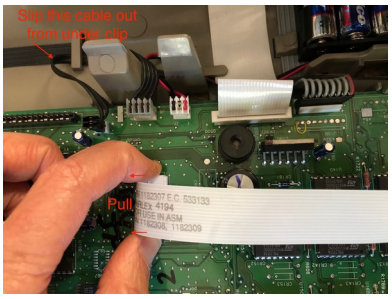
2. Remove the top half of the Wheelwriter case by inserting a thin screwdriver into the top of the slots in the lower half of the case on each side near the back and pushing in on the latches to release the top half, then rotate the top half upwards from the rear while sliding towards the front. The top will still be tethered by a cable to the LED display panel.

3. Gently push on the back side of the LED panel to disengage it from the top half of the case, then feed it back through the hole so the top half is completely free.

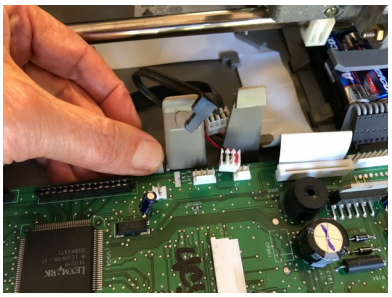
4. Remove the ribbon cartridge by pushing on the release lever and then lifting up and out, then manually push the carriage all the way to the right so it is out of the way.



5. Remove the keyboard from its mounting by releasing four latches along the back edge of the keyboard and then rotating upward slightly and pulling the keyboard out from the catches at the front. Then you can set the keyboard down and pull the FFC (flat flex cable) cables out of the logic board connectors.

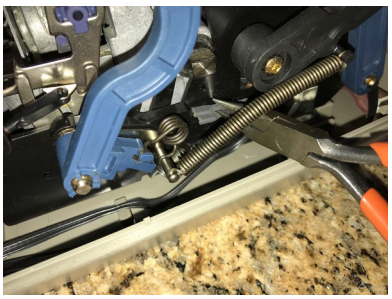


6. Unplug all the cables connected to the logic board. The connectors for the two white FFC cables are zero-insertion-force connectors where you pull on the clamp tabs to release the cable. All the other connectors lift straight up, but the 8-wire cable J15A is quite stiff and requires some force to lift. The black two-wire cable going to J3 needs to be slipped out from under the clip in the base and rerouted since the USB & RS232 Interface Board will cover that clip.



7. Remove the logic board by releasing three latches along the back edge and lifting it out of the catches at the front.

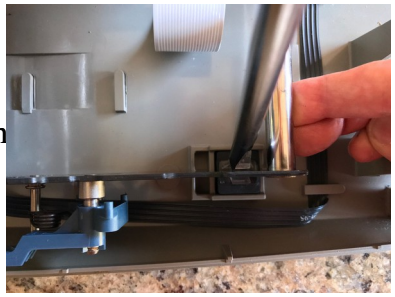
8. Unplug the connectors from the two servo motors at the back of the case (for platen rotation and carriage motion).



9. Unplug the two wires from tabs on the switch at the bottom of the paper bail load lever. It is not necessary to keep track of which wire was connected to which tab.

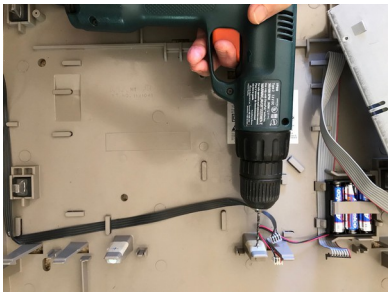
10. Push the carriage back to the left and slip the carriage FFC cable out from under the clip in the center of the case bottom. Insert a round object such as a center punch or pencil between the two layers of the carriage FFC cable where it makes a 90° bend in order to slip the cable out from under the inner clip at that corner, then slide the cable out from under the outer clip.

11. Remove the whole frame assembly by releasing the four clips at the corners of the frame assembly. Use a twisting motion with a large screwdriver on the inside of the sheet metal frame members (except the right rear which is outside) to pry the latches free from the slots in the frame while lifting the frame to completely remove it. The latch has to bend back more than 1/8" before it is free of the frame.



12. Move the power supply out of the way by prying two catches in the back side of the plastic base away from tabs on back side of the power supply's metal case and rotating the power supply out of the way (no need to unplug the AC connectors).

