Quantum Design DynaCool PPMS Multifunction Probe (MFP)

Make cable connections

Figure 1: plug in MFP thermometry cable

1) Plug in the Rotator/MFP experiment ("user instrument/thermometer") cable to the PPMS (Fig 1). This is necessary for more accurate temperature report and better T stability at the sample. It uses the Cernox thermometer on the green board below the 16-pin DIP socket.
2) Clear the workbench area and set up the blue bracket on left and V-block on the right.
3) Carefully lift out the MFP on the side of the PPMS. place the head in the blue bracket with the connector facing upwards, and the bottom cage area on the V-block (Fig. 2).

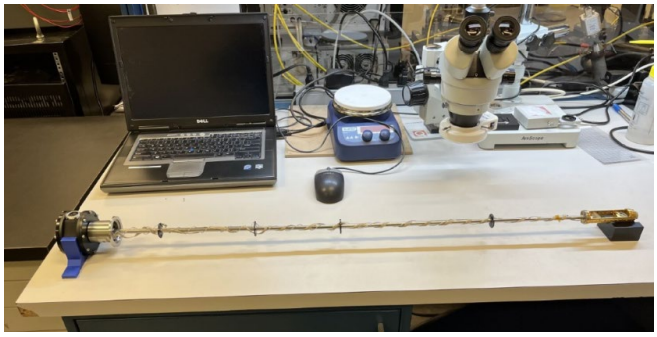


Figure 2: MFP in bracket and V-block on the bench

4) Move the electronics rack over near the workbench so that the white cable with Fischer connector will easily reach (Fig. 3).
   • You must move the rack far enough to allow a 1m wide path behind it for egress (i.e., emergency exit), without any cables, e.g., the USB-GPIB cable to the PC, blocking the way.
5) Plug in the Fischer connector of the white cable connecting the probe to the BNC switchbox. This takes some force, so secure the head with your other hand while you fully seat the Fischer connector (Fig. 4).
6) At the BNC switchbox, ensure all switches for both center conductor and shields are set to GROUND. This will protect your sample while it is being inserted on the probe.
7) At the bottom of MFP, orient the 16-pin DIP socket so that it is facing upwards (Fig. 5). If needed, loosen the screws using the green flathead screwdriver (Fig. 6) in the supplies drawer of white PPMS cabinet, and gently tighten them once socket is in position.

Figure 3: rack positioned to allow lab emergency exit.

   • Avoid touching any of the small Constantan wires on the backside of socket, these are very fragile!
   • If the screw heads are getting worn, or too tight, or if there is any issue please contact Neil ASAP!
8) You may wish to verify continuity in the wiring on the probe before putting a sample in. Do this by floating the center conductor switches of 1...16 on the BNC switchbox and using the Fluke meter to test resistance between a DIP socket (1...16) and the center pin of the corresponding BNC at the switchbox. Resistance should be 90-100 ohms (Constantan wiring resistance). See pin numbering in Fig. 5. Switch all contacts back to Ground before proceeding.

9) If your samples are highly ESD sensitive, put on the wrist ground strap that is clipped to the grounded bare metal case of the CryoFMR box. Make sure that the metal of the strap is against your skin.

10) Push your DIP package into the socket using even pressure until it is fully engaged (Fig. 7).

11) Make connections between your measurement electronics and the BNC switchbox on the electronics rack, carefully noting the grounding and providing ONE quiet ground for your experiment. See notes on ground references later in this document.

12) I recommend bench testing your sample with the electronics you connected, unless it requires the electrostatic shielding of the PPMS sample chamber.

13) Before inserting probe in the chamber, ground all contacts again at BNC switchbox.

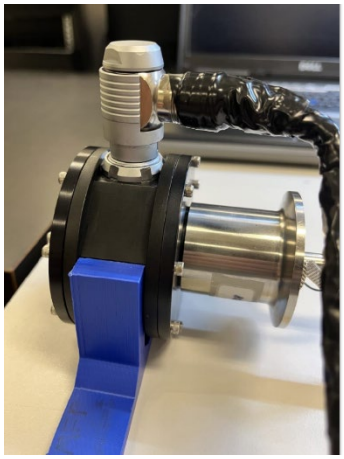


Figure 4: Fischer connector fully seated.

