



MODEL 102 PORTABLE FTIR INSTRUCTION MANUAL



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System Description

The Model 102 Portable Field Spectrometer is a complete person-portable infrared spectrometer packaged in a small case. It includes a miniature Michelson interferometer, with input optics and infrared detector, drive and sampling electronics, and embedded PC type computer. Software is supplied to acquire, process, and store spectra on an internal hard disk. A USB memory device or LAN connection can be used to transfer data to another computer. The software is controlled via a miniature keyboard, with all data displayed on a built-in miniature 6.4" diagonal color LCD screen. The screen is an active TFT type, with LED backlight, and is sunlight readable. If desired, any PS/2 type keyboard can be substituted for the miniature one and an external VGA monitor can be used in parallel with the internal LCD.

The entire instrument is ruggedized and sealed from the environment, allowing its use in the harsh conditions in the field. Operation from AC, battery, or automobile cigarette lighter is possible. Internal power use has been minimized to give the longest time on battery power.

A worldwide AC supply is standard equipment, and allows prolonged use where AC is available. The power cable for the system is a standard cigarette lighter plug, which facilitates operation from an automobile cigarette lighter socket. The input voltage is displayed on a miniature digital voltmeter on the main panel. The operating voltage range of the instrument is 10.8 to 13.2 volts DC, with positive on the center terminal of the power cord. The maximum current draw is about 6 amps when all functions are drawing maximum power. The nominal current is more like 1-2 amps, including the computer and scan. When asleep, the system draws less than 1 amp.

Optical Subsystem

The core of the spectrometer is the Michelson interferometer. This contains infrared optics, beam splitter, and a scanning mirror assembly. Input light passes through the fore optics, an aperture, and a lens (which also seals the unit) into the interferometer. The internal mirrors are servo driven at a constant speed, producing the interference patterns. The output light passes through a focusing lens (which also seals the unit) onto an infrared detector in a liquid nitrogen (LN₂) dewar. The standard detector is a dual sandwich type, consisting of Indium Antimonide (InSb) and Mercury Cadmium Telluride (HgCdTe, or MCT). This detector set has a spectral range of approximately 2 to 16 micrometers. The Dewar must be filled with liquid nitrogen before use, using the funnel provided. Be very careful when filling the detector, and always wear gloves and eye protection. The best technique is to put in about 3-4 funnels, then let the detector cool for a while. It will eventually spout a plume of vapor as the internal Dewar surface is finally cooled to 77 degrees K. After that, more liquid nitrogen must be added to fill the tank nearly to the top. If too much LN₂ is added initially, the Dewar may spout liquid nitrogen and spray it up out of the filling hole. Do not put any exposed body parts near the detector fill hole when filling the detector. Severe frostbite can result!

A temperature controlled laser diode (LD) provides the reference for the servo and sampling electronics, and wavelength calibration for the spectrum. The temperature set point for each laser diode is internal, and is preset at the factory. Since the temperature of this laser determines its wavelength, sufficient time must be allowed after powering the unit for this controller to reach its set point. This is indicated by an LED labeled "LD" on the control panel,

and is usually 1-5 minutes. The “LD” LED will be red if heating the LD, green if cooling it. It should be dim or extinguished when the set point is reached.

The detachable fore optics are used to aim the instrument at a target visually, and direct target energy into the input of the interferometer. It is a two piece assembly, having a separate eyepiece assembly and rotating input optic. The standard input optic is 1 inch in diameter, with a 4.8 degree expanding field of view. This gives a 4 inch diameter spot at about 3 feet away. An optional 2-inch diameter input optic can be used, which has a 2.4 degree expanding field of view. There is no focus for the infrared energy, it is an expanding beam with increasing spot size as the distance to the target increases.

There are multiple positions of these input optics for the optical viewer focusing. The first stop is used for focusing at close range, which is good for most tripod work, looking down at the ground. The other stops, further in, are focused from about 10 feet to infinity. The input optic snout can also be used for aiming by rotating it. To view a target, the small lever in the base of the eyepiece assembly is pulled up to provide “through the lens” viewing of the target. To take data, the lever should be dropped down. This directs the input through to the spectrometer.

Electronic Subsystem

The electronic subsystem consists of a set of two printed circuit boards. One drives the scanning mirrors in the interferometer and derives control signals used throughout the system. The other performs detector signal conditioning, interface to the analog to digital converter, and three temperature control functions. Power is provided both directly by the input source and from an internal power supply contained in the computer subsystem.