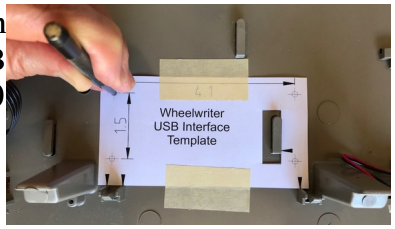
13. Drill 3/32" holes in the two keyboard support posts adjacent on both sides of where the USB & RS232 Interface Board will go, located 1.35" from the floor of the Wheelwriter case and centered in the width of each post. Marking the location on a piece of masking tape and center-punching with an awl may help. Drill only through the near surface of the post which is less than 1/8" thick. Cut threads in both holes with a #4 truss head screw for easier insertion later. Snap the power supply back into place and slip its cable back under the clips in the base.



14. Slip the platen motor cable that runs along the left side of the base out from under its clips where it crosses the location where the USB & RS232 Interface Board will go in the middle of the base, and fold it back out of the way.

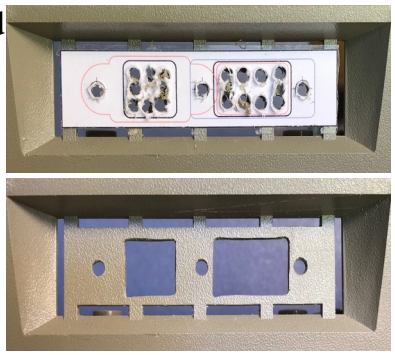
15. Print and cut out the two templates provided on a later page of this document. Verify that the printer scaling is accurate by measuring the dimensions as shown on the Wheelwriter USB & RS232 Interface Template, and reprint with adjusted scaling if necessary.

16. Place a scrap piece of 3/16" plywood or other material underneath the middle of the base to support it where holes to mount the USB & RS232 Interface Board will be drilled. For a Wheelwriter 1000 that has a thin aluminum static shield covering the base (not present on the unit in these photographs), use masking tape along edges of cutouts to hold the shield from moving. Position the Wheelwriter USB & RS232 Interface Template against the reference points indicated by arrows, and tape in place. Center-punch for the four USB & RS232 Interface Board mounting holes indicated on the template. Drill 1/8" mounting holes from the top.

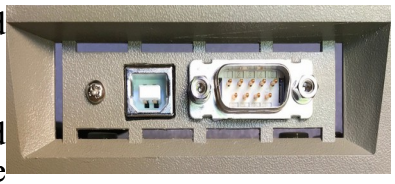


17. From the underside of the case, countersink the four mounting holes for the USB & RS232 Interface Board standoffs so the flat-head screws will be below the surface.

18. The second template shows the cutout patterns for the USB-B and DE-9 RS232 connectors. Two variants are provided; the one pictured shares one screw between the two connectors. Use double-sided tape to attach it to the knockout panel in the rear of the lower half of the case (on the right as viewed from the rear). Use an awl to center-punch for the mounting screw holes and holes at the corners and midpoints of the center cutout areas, then drill 1/8" holes for the mounting screws, corners and midpoints. Clear out the cutouts to the black lines with snips, saw, file, razor knife and/or Dremel tool.



19. Use a file or razor knife to shave about 1/32” of the plastic around the captive nut on the right side of the USB-B panel-mount connector to ease the fit next to the back side of the DE-9 connector. Install the USB-B connector using one of the provided screws on the left. Thread the 2x5 IDC socket of the RS232 cable through the cutout and install the DE-9 connector on the outside of the panel using two jackscrews with one flat washer on the outside. The middle jackscrew threads into the USB-B connector. The jackscrew on the right gets the solder lug (if used), then a flat washer, lock washer and nut.



20. Route the ribbon cable underneath the USB cable as pictured, then restrain the USB cable with a cable clamp screwed to the left post inside the knockout panel area using one of the #4 truss head sheet metal screws.

21. Set the frame assembly loosely back in position making sure not to pinch any cables.

22. Connect the two wires to the tabs on the switch at the bottom of the paper bail load lever. It does not matter which wire goes to which tab.

23. Slide the carriage FFC cable back into the corner clips so the bottom layer is under the inner corner clip and then the fold slides into the outer corner clip. Then insert the round object to bow up the upper layer to get it under the inner corner clip. Also slide the cable back under the clip in the center of its track.

