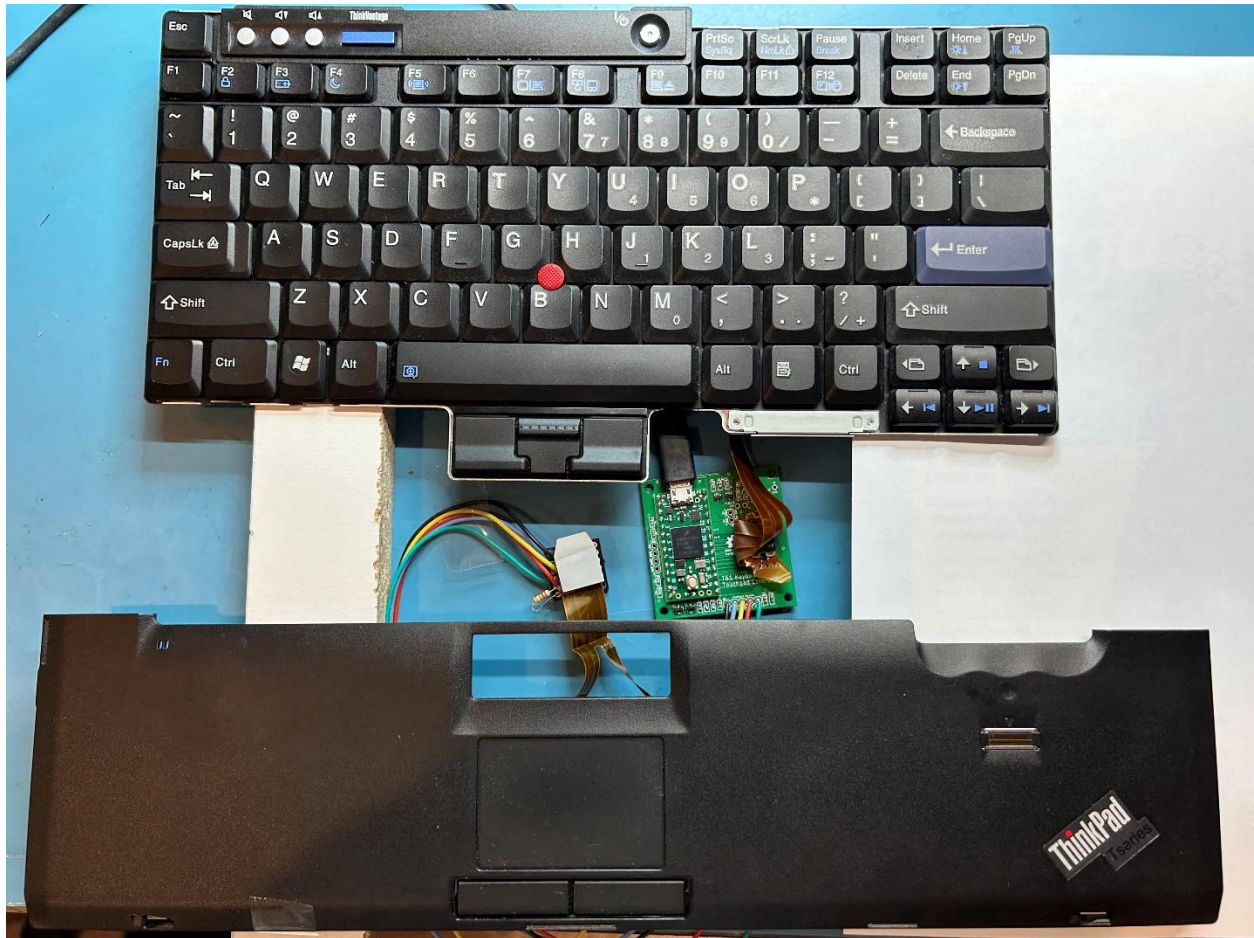# T61 Keyboard, Trackpoint, and Touchpad Controller using a Teensy 4.0
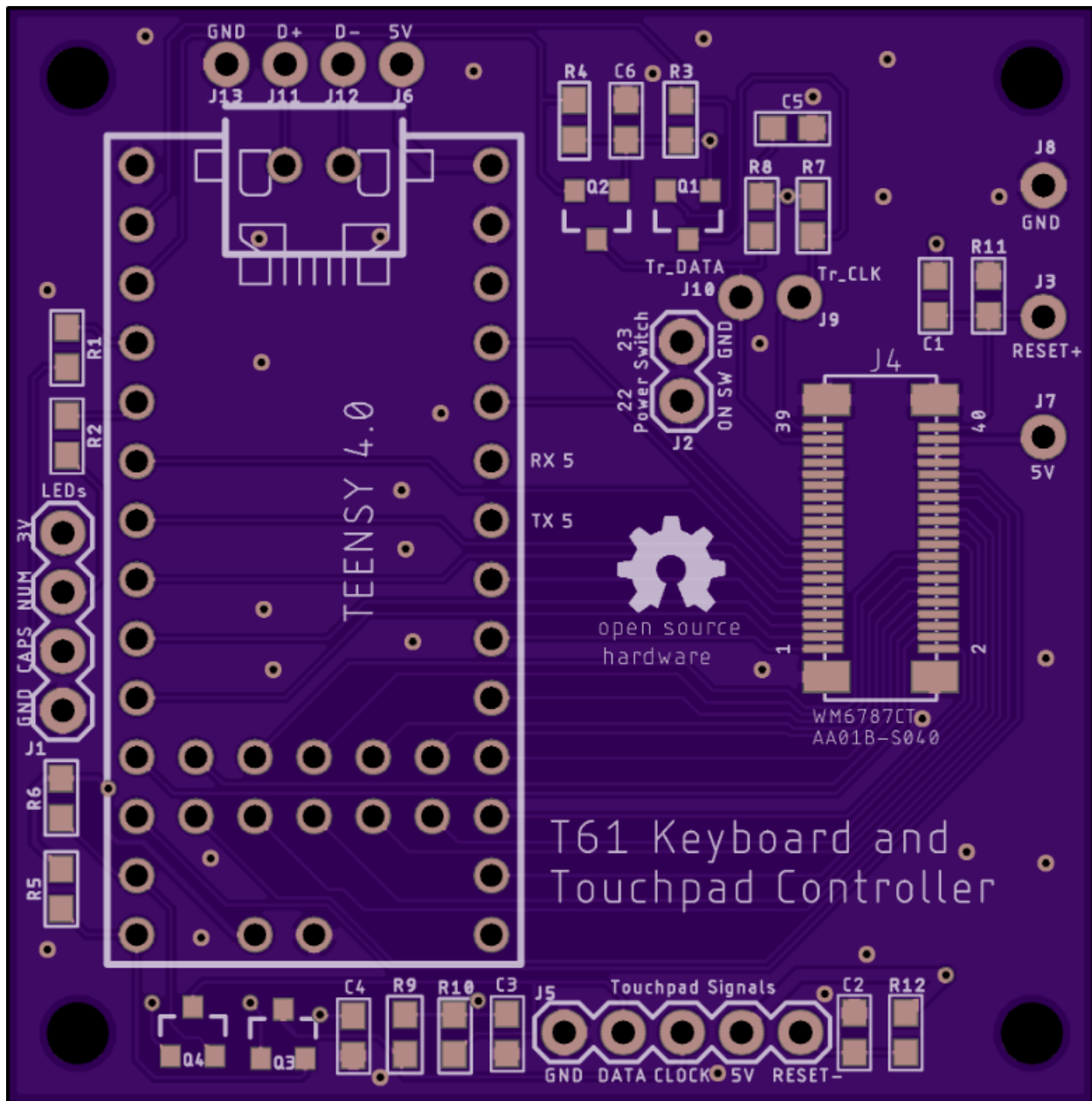
The picture below shows a Teensy 4.0 on a circuit board with a T61 keyboard connector. A smaller board has a T61 touchpad connector with wires back to the Teensy. The Teensy is programmed to scan the keyboard, then poll the trackpoint and touchpad over PS/2. The resulting keyboard and cursor movements are sent back to the host computer over USB. All files for this project are located at my GitHub repository.

