TXR INTERFACE MANUAL v. 1.1

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Introduction

The NIST Thermal-infrared Transfer Radiometer (TXR) is a portable radiometer that can provide NIST-traceable verifications and intercomparisons of the radiance scale of users' blackbody sources at users' facilities. More details on the purpose and internal design of the TXR were given previously [1,2].

To enable practical shipping and retain calibration, the TXR is housed inside of its own portable cryostat. The TXR Cryostat mainly consists of a cold plate on which the TXR optics are mounted, a liquid-nitrogen dewar in intimate contact with the cold plate, a vacuum shell surrounding the cold plate and dewar, an outer case with mounting holes for mounting in the user's facility, and a ZnSe window through which the TXR views the user's blackbody source. The overall weight is 26 kg, and it will fit into a box 40 cm tall, 40 cm deep (along the optical axis), and 32 cm wide. See Figure 1. An electronic version of this drawing in AutoCad format is available to facilitate design of proper adapter mounts, flanges, etc.

The typical user facilities (including one located at NIST) operate their blackbody sources in large vacuum chambers (pressure < 10^{-6} Torr) that may or may not have inner shields cooled with liquid nitrogen to reduce infrared radiation background and simulate space. In some other cases, however, blackbody sources are operated in a room-temperature laboratory at atmospheric pressure. Thus, the TXR has two modes of operation: chamber mode and ambient mode, depending upon the environment in which the blackbody source is operated. In the chamber mode, the entire TXR Cryostat is placed inside of or mounted to a viewport of the user's vacuum chamber, henceforth referred to as the host chamber. In the ambient mode, the TXR Cryostat is simply placed on an optical table, for example, in the user's room temperature, atmospheric pressure laboratory. Many of the interfacing considerations discussed below will apply only to the chamber mode, as the ambient mode interfacing is rather trivial in comparison. In the chamber mode of operation the entire TXR Cryostat, including its outside case, fittings, tubing and cables leading to it, will be in vacuum and cooled by conduction and radiation to temperatures somewhere between 77 K and 300 K, depending on the host chamber. The TXR Cryostat and its feedthroughs are specifically designed to provide leak-free operation under such conditions.

1. General Description and Mounting

The TXR is built into its own portable cryostat. Figure 1 is the cryostat top-level drawing in machine drawing format, showing a plan view (from the top), an elevation view (from the side), and a bottom view. The **body** of the cryostat is the right circular cylinder (12" outer diameter, shown in red). The **can** is the right circular cylinder (12" outer diameter, shown in blue) that seals to the body via an indium seal. This indium seal is tightened by the 36 bolt flange (13.5" outer diameter) outside of the cylinders. The can, body, and flange are all made from aluminum. The 36 bolts are 1/4-20 stainless-steal socket head cap screws. The holes on the body side of the flange are clearance holes, while those on the can side are tapped for 1/4-20.

The rectangular **baseplate** (15.25" x 12.5", shown in blue) is dimensioned on the bottom plan view. The baseplate has been mounted to the can by a vacuum-compatible two-component epoxy (DER 331/Versamid 140 made by Dow Chemical – this is similar to DER 332/Versamid 140). The baseplate has 4 clearance holes (0.265 diameter) at the corners of a 10" x 10" square centered on the can cylinder axis. These are intended to be used to bolt the TXR onto the host chamber mount using four ¼-20 bolts. A set of vented stainless-steel socket head cap bolts and belleville spring washers will ship with the TXR for this purpose.

The proposed method of mounting the TXR in a chamber is through a mounting plate on the bottom of the TXR Cryostat. The user needs to design an adapter for mounting from this plate into the host chamber. The TXR Cryostat is a side-looking instrument, designed for viewing horizontally radiating blackbody sources. For vertical radiating sources or other configurations, a mirror can be used.

In order to measure radiance, the TXR needs to be mounted close enough to the source exit aperture that the TXR field of view is overfilled by the source. The angular field of view of the TXR is 2° measured at the entrance aperture, and the diameter of the entrance aperture is 2 cm. For example, for a source exit aperture of 3.8 cm, the TXR entrance aperture must be no more than 30 cm from the source exit aperture. The preferred location of the TXR in an environmental chamber is the location where flight instruments reside when they are calibrated against the blackbody source.