14) At MultiVu, verify temperature = 300 K and magnetic field = 0 Oe. If not, set these by clicking in the respective areas in the tray at bottom of MultiVu to set them and wait until they are stable before proceeding.
    • If temperature was initially < 270 K, you must wait an additional 30 minutes after reaching 300 K to ensure all parts of chamber have warmed.

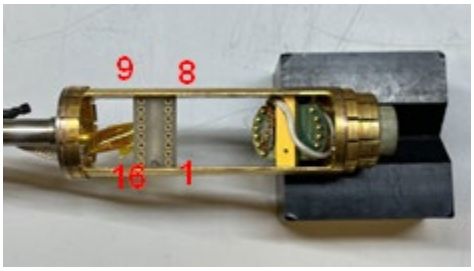


Figure 5: 16 pin DIP socket facing upwards for mounting the sample carrier. Pins numbered.

15) Vent the chamber: click in bottom tray in the area where the pressure is reported to pull up the Chamber dialog, then click *Vent/Seal*.

16) When vented, remove the baffle assembly and place it in an available tube at the side of DynaCool. Leave the KF-40 o-ring in place on the chamber, this will be needed for the MFP.

17) Ensure there is NO sample in the chamber by shining a light down and seeing the empty chamber (gold ring, pins).
    • If there is a puck in the chamber and you are not trained in removing pucks, contact Neil and do NOT try to remove it yourself.

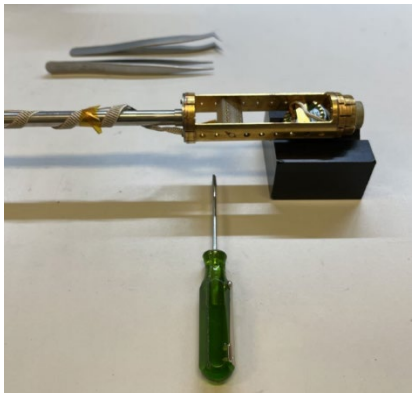


Figure 6: tools used for orienting socket and for inserting sample.

18) Carefully lift the MFP out of the bracket and hold at two places along the probe that do not pinch the wiring. These can be the head of probe and one of the black baffles, or an upper and lower baffle (in this case beware of probe being top heavy).

19) Insert probe into PPMS with the key on the bottom connector facing forward (Fischer connector will be facing toward the back of the system).

20) Lower carefully into the chamber and seat it into the bottom of chamber by pressing down lightly and seeing that the KF-40 flange is seated.

21) Put the clamp on the KF-40 flange.

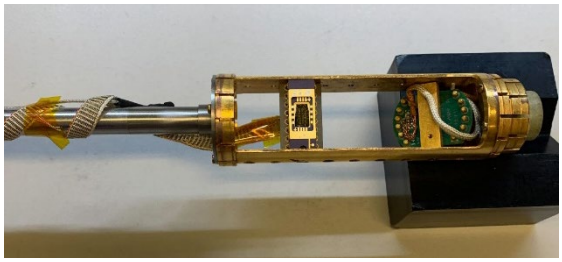


Figure 7: sample chip carrier fully inserted in the socket.

22) So important:
    - Purge/Seal the chamber in MultiVu
    - Verify that the pressure stays below 20 torr at end.

23) Move the electronics rack back to the wall, in it's blue tape outline.
    - Pick up the power cord for the rack when moving it, don't run over the cord!

24) In MultiVu, activate the temperature control for the MFP:
    Utilities > Activate Option... > Multifunction Probe (Activate -->>)
    Select MFP-407 in the dropdown menu, enable user temp

25) You will see a blue background for the temperature in the Multivu tray when the user temperature is being reported.

26) After chamber purging concludes, float the center conductors of pins needed for measurement and proceed.

When finished with measurements

27) Stabilize temperature at 300 K, field at zero. If coming from low T (< 270 K), allow 30 minutes for whole chamber to warm. Alternately, open BRlog (*Utilities > Tools > _BRLog*) and monitor "high next therm (K)" so see that it has reached 300 K.

28) Ground all the switches at BNC box.

29) Deactivate the MFP user thermometer: in MultiVu, *Utilities > Activate option...* (select *Multifunction Probe* and <<-- *Deactivate*).