24. Push the frame assembly back down into its four corner latches.

25. Plug in the ribbon cables for the two servo motors at the back.

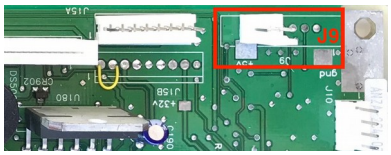
26. Slip the platen motor cable back under its clips where it will cross under the USB & RS232 Interface Board.

Logic Board Modifications

1. Use a desoldering tool or solder wick to remove solder from the leftmost 3 holes of unpopulated J9 on the logic board (in the right rear corner).

2. Install a 22-27-2031 3-pin Molex connector in the leftmost 3 holes of J9 with the latch away from the edge of the board.

3. (optional) Clean soldered areas with solvent to remove flux.



Install ASCII Keycaps

The original keycaps of the Wheelwriter keyboard do not show all the ASCII characters, but they can be replaced with new keycaps from Unicomp, Inc. who still make modern keyboards using the same underlying key mechanism.

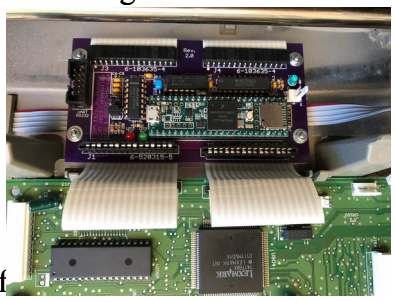
The appropriate keycap placement is shown in the following photo. The old keycaps can be removed simply by prying them up with a screwdriver. The new ones snap in place, being careful to position the spring into the stem of the new keycap.

Install the USB & RS232 Interface Board and Cables

1. Attach four standoffs for mounting the USB & RS232 Interface Board using flat-head screws from the underside, but don't tighten them.

2. Reinstall the logic board but do not attach any cables yet.

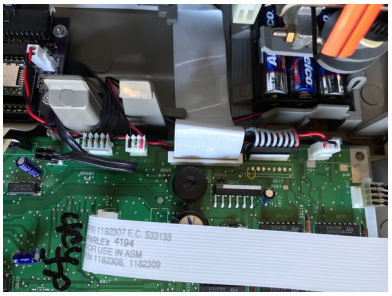
3. Insert FFC interconnect cables into the Interface Board with the contacts facing up. The cable in J3 on the left has contacts on the same side at both ends; the one in J4 on the right has opposite contacts. Fold the cables back under the board right at the edge of the board. Plug the other end of the FFC interconnect cables into the logic board.



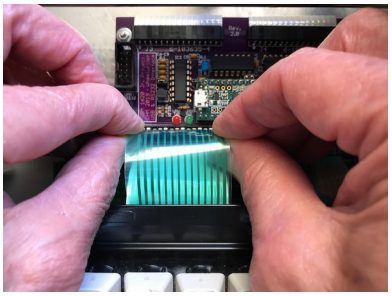
4. Install the Interface Board onto standoffs with washers and nuts. Finish tightening using a wrench or nutdriver on the nuts and tighten the screws from underneath.

5. Where the FFC interconnect cables come up from under the Interface Board by the logic board, pull the cables taut and fold them away from the Interface Board right at the connectors on the logic board, then crease the excess so they will stay under the keyboard (see photo above).

6. Cut two 8” pieces of hookup wire, preferably red and black. Strip the ends about 1/8” and crimp on the Molex 08-50-0114 female pins. Twist the two wires together to make a cable. Insert the pins into the Molex 22-01-3027 2-pin housing so that red mates to the pin marked +5 on the Interface Board. At the other end, insert the pins into the Molex 22-01-3027 3-pin housing with black toward the corner of the logic board and red at the opposite end. The middle position is empty.