The keyboard backside is shown below.

The photograph shows the backside of a keyboard with a label reading:

PARTS NO-42T3177
FRU NO-42T3209
ID
MODEL NO-87W258
MW-US

87T178428

*1IS42T3172I2CB887W258*

ASSEMBLED IN CHINA

The picture below shows the Teensy 4.0 keyboard connector board as depicted by OSH Park.

The Eagle file "T61.brd" can be sent to OSHPark.com for fabrication or the zipped Gerber file "T61_2023-10-14.zip" can be sent to any board fabricator including JLCPCB.com

The AA01B-S040 keyboard connector on the motherboard is available at AliExpress. A similar WM6787CT-ND keyboard connector is available from Digikey. Both are shown below so you can see the WM6787CT-ND lacks the alignment piece on the ends.
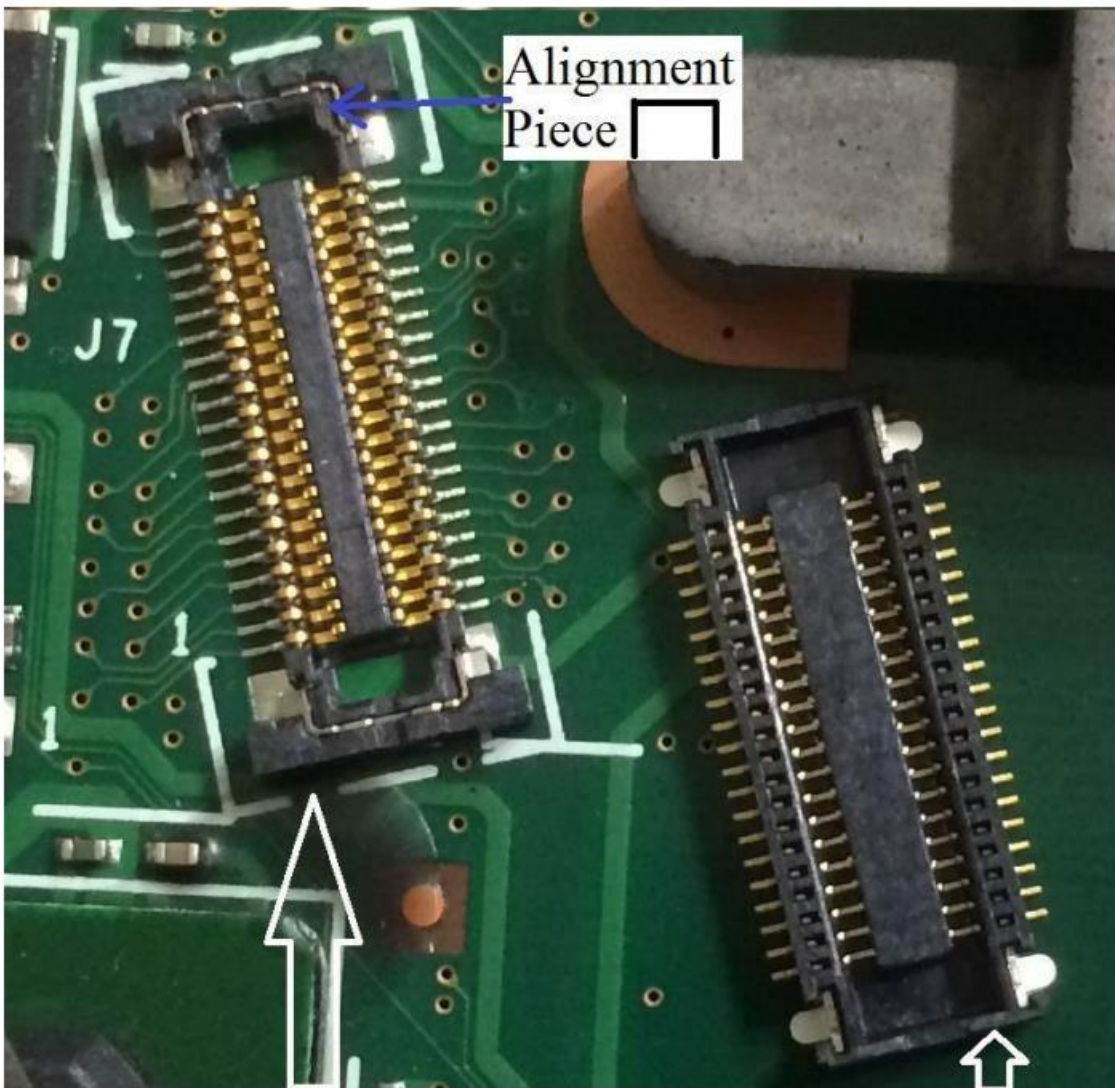