30) Quit any software using USB cables, send your data files to yourself over the network.

31) Unplug USB cable to PC.

32) Move the electronics rack back near the bench as shown in Fig. 3.

33) Vent/Seal the chamber and remove the probe:
    Careful to keep it vertical the whole way out of chamber and not stress the probe

34) Put probe back into blue bracket and V-block on bench.

35) Make sure the o-ring is in place on top of the chamber, then put the baffle set back into the chamber and Purge/seal chamber.

36) Wear the ESD wrist strap if needed for your sample.

37) To remove sample carrier, loosen the screws on sides of the cage to again orient it upwards, then tighten them only slightly. Work the blunt head tweezers or other tool (not the fine tipped tweezers) underneath the carrier on each of the 4 corners in turn to lift it out.

38) To unplug the Fischer connector: hold the probe head with one hand, rest the other hand also on the head and pull back the collar on the connector slowly to work it out.
    - Be very careful to keep the probe still while pulling

39) Put the MFP back into a free tube at the side of DynaCool.

40) Move the electronics rack back to its place against the wall in its blue tape border. Lift the power cable to keep it out of the way.

41) Unplug all your BNC cables, remove adapters from them (T, banana/BNC, etc.), and hang them on cable comb on left of the rack. The next user should not have to disassemble your wiring.

42) Last thing is to unplug the Rotator/MFP user experiment cable from side of the DynaCool.

MFP transport probe at Birck Spin Lab

Designed/built by Terry Hung, Zhihong Chen's group, with help from Rokhinson Lab (2015)

This probe provides 16 wires for transport measurements in the PPMS on a 16-pin DIP sample carrier. The wires go in twisted pairs up the probe to a 24-pin Fischer connector at the probe, and a white cable takes the signals to a BNC switch box on the electronics rack. From there the user routes BNC cables to the electronics of choice.

There is also a green sample mount, identical to the mount found on the QD rotator probe, below the DIP socket on the probe. It has a thermometer built in and is turned on by activating *Multifunction Probe* option in MultiVu. Consult the Rotator instructions for help with cable connections. In these instructions below, I will assume the 16-pin DIP is being used.

Wiring your sample: Chip diagram below shows the pin assignment relative to an alignment notch typically on chips and also found on the DIP socket on probe. The numbers correspond to numbers on the BNC switch box.

There is a black dot on the side of the DIP socket indicating pin #1.