The servo function drives the interferometer at a constant speed, using the laser channel of the interferometer signal as a reference. This same laser channel provides a sampling signal for the infrared detector channel. There are two BNC outputs on the panel for monitoring purposes:

“LAS” provides the laser signal, an 8-10 volt peak to peak clipped sine wave at about 5 kHz
 “DET” brings out the infrared detector signal, a burst of around +/- 1-2 volts at zero optical path difference (OPD) once per scan, or about once per second, normally.

These are good diagnostics for troubleshooting, but are not used otherwise. There are various LED indicators on the panel, located underneath, and shaded by, the mini-keyboard. They are arranged in two sets; one set contains four LEDs (3 green, 1 red) and the other set has three bicolor LED's. Between the sets of LED's is a pushbutton switch, called “BOOST”. The functions of the LED's and switch are as follows:

“DG”	(green)	flashes on during data transfer, off in between
“SCAN”	(green)	turns on when scan power is applied
“STBY”	(green)	indicates standby and computer power, no scan on
“ERROR”	(red)	indicates a problem with the laser signal

The only input to the servo function is the “BOOST” push button. This is used when the servo cannot start the scan, usually in cold conditions. This is indicated by the red “ERR” LED. This should not be applied for more than 10 seconds, as it may overheat the drive electronics:

“BOOST” (pushbutton) applies full power to the servo to get it started

The second set of LED's indicate the state of the three temperature controllers in the system. They are two-color type LED's. Green indicates the controller is cooling, red indicates warming. The brightness indicates how hard the controller is driving the temperature. When the temperature set point is reached, the LED will become dimmer and flicker a little. Off means the controller is not operating.

“INST”	(bicolor)	green means the instrument is being cooled, red means warm
“BB”	(bicolor)	green means the blackbody is being cooled, red means warm
“LD”	(bicolor)	green means the laser diode is being cooled, red means warm

There are three temperature control loops in the instrument. One controls the laser diode (LD) temperature, maintaining it at a precise internal set point, which then holds the laser reference wavelength at a precise value. This will come on for a time when power is first applied to the instrument. No data should be acquired while the LD is being driven to its set point, as it would be uncalibrated in wavelength.

A second loop controls the temperature of the interferometer, which aids in maintaining a precise calibration as the ambient temperature changes. This temperature controller is initially turned on and set automatically to the temperature at turn-on of the instrument. The set point can be changed by the user, or the controller turned on and off, under the Instrument-Temperature software menu. A change in set point may become necessary if the ambient temperature changes dramatically during an extended acquisition period. Re-setting the temperature may require a stabilization time of up to 30 minutes. It should be noted here that the temperature control has an easier time heating than cooling. For this reason, the instrument temperature should never be allowed to get below 5 degrees C of the ambient temperature. This condition could cause the controller to overheat, possibly damaging the electronics. Generally, if very high (above 35 C) or very low (below 15 C) temperatures are expected during measurement, it is best to preheat the system for an hour or more before taking it out. The set point chosen should be 1 or 2 degrees above the highest expected temperature of the measurement period.

The third temperature control loop is for the stabilized blackbody accessory. The blackbody connects externally, and is used to calibrate certain kinds of measurements. The set point and on/off control for this is done in software, under the Instrument-Temperature software menu. The three temperatures of these controllers, and a fourth ambient temperature sensor located inside the enclosure, are read out in a status line at the top of the screen. They are also stored with the data.

Temperature Alarms

There is a temperature monitoring function in the software that will warn of certain temperatures in the system being out of range. This will be evidenced by an audible alarm and flashing messages on the screen. The <alt>F9 key silences the alarm. There are three alarm conditions:

- 1.) The instrument temperature control is on, and the instrument temperature is different from the set point by the tolerance set under Factory Setup (<alt>F10). The recommended setting is 5 degrees. Any larger can result in damage to internal electronics;
- 2.) The instrument temperature is beyond the limits set under Factory Setup (<alt>F10). The instrument is designed to run between 15 and 35 degrees C;

- 3.) The ambient air temperature inside the instrument enclosure is beyond the limits set under Factory Setup (<alt>F10). The air temperature for normal operation should always be between 5 and 40 degrees C. Otherwise, components can be damaged.