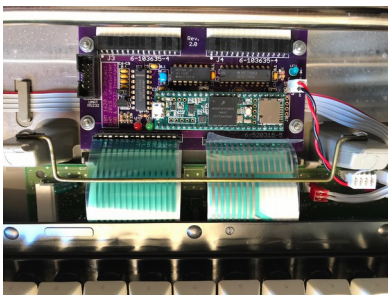


7. Install the new power cable from the logic board to the USB & RS232 Interface Board, routing it underneath all the other cables along the back edge of the logic board. Bend the wires down sharply at the connector on the USB & RS232 Interface Board to avoid interference with the carriage. Now reconnect all the existing cables to the logic board. To insert the FFC cables for the carriage and the LED panel, first pull the connector clamp open, then insert the cable, then push the clamp closed. The black 2-wire ribbon cable to J3 on the logic board has excess length now because it no longer hooks through the clip that is now under the Interface Board, so bend that excess over the logic board.



8. Lay the keyboard loosely over its position and insert the FFC cables from the keyboard into the connectors on the Interface Board (this is not easy – it may require padded forceps). There will still be about 0.1” of the wide portion of the conductors above the top of the connectors when the cable is fully inserted.

9. Make a bracket to depress the keyboard FFC cables by manually bending steel coat-hanger wire using needle-nose pliers according to the dimensions shown in the CAD diagram below.



10. Install the bracket to hold back the keyboard FFC cables using two #4 truss head screws into the holes drilled into the keyboard support posts.

11. Install the keyboard into its front catches and then rear clips.

12. Plug the micro-USB connector into the Teensy and plug the RS232 ribbon cable into the board. Then adjust the position of the cables behind the left rear foot and restraining both cables with one or two cable ties to the existing clip for the platen motor ribbon cable at its front corner.

13. Plug in and power on the Wheelwriter. Plug a USB-B cable into the new panel connector at the back of the Wheelwriter and connect it to the host computer, then download appropriate firmware into the Teensy. It will be necessary to cycle power on the Wheelwriter after the download before the logic board will be properly operating with the firmware on the USB & RS232 Interface Board. Verify operation with appropriate test programs.

14. Reinstall the top half of the Wheelwriter case: pull the paper release and paper bale levers forward; thread the LED panel loosely through its hole in the case top; hook in the catches at the front of the machine and then tilt down the back until the latches meet and catch; and finally snap the LED panel back into place. The column index marker can be adjusted to line up with column 0. The “Artisan 10” printwheel #1353520 is recommended.