Original Connector
JAE AA01B_S040VA1

Substitute Connector
WM6787CT-ND

The WM6787CT-ND takes visual alignment and multiple plug-in attempts to make it work. Another approach is to unsolder the keyboard connector from the motherboard. The easiest way to do this is with a heat gun or low cost hot air rework station. First use a soldering iron to apply flux and Chip Quik removal alloy on all the connector legs and ground tabs. Then stand the motherboard on edge in a vise and blow hot air on the connector from the back side. The board will protect the connector from damage and the heat will transfer thru the board to the connector legs and tabs. When the solder goes molten, use needle nose plyers to gently lift the connector from the board. Clean up all the legs with flux

and solder wick. To make sure there is no removal alloy remaining, melt some regular solder on each leg and remove it with flux and solder wick.

Some of the keyboards I've used have missing alignment tabs as shown below. The tabs break off after multiple insertions.
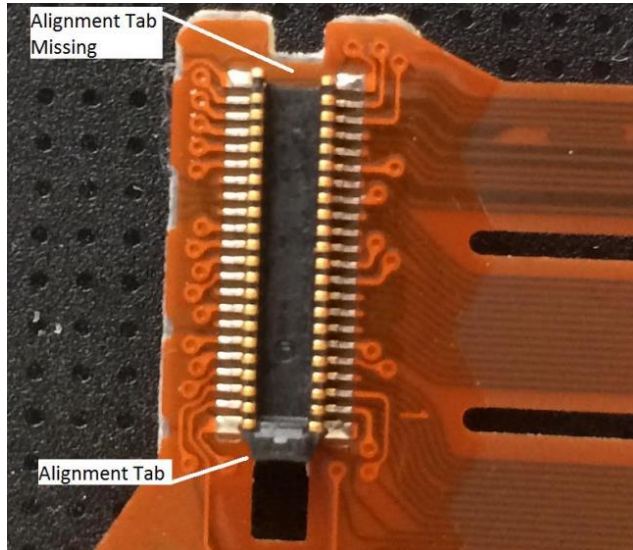

If both ends are missing tabs, visual alignment will be needed as shown below.
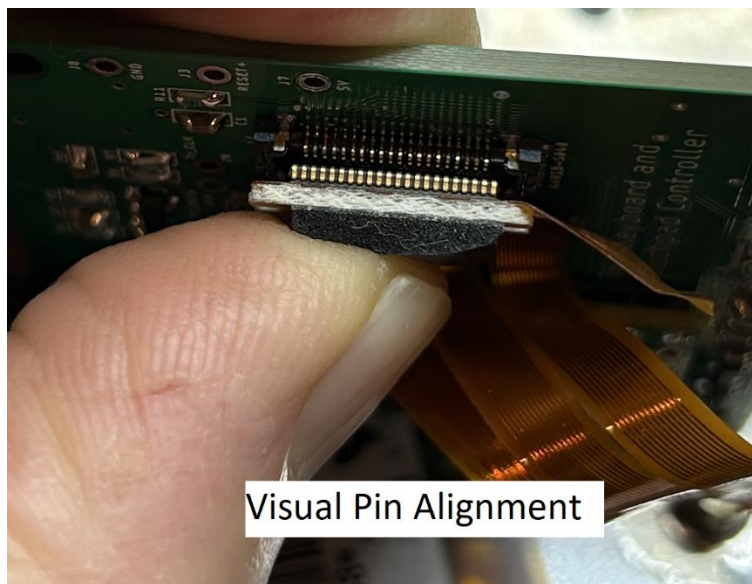
Note that the keyboard connector actually has unused pins at the corners so it is a 44 pin mating into a 40 pin motherboard connector.

To assemble the board, you can solder all the surface mount components with an iron but the fine pitch of the keyboard connector makes it difficult. I prefer to use a stencil to apply solder paste and then flow the solder with my converted toaster oven.