As an option for kinematic mounting, the base plate also has kinematic mounting holes milled into its bottom surface (Fig. 1, bottom view). One of the holes is a divot, one is a right circular blind hole, and one is a slot (There are 4 sets of these holes). With a mating pattern on the host chamber mounting plate, three spherical balls placed into the three holes will form a kinematic mount. These holes are fully vented to avoid virtual leaks, in the case that a kinematic mount is not required and the base plate simply rests on top of a flat plate.

2. Optical

On the plan views, the 90° line indicates the TXR optical axis. The elevation view shows that the TXR optical axis is 2.5" above the bottom of the base plate. The single optical port into the TXR cryostat is through the plane-parallel ZnSe window mounted normal to the optical axis. The ZnSe window is sealed to a weldable stainless steel flange (Part #9791886 from Insulator Seal, Inc.), which is in turn welded onto the can. This window flange is specified to be leak-tight from room temperature down to 77 K.

The TXR aperture stop is located 14.4 cm behind the front edge of the base plate. The TXR aperture stop is 2 cm in diameter and the nominal full field of view as measured from the aperture stop is 2° centered on the optical axis. The blackbody under test must be close enough to the TXR that the projected spot size of this field of view fits (with clearance for alignment tolerances) in the blackbody exit aperture. This is very important, as an accurate measurement of blackbody radiance temperature relies on this condition being true.

For x-y alignment of the TXR optical axis relative to that of the blackbody under test, the TXR has an internal red laser beam that (when on) emerges from the ZnSe window on the TXR optical axis. This can be used to check alignment during the mounting. This laser beam works whether the TXR is at room temperature or cooled to 77 K. However, it is not anticipated that a means for detecting the position of this beam on the blackbody source will exist in the typical chamber facility when the chamber is closed.

To control the blackbody cavity loading effect to some degree, the front end of the TXR is equipped with a black plate called the scene plate(not shown in Fig. 1). The baseplate has a set of six tapped holes (#1/4x20) in the front of the TXR, in a line on 2” centers, providing for the mounting of TXR scene plate. The scene plate is mounted normal to the optical axis from an angle bracket bolted to the baseplate via the six tapped holes (1/4-20 on 2” centers) on the front (90° direction on the bottom view) of the base plate. On the surface that faces the blackbody source under test, the scene plate is painted with MH2200, a vacuum-compatible diffuse black paint. The purpose of the scene plate is to provide a nearly black scene for the blackbody under test, thereby baffling the blackbody under test from chamber or room reflections from the shiny TXR cryostat surfaces. The scene plate has a hole in it centered on the optical axis to enable the radiance from the blackbody to pass through to the ZnSe window. This hole is a non-limiting aperture. Both the TXR window flange and the blackbody scene plate each have a temperature sensor attached to them. The scene presented to the blackbody under test by the TXR is that of the scene plate with a view of the ZnSe window as seen through the hole. This scene is easier to model, if that should become desired, than the highly reflective scene that the TXR would present to the blackbody if the scene plate were removed. Data on the spectral reflectance of the ZnSe window and the MH2200 paint will be available for use in models used to correct the blackbody emitted radiance for cavity loading effects.

The space between the blackbody scene plate and the ZnSe window flange is reserved for a future upgrade to the TXR, which will involve a small blackbody on a small stepper-motorized translation stage. This blackbody will function as an operational check source. It is not yet available in the current TXR version.

3. Cryogenic

During operation, the TXR Cryostat must filled with liquid nitrogen. The level can be maintained by an auto-refilling system from a liquid-nitrogen storage tank self-pressured to about 25 PSI. The auto-refill system will ship with the TXR. It uses a capacitive level sensor mounted in the TXR Cryostat internal nitrogen dewar. A suitable storage dewar can be shipped with the TXR, but since liquid nitrogen is typically used in the user’s facilities, it may be less expensive and simpler for the user to provide this. The TXR Cryostat internal nitrogen dewar has a 4.5 liter capacity, and after an initial cooldown, the time between liquid-nitrogen autofilling events will be greater than 12 hours. The liquid-nitrogen usage is less than 40 liters for the initial cooldown and less than about 15 liters per day thereafter.