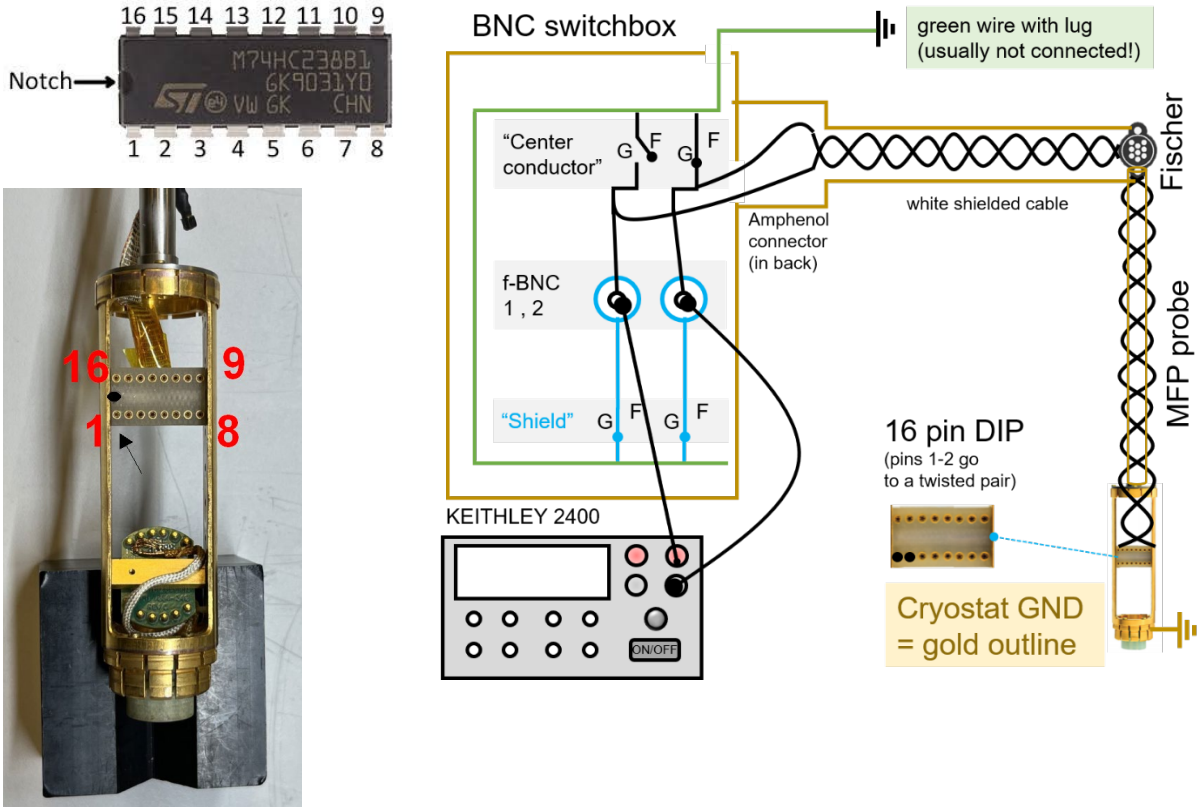


Figure 7: LEFT: pin numbering on a DIP-16, showing location of pin 1 indicated by a black mark on top as well as a black dot on side of socket (see arrow).
RIGHT: grounding scheme of this MFP with a simple example of measuring across pins 1-2 with a Keithley 2400 sourcemeter; notes below.

Notes:

- BNC switchbox labels:
  - Ground (switch will be thrown TOWARD the BNC connector). Recommend grounding all connections when inserting probe or changing wiring, so you minimize risk of ESD.
  - Float, use this to pass your signal through.
- Top row of switches is for shield of BNC (only used internally in box), while bottom is for center conductor.

- In grounding scheme drawing above, note that the *noisy* cryostat/enclosure ground (gold) follows through to the body of the switchbox, while the *quiet* experiment ground (green) is determined from the quietest analog ground of your experiment (usually the low side of a sourcemeter or gating voltage).
- In the exampe above, the LO side of the Keithley 2400 connects to pin 2 and provides that ground by setting the Center Conductor switch to ground, thereby connecting it with the green wire bus.
- The gold and green are to be kept ISOLATED from each other.
- There green wire had a ground lug (out the back of the BNC switchbox) but was removed because this causes more problems than it solves. Simply reference your quiet ground to your instrument LO measurement.
- Only ONE ground reference should be supplied for experiment ground, otherwise ground loops result and can have noise and ESD damaging effects on samples.
- For low impedance (<kOhm) samples which require more current to generate a signal: Follow the twisted pairs for your signal pairs I+/I-, V+/V- . This reduces inductive crosstalk which is important in low impedance samples (higher drive currents → higher inductive coupling).
  The pairs are 1-2, 3-4, 5-6, …, 15-16.

More details on the probe design

Wiring diagram: from front of BNC switch box to 16 DIP at bottom of MFP probe.

BNC	Mil.	cable	Fischer	DIP
16	s	blue	2	16
15	c	brown/B	7	15
14	d	brown	10	14
13	R	blue/B	8	13
12	N	orange/B	21	12
11	P	orange	20	11
10	e	yellow/B	22	10
9	g	purple	23	9
COAX	Z	light green	19	COAX
1	E	pink	18	1
2	D	grey	17	2
3	C	white/B	16	3
4	B	white	15	4
5	A	pink/B	13	5
6	T	yellow	14	6
7	X	purple/B	24	7
8	W	grey/B	12	8
19	j	red	N/C	N/C
18	b	light blue	N/C	N/C
17	a	light green/B	N/C	N/C
23	V	green	N/C	N/C
22	U	green/B	N/C	N/C
21	f	red/B	N/C	N/C
20	h	light blue/B	N/C	N/C