Once the SMDs are soldered, prepare the backside I/O pads of the Teensy for connection to the board. If you are trying to keep the height of the assembled board to a minimum, buy a Teensy without pins and solder flying leads for the backside I/O as shown below.
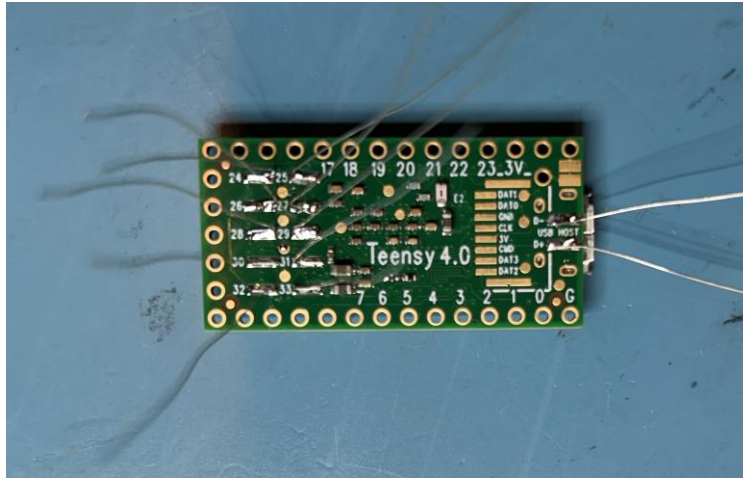
Use tweezers to insert each of the flying leads into the board as shown below.
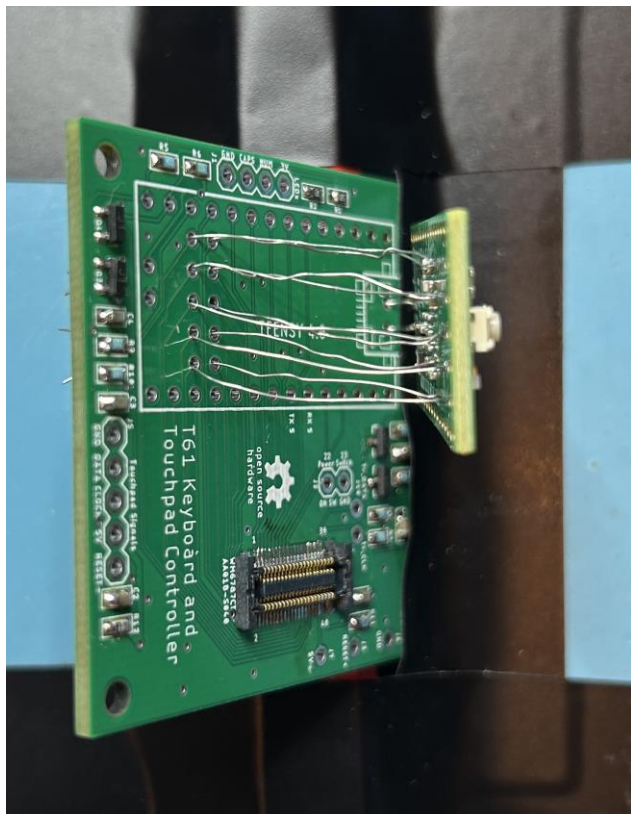
Then solder short wires for the perimeter Teensy pins instead of header pins. This picture shows the finished height is much lower when using wires instead of headers.
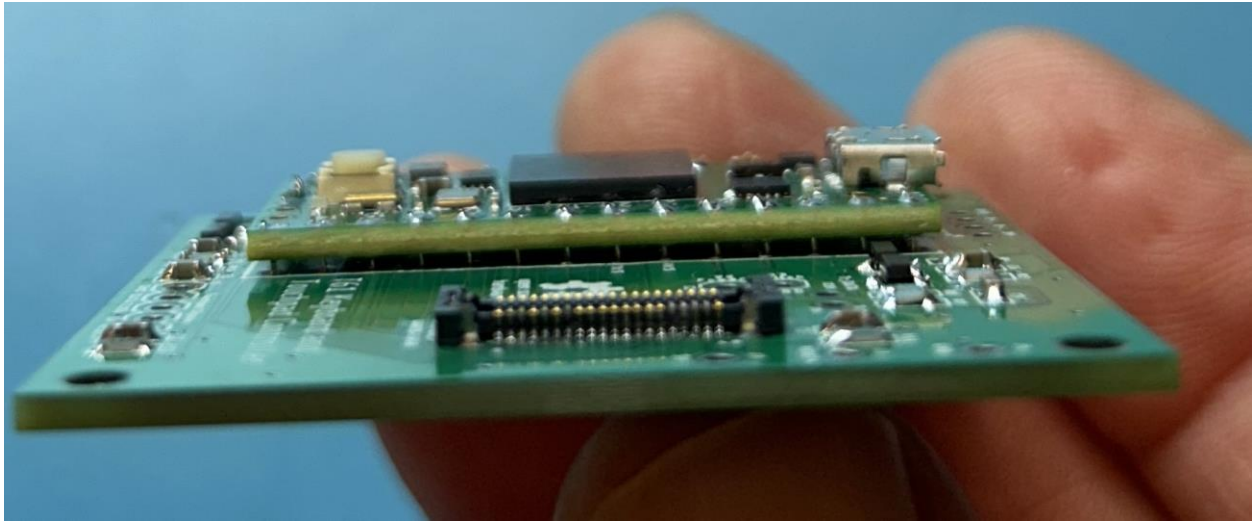
If height is not a concern, buy a Teensy with header pins and solder right angle header pins for the backside I/O. The right angle header pins are a little too long for the pads on the Teensy so use your wire cutters to trim them a bit. Use a prototyping board with 0.1 inch hole spacing to hold the header in alignment for soldering.