Parts List

Count	RS232	Description	Source	Source PN	Cost	Note
1		USB & RS232 Interface PCB	OSH Park	TIkAO4NE	17.42	1
1		Teensy 3.5 without pins	PJRC	TEENSY35	24.25	2
2		32 SIL header pins for Teensy	DigiKey	952-2521-ND	10.46	2
1		48-pin socket for Teensy	DigiKey	ED3648-ND	3.84	2
1		74LS540 PDIP IC	DigiKey	296-3715-5-ND	1.64	
1	1	RS232 transceiver PDIP IC	DigiKey	MAX3232ECPE+-ND	5.37	3
1	1	Transistor PNP 40V 0.6A TO-92	DigiKey	2N4403-ND	0.30	
1		10K x 13 resistor network	DigiKey	4114R-2-103LF-ND	1.12	
9	4	0.1 µF capacitor	DigiKey	399-4264-ND	1.50	4
1		10 µF capacitor	DigiKey	490-14508-ND	1.21	
1		3mm LED (blue) for LED1	DigiKey	VAOL-3LSBY1-ND	0.65	5
1	1	3mm LED (green) for LED2 RxD	DigiKey	VAOL-3LDE2-ND	0.44	5
1	1	3mm LED (red) for LED3 TxD	DigiKey	732-5006-ND	0.17	5
1	1	75 Ω 1/8W resistor	DigiKey	CF18JT75R0CT-ND	0.10	5
1	1	220 Ω 1/8W resistor	DigiKey	CF18JT220RCT-ND	0.10	5
1		4.7K Ω 1/8W resistor	DigiKey	CF18JT10K0CT-ND	0.10	5
1	1	10K Ω 1/8W resistor	DigiKey	CF18JT10K0CT-ND	0.10	
2		TE/AMP 6-520314-5 FFC connector	Heilind	6-520314-5	1.48	6
2		TE/AMP 6-520315-5 FFC connector	Heilind	6-520315-5	1.48	
1		6” Flat flex cable, same side contacts	Wavelink	254-015-0155-AA	10.00	7
1		6” Flat flex cable, opposite side contacts	Wavelink	255-015-0155-AB	10.00	7
1		Molex 22-27-2021 2-pin connector M	DigiKey	WM4111-ND	0.27	
1		Molex 22-01-3027 2-pin housing F	DigiKey	WM2000-ND	0.12	
1		Molex 22-27-2031 3-pin connector M	DigiKey	WM4112-ND	0.35	
1		Molex 22-01-3027 3-pin housing F	DigiKey	WM2001-ND	0.18	
4		Molex 08-50-0114 female pins tin	DigiKey	WM1114-ND	0.78	
3	1	1x2 header for J6,J7,J8 jumper	DigiKey	732-5315-ND	0.39	8
3	1	Shorting jumper for J6,J7,J8	DigiKey	S9337-ND	0.30	8
4		3/16 x 3/8 female-male standoff	DigiKey	1772-2032-ND	4.20	
4		0.28” diameter flat washer for #4-40	DigiKey	36-4692-ND	0.33	
4		Hex nut 3/16” #4-40	DigiKey	36-4694-ND	0.30	
4		#4-40 3/8” flat-head screw, phillips	Bolt Depot	3717	0.20	
3		Self-tapping screws for bracket, clamp	Bolt Depot	7754	0.15	
1		Bracket to depress keyboard cables	coat hanger			9
1		USB cable B panel to micro male, 24”	DataPro	1581-02C	10.95	
1		Cable clamp for USB cable	DigiKey	RP325-ND	0.10	
1		Cable tie	DigiKey	298-1017-ND	0.05	
1	1	2x5 header, 4-wall, keyed	DigiKey	3M155831-ND	2.01	
1	1	2x5 IDC ribbon cable socket	DigiKey	3M156030-ND	0.74	
1	1	2x5 IDC strain relief	DigiKey	MESR10-ND	0.46	
1	1	10-wire ribbon cable, 1 meter	DigiKey	732-11801-ND	2.25	10
1	1	DE9-M panel mount IDC	DigiKey	MMR09K-ND	6.34	
2	2	Jackscrew Socket with hardware	DigiKey	160-17FA-ND	1.68	
1	1	Solder lug for DE9 shield ground	DigiKey	36-7328-ND	0.17	10
2		Hookup wire, red & black 24AWG, 8”	DigiKey	A2924R-100-ND	0.70	11
1		Set of ASCII keycaps	Unicomp	PSET 104+ (see note)	26.60	12
		Total			151.35	13

Notes:
If the RS232 interface is not needed, reduce the part count by the number in the RS232 column.

1. Minimum order from OSH Park is three boards. Order at: https://oshpark.com/shared_projects/TIkAO4NE
2. Alternatively use Teensy 3.5 with pins plus two 24x1 sockets from PJRC.
3. Or alternates MAX3232EEPE+-ND, ADM3202ANZ-ND, SP3232E, MAX3232EPE+-ND
4. Only 9 capacitors are needed, but buy 10 for the price break.
5. Any LED color may be used, but may need a different resistor value for appropriate current and desired brightness. These were selected for similar appearance; 5mm LEDs may be substituted.
6. There may be no stock of this right-angle connector at the factory or any distributor, but the vertical connector 6-520315-5 can be modified for right-angle mounting, so buy four.
7. FFC cable sources in decreasing order of preference:
   - Get custom order cables as listed, contact Chris Dobens, cdobens@wavelinkcable.com
   - If not available, substitute 80 conductor 0.5mm pitch 150mm length FFC, one each with conductors on same and opposite sides, available, for example, on ebay in sets of five at https://www.ebay.com/itm/273811880007 and https://www.ebay.com/itm/372654797782
   - Use latching connectors and cables per USB Interface Board Rev 1.6 BOM and instructions.
8. Fewer needed if you want to hardwire the terminal mode and/or enable of the RS232 LEDs.
9. Bend steel coat hanger wire using needle-nose pliers to form bracket per CAD diagram.
10. Alternatively use 9-wire ribbon cable 732-13985-ND if shell ground is not desired.
11. Minimum order is 100' roll. Any hookup wire can be substituted.
12. Order the following keycaps at https://www.pckeyboard.com/page/category/Buttons:
    - Complete Printed Buckling Spring Button Set, PSET 104 Pearl/Pebble – US
    - Single Unit Key – Buckling Spring – printed, Pearl, characters "| \" (vertical bar, backslash)
    - Single Unit Key – Buckling Spring – printed, Pearl, characters "Setup"
    - Single Unit Key – Buckling Spring – unprinted
13. Shipping charges and taxes not included.