The user should make all attempts to correct the alarm condition. The alarm for the instrument set point condition can be fixed by resetting the instrument temperature set point. This is done in the Instrument-Temperature software menu function. This will then require some time to equilibrate. It may also involve bringing the instrument to a warmer or cooler environment for a while. At the very least, all attempts should be made to complete data collection as soon as possible. Pressing <alt>F9 will turn off the audible alarm, but the on screen flashing messages will continue until the alarm condition is fixed. The alarms for instrument and ambient temperature limits have a built in hysteresis of two degrees C. Therefore, the instrument temperature must be brought up to 2 degrees above the lower alarm point, or down to 2 degrees below the upper alarm point to de-activate that alarm. Similarly, the ambient air temperature would have to be brought up to 2 degrees above the lower alarm point, or down to 2 degrees below the upper alarm point to de-activate that alarm.

Computer Subsystem

The computer subsystem is built up from modules conforming to the PC/104 buss standard. Three modules are used:

- 1.) Hi efficiency 50 watt power supply;
- 2.) CPU, video, and peripherals;
- 3.) Analog and Digital Input/Output (I/O).

The power supply for the computer subsystem is used to power the entire electronic package as well. The CPU module contains all the functions of a PC type computer, including video (CRT and LCD), RAM, hard and floppy disk, keyboard, mouse, serial, parallel, USB, LAN, and external VGA. A hard disk drive is mounted to this assembly. The LCD display is a standard 1024 X 768 pixel color type. The I/O board has 16 channels of 16 bit analog input, four channels of 12 bit analog output, and eight each digital inputs and outputs.

The field keyboard is a miniature 6.25" X 3.25" size, with all keys needed to run the software functions. A second keyboard supplied is an 11.3" X 5.5" unit with 88 keys, for use either inside, or in the field. Any PS/2 type keyboard can also be substituted. The 2 mice supplied with the system are a standard nine pin serial desktop mouse, and a handheld USB trackball type for use in the field. No mouse is required to run, but one can be used if desired. A standard VGA monitor can be connected to the VGA port on the panel. A printer can be connected to the parallel port or USB port for hard copy output. The USB or LAN port is used to get data off using any USB memory device.

The only external control for the computer is a "COMPUTER RESET" switch, which is a recessed pushbutton type located next to the mouse connector, under the mini-keyboard. This is used to reboot the computer if it becomes hung up at any time. It is not used under normal circumstances. There is a backup CMOS battery and speaker located under the panel. The backup battery is for time and date only, and needs changing about every 5 years. A lithium 3.6 volt type is required.

Software Operation

The software runs under Windows XP™, and is designed to look and feel like our previous DOS software, and also like any other Windows program. A mouse makes some operations quicker, but is not necessary, as all functions can be accessed easily via the keyboard. In general, either a function key, single underlined character in a menu item, or one of the cursor arrow keys can be used to navigate the screens. The ESC key generally backs out of a function, and the TAB and <shift>TAB keys are used in some screens to move forward or backwards. Every effort was made to facilitate use in the field without a mouse or other pointing device, yet still allow one when operating in more of a laboratory or other inside environment.

The main menu items are across the top of the screen, and are accessed using the mouse or using the <Alt> key and the first (underlined) letter of the title,. They are:

File Instrument Display Process Help

Each of these menu items has a drop down submenu of available functions, which will be described in turn below. There are also 10 function keys assigned for the most commonly used repetitive operations. Their functions are listed in a row of boxes located just below the main menu titles at the top of the screen. Either the function key or mouse click on the box activates them. The Function key assignments are:

F1-Acquire	F2-Open	F3-Save As	F4-Refresh	F5-Export	F6- TBD
F7-Cursor	F8-X scale	F9-Y scale	F10-Status		
<alt>F9-Disable Temp Alarm			<Alt>F10-Factory Setup		

The middle of the screen is used for graphics, either one or two windows, depending on the plot type selected under Display-Plot Type. When a plot is being displayed and no menus are active, the cursor keys are used to change plot scales in factors of 2, and, with the “Ctrl” key, pan to different plot regions one-quarter screen at a time. The operation is as follows:

Right arrow (>) = Zoom X scale 2X	<Ctrl> Right arrow [ctrl+] = Pan plot ¼ right in X
Left arrow (<) = unZoom X scale 2X	<Ctrl> Left arrow [ctrl+] = Pan plot ¼ left in X
Up arrow (^) = Zoom Y scale 2X	<Ctrl> Up arrow [ctrl+] = Pan plot ¼ up in Y
Down arrow (v) = unZoom Y scale 2X	<Ctrl> Down arrow [ctrl+v] =Pan plot ¼ down in Y

The title bar at the top of the screen is used for one line of information display, including the 4 system temperatures on the right.