This picture shows the connector board after being assembled. The pads on the left side can be wired to 2ma CAPS and NUM lock LEDs. There are also pads for wiring the power button on the keyboard to a turn-on circuit.
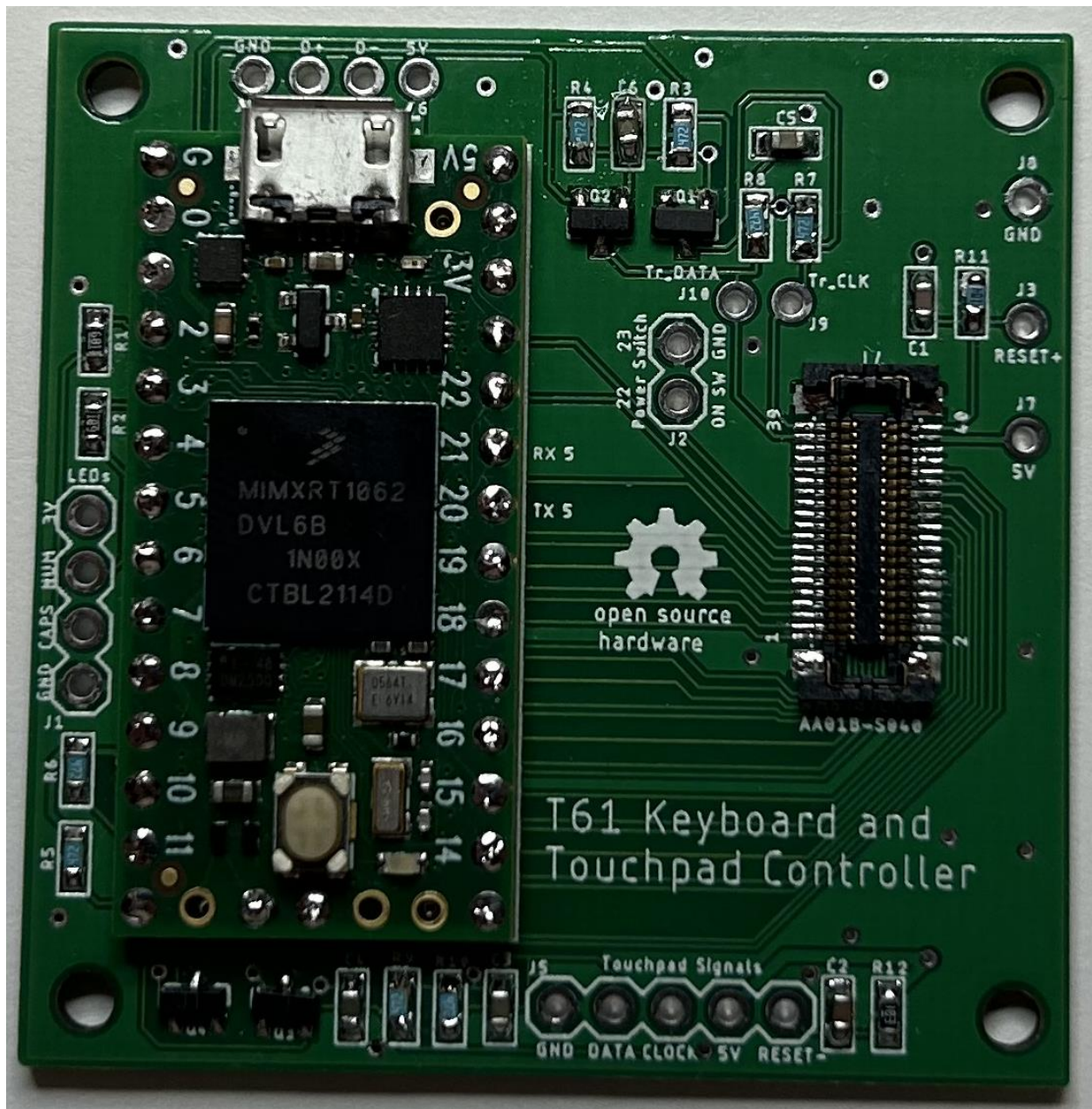

Parts List:

Qty	Description
1	Teensy 4.0 with pins and 2x7 right angle header pins or Teensy 4.0 without pins and flying leads for the backside I/O (gives minimum assembled height)
4	0.1uf 0603 10V 10% ceramic caps (C3 thru C6)
2	2.2uf 0603 10V 10% ceramic caps (C1 and C2)
8	4.7K 0603 1% 0.1 W thick film resistors (R3 thru R10)

1	17K 0603 1% 0.1 W thick film resistor (R12)
1	100K 0603 1% 0.1 W thick film resistor (R11)
2	715 ohm 0603 1% 0.1 W thick film resistors (R1 and R2)
4	BSS138 N Channel FETs Digikey part number 4530-BSS138CT-ND
1	AA01B-S040 (preferred) or WM6787CT-ND keyboard connector
1	Printed circuit board from Eagle file T61.brd or zipped Gerber file T61_2023-09-03.zip