The TXR cryostat houses a 4.5 liter capacity liquid nitrogen fill-type dewar. This dewar is supported from the top flange of the cryostat body via three equally spaced tubes (see top plan view) that lead into the dewar nitrogen space. Each of these tubes is fitted on the top with a 1.33” outer-diameter mini-conflat flange. One of these tubes is occupied by a liquid nitrogen fill tube terminated in the dewar with a phase separator. The second is occupied by a liquid nitrogen vent tube. The third is occupied by a capacitive liquid nitrogen level sensor* (American Magnetics Inc. Model 186). A fourth tube penetrates the TXR top flange of the cryostat body at the center of the cylinder axis. It is also fitted at the top by a 1.33”outer diameter mini-conflat flange, and can be used to evacuate the TXR internal cryostat vacuum. This is the sole, common vacuum space in the TXR cryostat, and is the vacuum surrounding the optical components. The fill tube, the vent tube, and the evacuation tube all terminate in ½” Cajon VCR fittings (Cajon VCR Metal Gasket Face Seal Fittings, ordering # SS-8-VCR-3 for socket weld gland, original style copper gaskets, ordering # SS-8-VCR-1 for female nut.) The rotatable female nut is on the TXR side of these fittings. The TXR will ship with the necessary copper gaskets and tools required to make these vacuum seals.

In general, the TXR requires two (2) nitrogen tubes and one (1) evacuation tubes. All three of these tubes must connect to the top of the TXR cryostat through 1/2" Cajon VCR fittings that mate to those described above (male side on tubes), feed through the host chamber shroud (if there is a shroud) and vacuum wall, and be available for connection to the liquid nitrogen source or the vacuum pump. One of the nitrogen tubes is used for filling liquid nitrogen into the TXR Cryostat internal dewar, and one is used for venting the nitrogen boiloff from the TXR Cryostat internal dewar. NIST recommends using 1/2" flexible stainless steel tubing for these tubes. The TXR can be shipped with the necessary tubes, but the user must supply NIST with information regarding the necessary tube lengths and required connectors on the host chamber side of the tubes.

Omission of the evacuation tube (and hence requiring only the two nitrogen tubes) would mean the TXR and host chamber would share a common vacuum. This would probably allow a better TXR vacuum, since pumping the TXR vacuum through a long evacuation tube via an independent pump would probably result in a lower pumping speed from the TXR vacuum space. However, in cases where desired, the TXR can ship with a portable turbomolecular pumping station (the one used for the TXR ambient mode) so that it can be evacuated independently of the host chamber.

4. Electrical

The TXR wiring chart is shown in Table 1. The TXR cable harness terminates at a single 50-pin D-subminiature connector. This is a Cinch type DDM-50P male connector. It is the standard 0.109" density design and will mate with a 50 pin D-subminiature female connector such as Cinch type DDM-50S or equivalent. NIST can supply such a mating connector if necessary. This connector is denoted DB-50 in Table 1. The other columns in Table 1 show the individual leads in the TXR cable harness and the pinouts of the TXR components.

The TXR cable harness leads from the DB-50 connector to two, 25 pin D-subminiature connectors on the TXR, denoted DB-25 A and DB-25 B. The connectors used are Cinch type DBM-25S socket on the TXR side, and Cinch type DBM-25P plug on the cable harness side. Each DB-25 socket connector is mounted on a connector block outside of the TXR vacuum that is mounted near a hermetic 25-pin electrical feedthrough that actually penetrates the TXR vacuum housing. The positions of these two electrical feedthroughs, are shown in Fig. 1.

The cables used to make up the TXR cable harness, and the recommended cable for host chamber extension cables, consist of 4 teflon-insulated wires surrounded by a shield, which is in turn surrounded by an outer teflon insulation. NIST can supply this type of cable if necessary. The TXR cable harness consists of 10 such cables. Table 1 shows which component leads are grouped into which cable. That is, DB-50 pins 1 to 5 connect through cable 1, DB-50 pins 6 to 10 connect through cable 2, etc. The shields of all 10 cables do not connect to ground at the TXR (NC = no connection in Table 1). Since it is best to ground the shields only at one common grounding point, they are fed through the DB-50 connector on every 5^{th} pin, as shown in Table 1. The common grounding point is at the TXR instrument rack.

The InSb and MCT detectors each have a cold-CMOS current-to-voltage preamplifier mounted next to them within the TXR, so the lowest level voltages from these are in the millivolt rms range, chopped at 42 Hz to 44 Hz by the TXR's internal tuning fork chopper. The highest levels on the signal lines are in the 10 volt range, again chopped at 42 Hz to 44 Hz by the TXR's chopper.

5. Data

The TXR instrumentation and data-logging is controlled by a personal computer via a GPIB interface, under software written using National Instruments' LabView. This computer will ship with the TXR.