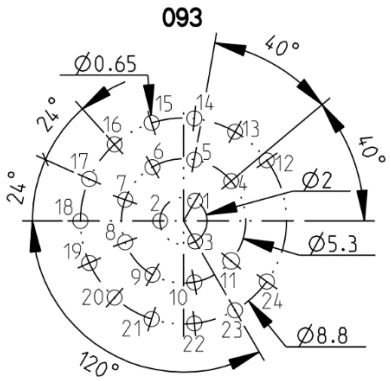
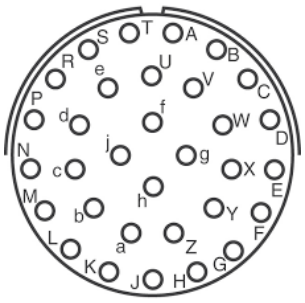


Figure 8: TOP: Fischer connector at the probe head, viewed from the OUTSIDE. BOTTOM: Amphenol 18-32 connector on rear of BNC switch box.



NOTES:

- BNC: connectors on front of switch box
- Mil.: round military (Amphenol) connector on back of switch box
- cable: white cable running to probe. The shielf braid of cable was grounded only mid-2019, and is now connected to switch box body with a short blue wire.
- Fischer: 24 pin Fischer DBPE 105 A093-80 (hermetic) at MFP probe head
- DIP: 16 pin DIP socket at bottom of probe.
- "COAX" from Fischer 17: this wire uses a separate braided coax (shield not used) instead of the Constantan wire loom used for the other wires. It terminates at a female pin socket near sample. Used for higher voltages for e.g. gating (up to 80 V used to date).
- wiring from Fischer to DIP: Constantan twisted pair loom (DIAM 75um???), provided by Yong Chen's group in physics. Single wire resistance ~ 90 ohms. Used for low static heat leak and for constant resistance vs. T (though the latter may not be important since we are making 4 terminal measurements). Colored cells in DIP column and ▢ indicate the twisted pairs are DIP 1-2, 3-4, 5-6, etc. This means that signals should run on these pairs (I+/-, V+/-).

- "/B": black stripe on wire insulation in white cable.
- note upper/lower case for Mil wires

Example wiring tables

General comments:

- **Gnd Ref**: indicates that this shield provides GND shielding for experiment. There is only ONE Gnd Ref. connection, otherwise ground loops result.
- GND wire (green) can provide Gnd Ref., alternately an SMU can provide that through a BNC.
- **Shld Fn.:** the shield of the connector on a SMU can be float/ground; also may have another function, e.g., current return
- There is a custom trigger link cable in the lab which goes from a 8-pin micro-DIN to a BNC: micro-DIN pin 2 goes to the center pin of the BNC while micro-DIN pin 8 (digital common) goes to the shield. To use this as a reference input to lock-in, on Keithley 6221 you should select line #4 for phase marker (and make sure the trigger in / out at CONFIG > TRIG menus do NOT use #4 otherwise you'll get an error). At front panel of K6221 you'll press CONFIG > WAVE > PHASE-MARKER : state = ON, OUTPUT-LINE = **4**. See K6221 manual for more detail.

BNC switchbox					External electronics (SMUs)	
Sample contact	**DIP**	**Ctr (F/G)**	**Shld (F/G)**	**Gnd Ref.**	**Shld Fn.**	**Make&Model ; cable connections ; comments**
GND wire for box (green) = G						not connected
I+	1	F	G	Y	I-	K6221 triax-BNC; output low=earth ground (Sec. 2-6 of manual)
I-	2	F	G		X	(connects to 6221 through cable to I+)
V+	15	F	F		G	SR830 A
V-	16	F	F		G	SR830 B
Measurement: Hall bar using "A-B" mode on SR830; lock-in trigger: from 6221 TRIGGER LINK 3(selectable on 6221)/8 (digital common) to BNC to SR830 REF IN						
LEGEND: **F** = float ; **G** = ground ; **X** = not connected ; **ban** = banana plug						

BNC switchbox					External electronics (SMUs)	
Sample contact	**DIP**	**Ctr (F/G)**	**Shld (F/G)**	**Gnd Ref.**	**Shld Fn.**	**Make&Model ; cable connections ; comments**
GND wire for box (green) = G						not connected
I+						
I-						
Vy+						
Vy-						
Vg HI						
Vg LO						
LEGEND: **F** = float ; **G** = ground ; **X** = not connected ; **ban** = banana plug						

(more tables should be added as more helpful examples get documented)