The Teensy connector board schematic "T61.sch" is given below. The trackpoint needs a positive reset pulse at power up, provided by R11 and C1 and can be monitored at the RESET+ test point. The touchpad needs a negative reset pulse at power up provided by R12 and C2 and can be monitored at J5 pin 5 labeled RESET-.
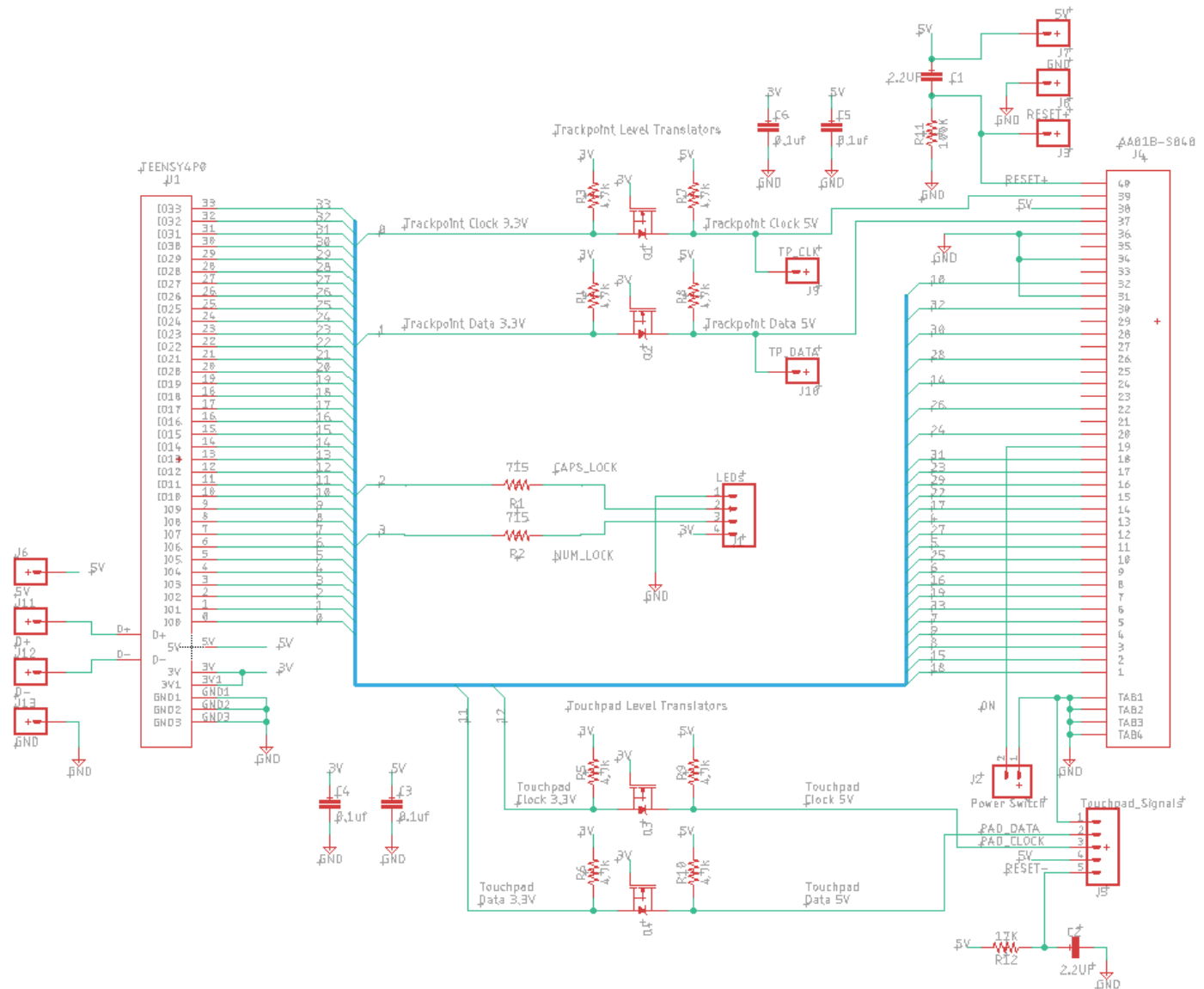
Instead of populating the board with surface mount components for the level translators, the Adafruit 757 can be used. Axial leaded resistors and capacitors can be used instead of surface mount components to create both reset signals. If a soldered USB connection is desired, the USB signals can be soldered to pads on the board instead of using a micro USB connector. Two flying leads for the USB D+ and D- must be soldered to the Teensy backside when preparing the other backside I/O signals.

The Teensy I/O's are wired to the keyboard connector and touchpad per the table below.

Keyboard Connector	Teensy I/O	Description
1	18	Fn Hot Key
2	15	Row Output
3	8	Column Input
4	9	Row Output
5	7	Column Input
6	33	Row Output
7	19	Column Input
8	16	Row Output
9	6	Column Input
10	25	Row Output
11	5	Column Input
12	27	Row Output
13	4	Column Input
14	17	Row Output
15	22	Column Input
16	29	Row Output
17	23	Column Input
18	31	Row Output
19		Power Switch (available at jumper pad J2-2)
20	24	Row Output
21		NC
22	26	Row Output
23		NC
24	14	Row Output
25		NC
26	28	Row Output
27		NC
28	30	Row Output
29		NC
30	32	Row Output
31		GND
32	10	Row Output
33		NC
34		GND
35		NC
36		GND
37		Trackpoint Data (level translated from I/O 1)
38		5 Volts (from USB)
39		Trackpoint Clock (level translated from I/O 0)
40		Trackpoint positive Reset (created using Resistor & Cap)
	12	Touchpad Clock (level translated)
	11	Touchpad Data (level translated)
	2	CAPS Lock to 2ma LED anode. LED cathode to ground
	3	NUM Lock to 2ma LED anode. LED cathode to ground
	13	Teensy on-board LED used for heartbeat
	20	Spare I/O (this is serial TX5 pin)
	21	Spare I/O (this is serial RX5 pin)

The file "Matrix_Decoder_T61.ino" was loaded into the Teensy and each key was pressed to give the I/O connections given in file "T61_keyboard_decoded.txt". The results from that list have been converted to the T61 keyboard matrix shown below. This matrix has been added to the file "Lenovo_T61_KeyboardandTouchpad.ino". This Teensy code scans the keys by driving each output row low, one at a time. The other row outputs are left floating so they don't interfere. The Teensy enables internal pull ups on the 8 column inputs so it will read a low if the key is pressed. The keyboard scan rate is approximately 30msec.

The Fn "Hot" key is not part of the matrix and has a dedicated connection to Teensy I/O 18. The other side of the Fn switch goes to ground. I/O pin 18 is programmed to be an input with a pullup so the Teensy can detect a logic low when pressed.

After the keyboard scan, the Teensy polls the touchpad and trackpoint with two separate PS/2 busses. If the trackpoint has movement or button changes, this information is sent over USB. If the trackpoint is not active, any touchpad movement or button changes are sent over USB.

<div align="center">T61 Keyboard Matrix</div>

I/O #	7	6	4	23	22	5	19	8
10		Scrl-lock	prntscrn	alt-r				alt-l
30	home		end	left	pause			up
8								
24	ins		F12	right				
29	del	Vol+	F11	down		mute	Vol-	ThinkVantage
27	-	p	0	/		;	[	'
16	F8	o	9		period	L	F7	
9	=	i	8		comma	k	]	F6
26	`	q	1		z	a	tab	esc
28					shift-r		shift-l	
32	cntrl-l				cntrl-r			
31	F1	w	2		x	s	Caps-lck	
17	F2	e	3		c	d	F3	F4
25	5	r	4	b	v	f	t	g
33	F9		F10	space	enter	\	bckspc	F5
15	6	u	7	n	m	j	y	h
14	Pg-up	GUI	Pg-dn	Page-rt	Page-left	Menu		

Other items of note:

1. Pressing Fn and F2 will toggle the touchpad off/on. Likewise Fn and F1 will toggle the trackpoint off/on. If I'm using a mouse, I like to turn these off because my palm sometimes brushes the touchpad and moves the cursor. Also my typing sometimes grazes the trackpoint and moves the cursor.