6. Power Requirements

For room-temperature rack-mounted electronics: 120 VAC, 50/60 Hz, 250 W to 500 W estimated total power consumption. Two standard outlets (one for each rack's power strip) required.

7. Items that will be shipped with TXR

TXR Cryostat (houses TXR)
Electrical cables, both ambient and chamber, with proper connectors.
Vacuum/cryogenic tubes and fittings, both ambient and chamber.
Room-temperature instrumentation electronics in portable 19" shipping rack.
Personal computer in portable 19" shipping rack.
Portable turbomolecular vacuum pump with dry roughing pump, and gauges.

8. Action items required for TXR chamber-mode use

Design adapters for mounting the TXR in host chamber.
Design host chamber feedthroughs, cables, and tubes for electrical and plumbing lines.
Fabricate interfacing hardware.

*The capacitive LN_2 level sensor requires a BNC cable for proper operation. However, its use is optional, as knowledge of the LN_2 level is not critical to the measurements and it can be estimated from ambient-mode experience. If a BNC chamber feedthrough is not available in the chamber already, it may not be worthwhile designing one.

References

[1] J. P. Rice and B. C. Johnson, "A NIST thermal infrared transfer standard radiometer for the EOS program," *The Earth Observer* **8** (3), 31-35 (1996).

[2] J. P. Rice and B. C. Johnson, "The NIST EOS thermal-infrared transfer radiometer," Metrologia **35** (4), 505-509 (1998).

Anticipated Changes to TXR Interface Manual for Version 2.0

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The TXR is scheduled to be modified during May-July 2000. Some of the changes will affect certain details of the interface. As a result, a revised version of the TXR interface will be written and become available as soon as the design details are completed. The new version of the interface manual, Version 2.0, is expected to be available by June 2000. As a way of delivering maximum information to prospective users, the changes that are being considered are summarized here:

1. The overall dimensions of the TXR will increase to: 47 cm tall, 55 cm deep along optical axis, 35 cm wide. This will be a result of replacing the existing can/baseplate with a new can/baseplate that features a removable window and has better support hardware for mounting the new checksource. The removable ZnSe window will be mounted onto the new can with a 4.5 inch conflat flange. The Versamid epoxy will not be used to mount the can to the baseplate – it will simply be bolted.

2. The optical axis will be 2.375 inches above the bottom of baseplate.

3. A vacuum-compatible checksource will be added to the front of the TXR. This will be basically a cap that is swung in front of the window by a stepper moter, providing a reproducible radiance into the TXR for checking the internal calibration of the TXR.

4. The number of required electrical feedthroughs leads will grow from 50 to nearly 100, to accommodate the motor leads, heater leads, and temperature sensor leads associated with the checksource. The format will be two, 50 pin D connectors, simply double the present format. Some of the pin assignments will change.

5. The vacuum line leading to the TXR is optional and probably not necessary. In a recent deployment test the TXR vacuum was simply valved off from the chamber using a cryogenic/vacuum compatible valve on the TXR that is now part of the TXR system.

6. The BNC connection to the TXR LN2 level sensor is not necessary, and can be deleted to save money if it is too difficult to implement.