There are quite a few file types used in the software. Raw binary data is saved in one of seven types of files, with distinct extensions. They are:

Setup File (.INI, .SET)	used to store instrument setup
Sample (.SAM)	used in all types of processing
Reference (.REF)	used in ratio, difference, absorbance processing
Cold Blackbody (.CBB)	used in radiance and emissivity processing
Warm Blackbody (.WBB)	used in radiance and emissivity processing
Downwelling Radiance (.DWR)	used in emissivity processing

Both raw and processed data can be exported as ASCII text files or .SPC files, so it can be imported to other applications for further processing and/or display. The ASCII file extensions all end in X. There are eleven types of exported files:

Sample (.SAX)	raw sample
Reference (.REX)	raw reference
Warm Blackbody (.WBX)	raw warm blackbody
Cold Blackbody (.CBX)	raw cold blackbody
Downwelling Radiance (.DWX)	raw downwelling radiance
Ratio (.RTX)	processed ratio SAM/REF
Difference (.DIX)	processed difference SAM-REF
Inverse (.INX)	processed inverse 1-SAM/REF
Absorbance (.ABX)	processed absorbance -log (SAM/REF)
Radiance (.RAX)	processed radiance
Emissivity (.EMX)	processed emissivity

The .SPC files all end in .SPC

File Menu

The File menu has 7 items in its submenu, selected by mouse, arrow key, or underlined letter. They are:

<u>O</u> pen	Save <u>A</u> s	Save <u>S</u> ettings	<u>D</u> ata File Name and Directory
Auto <u>N</u> ame	<u>P</u> rint	<u>E</u> xit	

File Dialog Box

Some of entries under File, and elsewhere in the software, refer to bringing up a “File Dialog Box”. Its appearance and operation are explained here. There are four sections in this box. Moving between sections can be done with the mouse or, if the keyboard is being used, the TAB key (to move forward) or <shift>TAB key (to move backward). To move within a section, the mouse or cursor key is used. The first section of this dialog box contains the directories available. The second section of this box lists various files in the current directory. They may be selected and traversed as desired. The third section will contain the file selected. The fourth section lists the currently active mask for file extensions. Once a file is highlighted, the Enter key selects it into the Filename box, and it can be opened or saved to by then selecting OK.

Menu Selections

File-Open first brings up a small dialog box containing the valid file types, as determined by the current settings for the Math function under Process. For all Math functions except Radiance and Emissivity, the choices are Sample or Reference. For Radiance, the choices are CBB (Cold Blackbody), WBB (Warm Blackbody), or Sample. For Emissivity, the choices are the same as Radiance, with the addition of DWR (Down-welling Radiance) type files. Once a file type is selected, the File Dialog Box appears, with the mask for the file type selected. All

files of that type in the current directory will be displayed in the center of the file dialog box. Any annotation saved with the file, and selected header information, is printed in the bottom of the window. The operation of the File Dialog Box is explained at the beginning of this section.

File-Save As works very much like **Open**, bringing up a small dialog box to choose a file type to save under, 1 of the 5 binary file types. Once a file type is selected, a dialog box appears for an annotation to be added to the data in the file. A line of text can be added in the long text box, or CANCEL will bypass the annotation and bring up the File Dialog Box, with the mask set for the file type selected previously. All files currently stored in the current directory with that mask will be displayed in the center section of the File Dialog Box. One of these can be used, or a new name typed in. The operation of the File Dialog Box is explained at the beginning of this section.

Save Settings has no submenu. It is used simply to save the current instrument settings into the default setup file WINFT.INI, which is loaded when the program starts. It has the same effect as when leaving the program, but does so without exiting.

Data File Name and Directory brings up a File Dialog Box. This is used to create and specify directories for data to be read from and stored to. A name entered in the File name box will be used as the base name for the Autname function.

AutoName controls the automatic file naming function. When turned on, this will automatically generate sequential filenames when taking large data sets quickly. When this menu item is selected, a submenu appears containing a dialog box for entering a root name, a selection to Activate (Off or On), and OK, CANCEL. A dot appears next to Off or On to indicate whether Autname is enabled or disabled. A root name can be entered in the space provided. If Autname is enabled, a three-digit number will be appended to that root name and files will be saved with auto-incrementing numbers. The appropriate three-character extension for the data type being saved will be added to the filename. File types (i.e. SAM and REF) can be mixed within a given root name, and annotation can be added at the time of saving the file. A prompt will appear at the time of the file save indicating the filename and extension used.