2. The ThinkVantage key is not currently used but could be programmed as any USB HID code.

3. Pressing Fn and Num Lock will toggle the embedded number pad on/off. If you are ever typing away and get numbers instead of JKLUIO, it's because the Num Lock was turned on.

4. Pressing the power button on the keyboard causes the pad labeled "ON SW" to be connected to ground. The switch measures 10 ohms when pressed. This switch can be wired to a power supply latch circuit.

5. You can lengthen or shorten the wires from the Teensy board to the touchpad board. It's low frequency and is not prone to interference.

6. The LED on the Teensy blinks as a heartbeat indicator. If it's not blinking, the Teensy probably doesn't have USB power.

7. CAPS and NUM LOCK LEDs can be controlled by the Teensy. The Teensy connector board has 715 ohm current limit resistors for 2ma LEDs. If higher current LEDs are used, R1 and R2 will need to be changed. The LED anodes should be wired to the pads labeled "CAPS" and "NUM". Both LED cathodes should be wired to the pad labeled "GND". The code will provide a logic high at the respective pads to turn on the LEDs.

8. The code prioritizes the trackpoint over the touchpad. If the trackpoint is moving the cursor, the touchpad is ignored, (the two are not added together).

9. The Page Back key acts like a Page Up key. The Page Forward key acts like a Page Down key.

10. During power up, the Teensy code tries to initialize the trackpoint over a "bit-bang" PS/2 bus. If the trackpoint fails its self-test, or gives no acknowledge, or causes a PS/2 bus time-out, a second attempt to initialize is made. If it still fails, the trackpoint is flagged as bad and no longer polled. The touchpad is initialized over a second "bit-bang" PS/2 bus in the same way. If the touchpad does not respond properly after two chances, it is flagged as bad and no longer polled. This means that only one full up version of Teensy code is needed, even if the touchpad is not connected.

The touchpad breakout board is designed to bring out the 20 signals from the DF12-20P connector (full part number DF12NB(5.0)-20DP-0.5V(51)) for easy jumper wire attachment. This connector is available for purchase or you can unsolder it from the motherboard. The Eagle file "T41_TPad.brd" or the Gerber file "T41_TPad_2023-11-21.zip" can be sent to the board house for fabrication. This is the OSH Park depiction of the board.
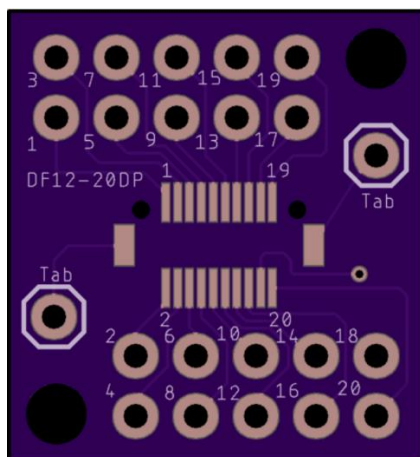
This table shows the touchpad connector pins and the corresponding "T" test points on the touchpad.

DF12-20DP	Touchpad	Description
5, 6, 17	T23	Ground
7	T22	5 Volts
11	T31	Touchpad Reset Active Low. Created by resistor and cap on Teensy board
13	T10	Touchpad Clock. Driven by Teensy I/O 12 thru level translator
15	T11	Touchpad Data. Driven by Teensy I/O 11 thru level translator
3	T8	TP4CLKPAD. Unused but must be pulled up with 100K to 5 volts
1	T9	TP4DATAPAD. Unused but must be pulled up with 100K to 5 volts
4	T7	BYPASS_PAD. Must be grounded

The signals TP4CLKPAD and TP4DATAPAD are inputs to the touchpad board and should be pulled up to 5 volts so they don't chatter. With the BYPASS_PAD signal grounded, these inputs are not used. The T61 motherboard used these signals to mux the touchpad PS/2 with the trackpoint PS/2. I've chosen to keep the touchpad and trackpoint PS/2 busses separately driven by the Teensy.

Parts List for the touchpad connector board:

Qty	Description
2	100K 1/10 watt 10% Axial Lead Resistors (value not critical)
1	DF12NB(5.0)-20DP-0.5V(51) connector
1	PCB from Eagle file T61_TPad.brd or zipped Gerber file T61_TPad_2023-11-21.zip

After soldering the DF12-20P connector to the board, solder jumper wires to the Teensy connector board pads near the label, "Touchpad Signals" as described below:

- Jumper wire from pad labeled GND to the Touchpad board pin 17. This ties Teensy ground to touchpad ground.
- Jumper wire from pad labeled 5V to the Touchpad board pin 7. This provides 5 volt power to the touchpad.

- Jumper wire from pad labeled CLOCK to the Touchpad board pin 13. This PS/2 clock signal is level translated from Teensy I/O 12 for the 5 volt logic in the touchpad.
- Jumper wire from pad labeled DATA to the Touchpad board pin 15. This PS/2 data signal is level translated from Teensy I/O 11 for the 5 volt logic in the touchpad.
- Jumper wire from pad labeled RESET to the Touchpad board pin 11. This signal comes from a resistor and cap on the Teensy board that provides a logic low on power up to reset the touchpad.

On the touchpad connector board:

- Jumper pin 4 to 6 in order to tie the signal "BYPASS_PAD" to ground.
- Add 100K resistor from pin 7 to 3. This pulls up unused input signal TP4CLKPAD.
- Add 100K resistor from pin 7 to 1. This pulls up unused input signal TP4DATAPAD.