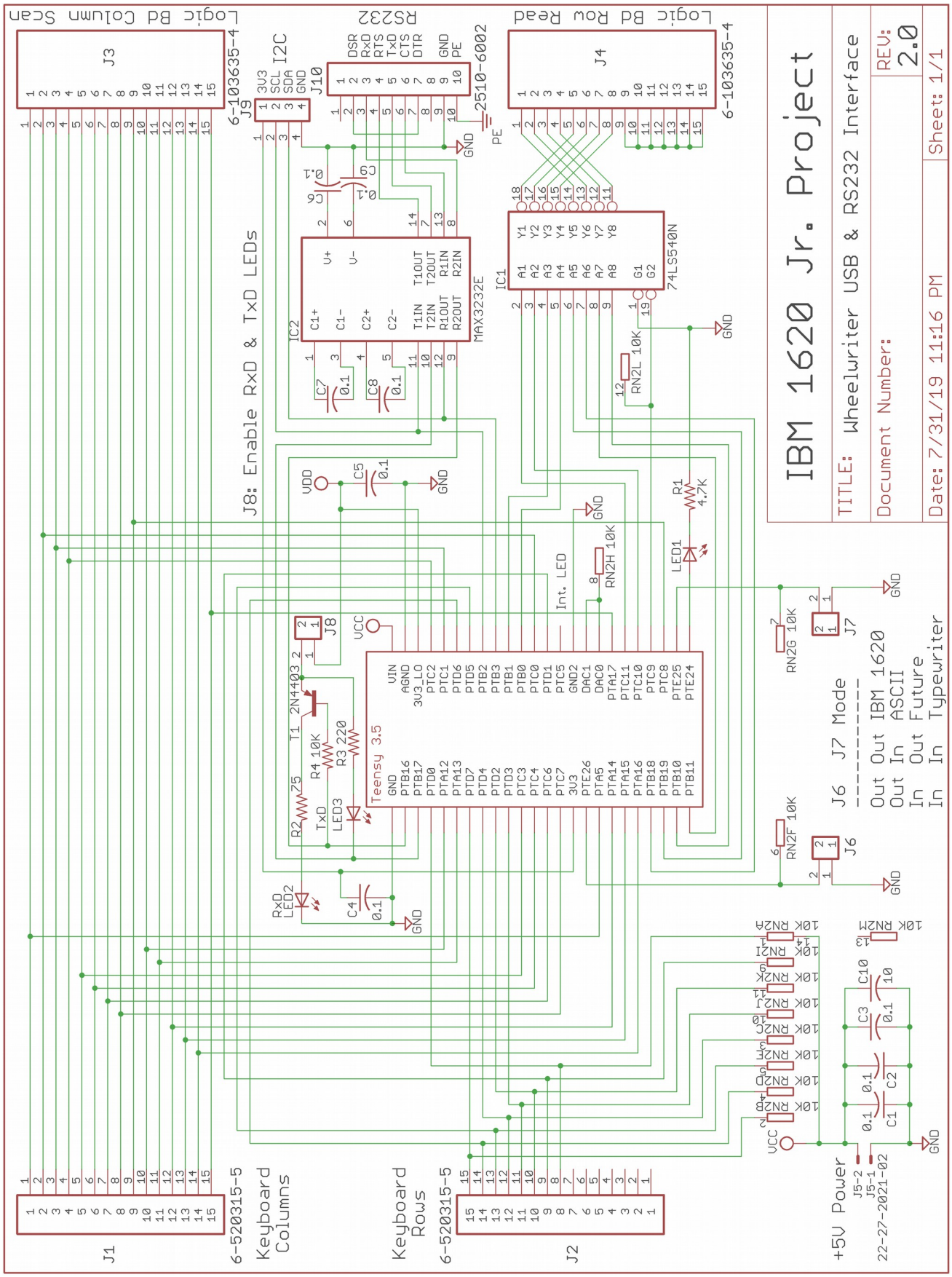
Tools Required

- phillips #0 and #1 screwdrivers
- large straight screwdriver
- 3/16" nut driver
- needle-nose pliers (may need two)
- diagonal cutters to clip PCB leads
- center punch and small hammer
- awl or ice pick
- IC insertion tool (optional)
- Xacto knife to cut Teensy trace
- soldering iron with fine tip
- desoldering tool or solder wick
- electric drill with 3/32", 1/8" and countersink drill bits
- Dremel tool with cylindrical bit, or file, to shape holes in plastic back panel
- vise or water pump pliers to seat ribbon cable and covers on IDC connectors