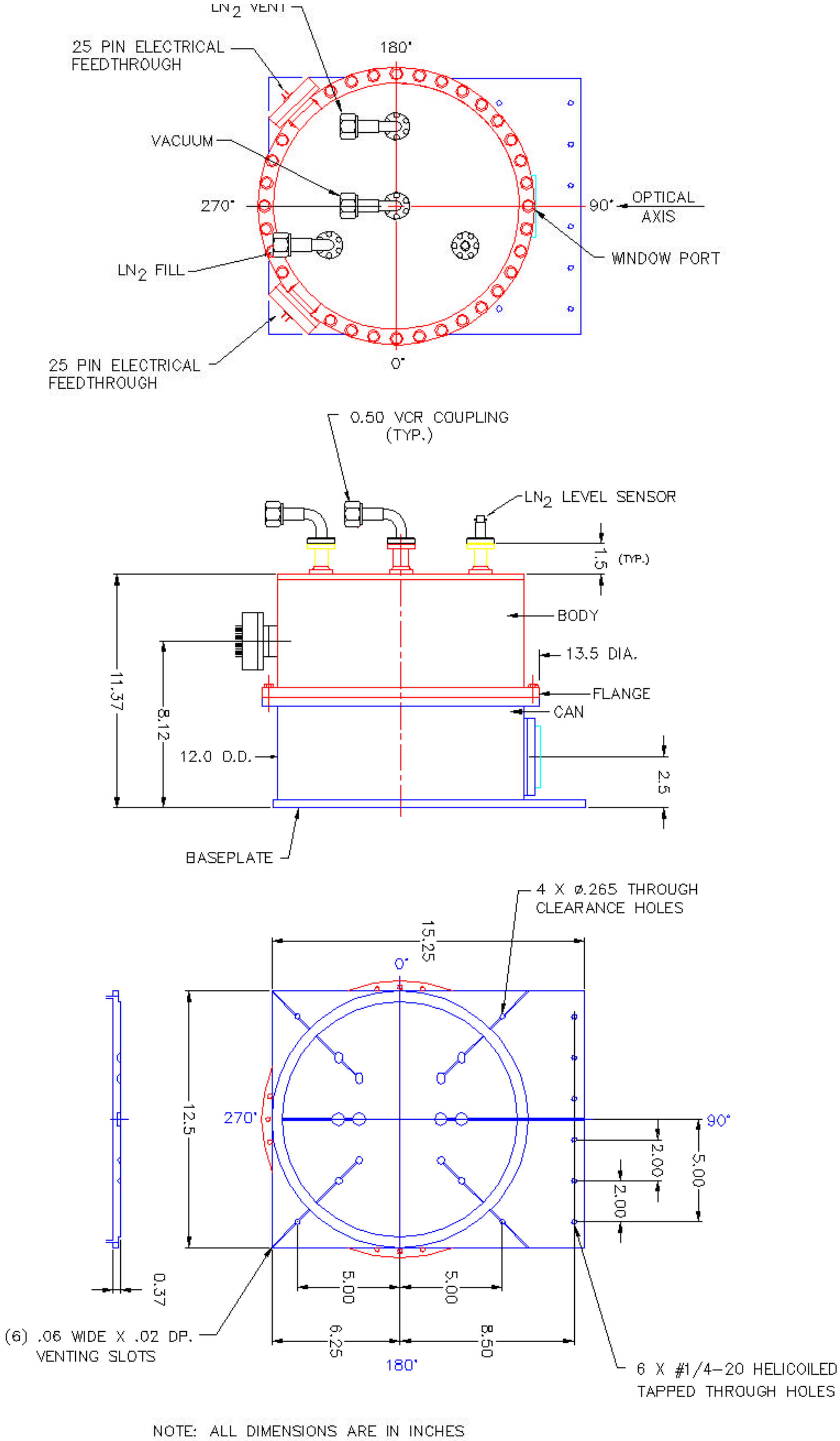
7. The field of view will decrease by as much as 25%, since the present aperture and field stops will be replaced by smaller ones.

8. The MCT cold preamplifier will be replaced with one having a larger gain, such that the MCT channel (10 μm center wavelength) signals will be on the order of 1 Volt. This may not work, in which case the MCT channel signal level with remain of the order of 2 mV.

Table 1: TXR Wiring Chart

Component	Lead	DB-25	DB-50
InSb Pre-amp	Out 2	A5	1
	GND	A6	2
	Vs+	A3	3
	Vs-	A4	4
	Shield	NC	5
InSb Temp. Sensor	I+	A7	6
	I-	A8	7
	V+	A9	8
	V-	A10	9
	Shield	NC	10
MCT Pre-amp	Out 2	A11	11
	GND	A12	12
	Vs+	A15	13
	Vs-	A16	14
	Shield	NC	15
MCT Temp. Sensor	I+	A17	16
	I-	A18	17
	V+	A19	18
	V-	A20	19
	Shield	NC	20
Stage Temp. Sensor	I+	A21	21
	I-	A22	22
	V+	A23	23
	V-	A24	24
	Shield	NC	25
Chopper Drive	Red	B5	26
	Green	B6	27
Laser	I+ (GND)	B15	28
	I-	B16	29
	Shield	NC	30
Chopper Temp. Sensor	I+	B7	31
	I-	B8	32
	V+	B9	33
	V-	B10	34
	Shield	NC	35
Stage Heater	I+	B11	36
	I-	B12	37
Chopper Sense	Black	B3	38
	White	B4	39
	Shield	NC	40
Baffle Temp. Sensor	I+	B17	41
	I-	B18	42
	V+	B19	43
	V-	B20	44
	Shield	NC	45
Plate Temp. Sensor	I+	B21	46
	I-	B22	47
	V+	B23	48
	V-	B24	49
	Shield	NC	50

Figure 1



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