The finished touchpad connector board with connections and resistors is shown below.
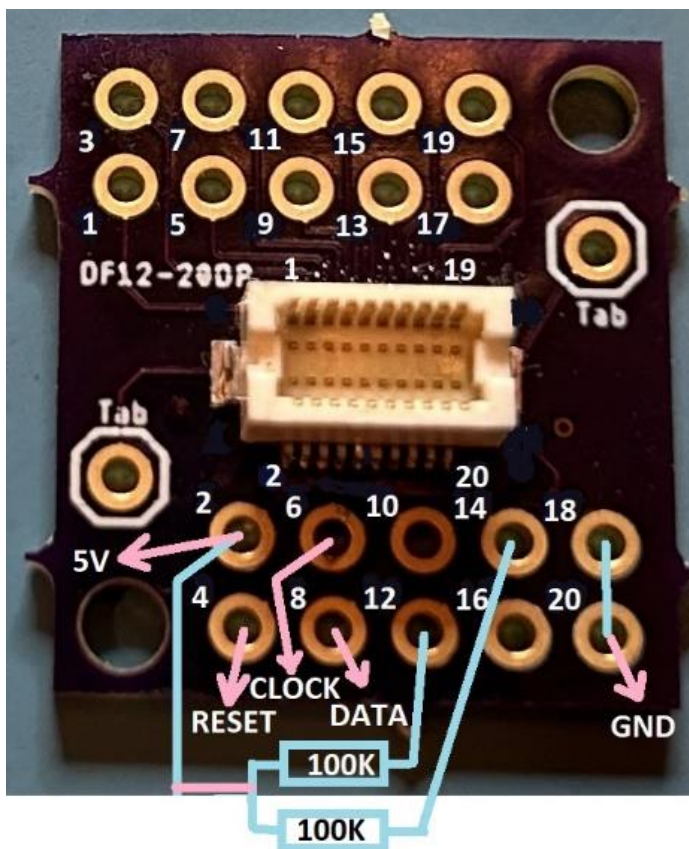
This picture shows the TM-00270-000 Synaptics touchpad circuit board and fingerprint reader attached to the palm rest.
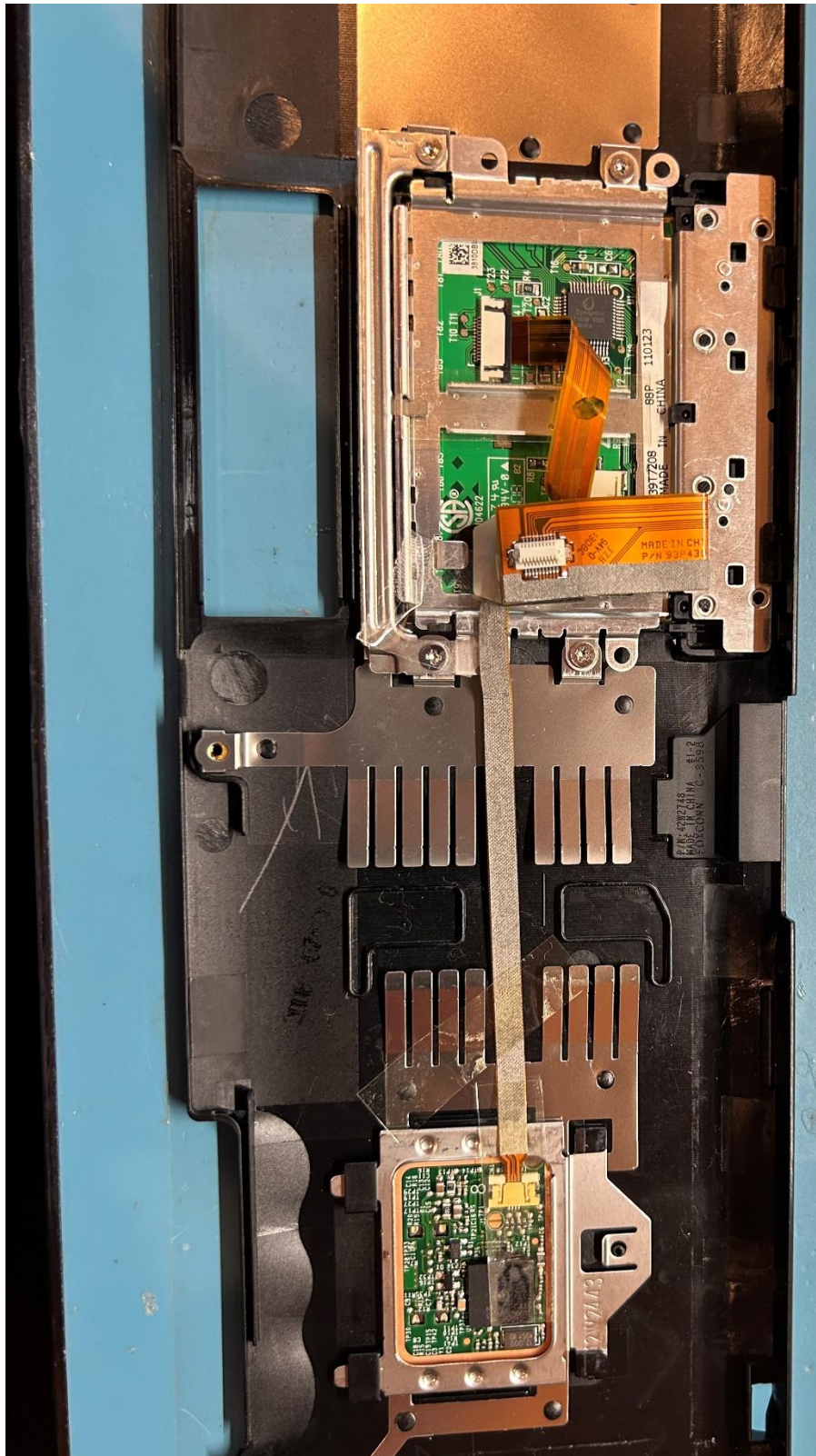
This picture shows the "T" test points on the TM-00270-000 touchpad. Wires could be soldered directly to these test points instead of using the FPC cable to a DF12-20P connector.