Materials

- masking tape
- double-stick tape
- scrap piece of 3/16" plywood or alternative

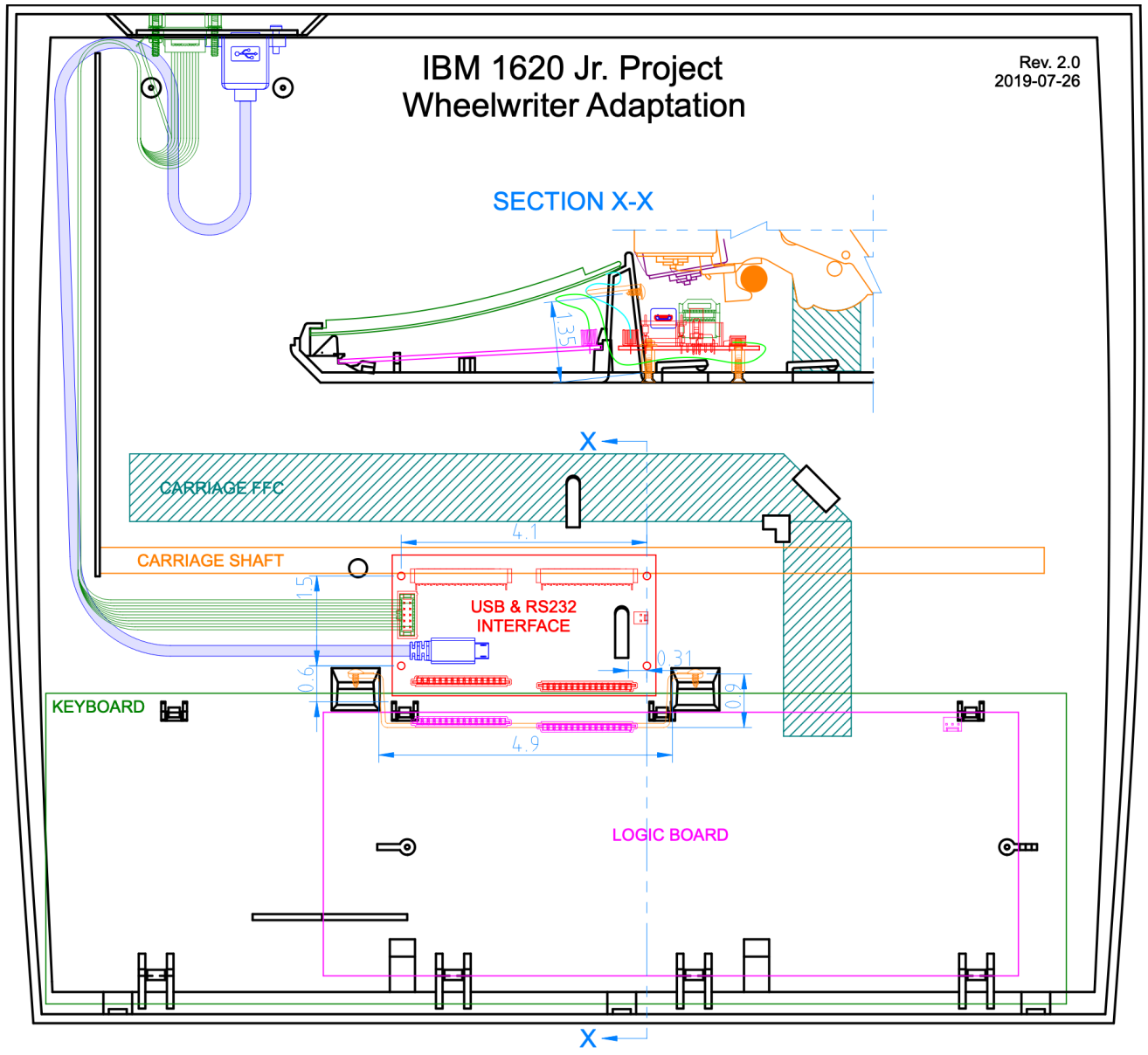
USB & RS232 Interface Board Rev. 2.0 Schematic



Modified Wheelwriter CAD Diagram

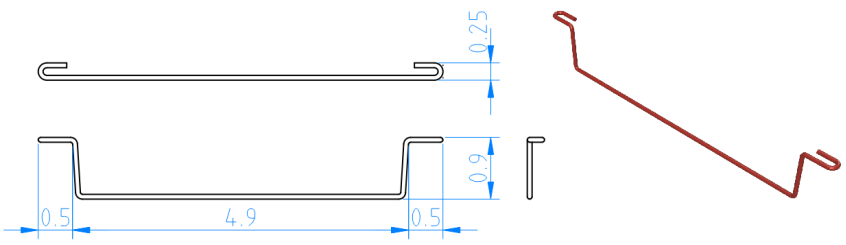
To see details in this diagram more clearly, try viewing the PDF file for this document online and zoom in. Better yet, view the original PDF of this diagram with black background and scalable graphics that is downloadable from:

https://github.com/IBM-1620/Cadetwriter/raw/master/docs/adaptation_guide/wheelwriter-adaptation-CAD.pdf



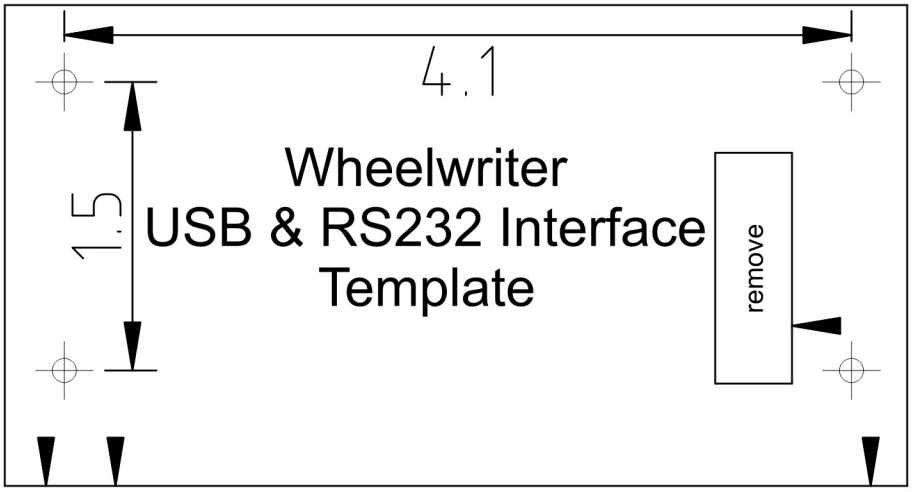
Flex Cable Depression Bracket

Dimensions and angles not indicated are not critical.
Material is 0.07" diameter steel coat-hanger wire.



Templates

Print and cut out these templates for use during the Wheelwriter modification procedures. Verify that the printer scaling is accurate by measuring the dimensions (in inches) as shown on the Wheelwriter USB & RS232 Interface Template which shows where to drill mounting holes for the board.



The second template is for drilling and cutting holes in the knockout panel at the rear of the Wheelwriter base for mounting the USB-B cable and RS232 cable. The black lines indicate the size of the cutouts while the red lines indicate the size of the connector bodies behind the panel.

Two variants are provided; the first shares one screw between the two connectors by overlapping the flange of the DE-9 connector on the outside of the panel with the ear of the USB-B connector behind the panel. The red lines indicate interference between rear bodies of the two connectors, but there is enough slop in the holes to allow the connectors to fit. To ease the fit, use a file or knife to shave about 1/32” off the plastic surrounding the captive nut in the USB-B connector. This arrangement works since the USB plug is narrow, as shown in the photo.

The second variant uses separate screws for the two connectors but leaves only a narrow section of the plastic panel to the right of the DE-9 connector and creates a rather tight space between the two connectors for getting in a tool to hold the nut. The distance between the mounting holes for the USB-B connector is 26 mm (1.024 inches) and for the DE-9 connector is 0.98 inches.