Print will bring up a standard Windows printing dialog box, then print the screen contents. A printer must be connected and installed into Windows prior to running this function.

Exit will terminate the program, but will first prompt the user whether to save current instrument settings into the WINFT.INI file, or exit without saving. The same action can be invoked with the <Alt>X keystroke combination.

Instrument Menu

The Instrument menu has 5 items in its submenu, selected by mouse, arrow key, or underlined letter. They are:

Coadds

Resolution

Zero Fill

FFT Apodization

Temperatures

Menu Selections

Coadds sets the number of spectra to be averaged into a coadded spectrum. Noise can be reduced by the square root of the number of coadds. Coadding takes extra time in data acquisition, and also results in larger data files, since all interferograms are saved to allow reprocessing at a later time. Selecting this brings up a small dialog box. The present number of coadds is displayed in a box. To change the number, select the box with mouse or cursor arrow keys and type the new value followed by Enter. Valid numbers are in the range of 1-100. Selecting OK sets the new value; Cancel retains the old value.

Resolution is used to specify the size of the FFT performed, and thus the resolution of the resulting spectrum. The number of points collected is not changed, and all interferogram data is stored in the raw data file, so any spectrum can be reprocessed later at a different resolution. Selecting this item brings up a dialog box with the choices for resolution (in cm^{-1}) on the left, with the current setting indicated with a dot. Clicking on any other setting with the mouse, or moving there with the arrow keys and hitting Enter will change the selection. On the right side is the OK, CANCEL selection. If this setting is changed, an automatic recalculation of all relevant spectra will be performed. The instrument raw resolution is 4 cm^{-1} , but is also affected by the Apodization, below.

Zero Fill is used to generate higher plot resolution at any spectral resolution. The raw FFT resolution in some cases can be quite coarse, and yield poor lineshape. By zero filling the interferogram to a larger FFT size, more points are generated in the FFT, giving better lineshape and smoother plots. The maximum FFT size in the instrument is 32,768 points. The scan length determines the maximum spectral resolution. The choices shown for a 4 cm^{-1} instrument under this menu are:

<u>N</u> one	no zero filling
<u>2</u> X	interferogram filled out with two times the number of points
<u>4</u> X	interferogram filled out with four times the number of points
<u>8</u> X	interferogram filled out with eight times the number of points

If this setting is changed, an automatic recalculation of all relevant spectra will be performed.

FFT Apodization sets the weighting function to be used to window the interferogram data before performing the FFT. Selecting this item brings up a dialog box with a list of 6 possible functions. Next to each selection is a multiplier for the Resolution selected under Instrument-Resolution, above. The currently selected function is marked with a dot. The choices listed are:

<u>N</u> one	gives the highest resolution of 1.0X
<u>T</u> riangle	gives the medium resolution of 1.5X
<u>H</u> anning	gives the medium resolution of 1.5X
<u>H</u> amming	gives the medium resolution of 1.5X
<u>G</u> aussian	gives the medium resolution of 1.5X
<u>B</u> lackman	gives the lowest resolution of 2.0X

In general, the apodization to be used depends on whether it is more important to

suppress noise or see sharp features. Going from the top of the table to the bottom, the sharpness decreases, while the noise suppression increases. Since all interferograms are saved, the apodization can be changed on data in memory or in stored files, and the spectrum recomputed. If this setting is changed, an automatic recalculation of all relevant spectra will be performed.

Temperatures is where all instrument and blackbody temperatures are set, and their respective controllers can be turned on and off manually. When this item is selected, a dialog box is displayed. At the top of this box, there are three entries for blackbody set points, all in degrees C. The topmost entry (Manual BB Set Point) is for manual control of the blackbody from this screen. After setting a temperature here, the blackbody must be turned on, using the BB on/off control at the bottom of this dialog box. The next two entries (AutoCalibrate Cold BB and AutoCalibrate Warm BB) are for the Cold and Warm set points for the blackbody in the automatic calibration sequence, which is explained under the **Process** menu description, **Calibrate** function. These are the set points that will be used in the calibration sequence of cold, then warm blackbody. They are entered here to avoid having to specify them each time a calibration is done.

Below the three blackbody set points is the Instrument Set Point. This is the set point for the instrument temperature controller. It is initially set at the current instrument temperature when the system is turned on. It may be reset manually at any time. To change any of these set points, use the mouse or Tab keys to select it, and type the new value, followed by Enter. The new value should appear in place of the old.

Below the set points are two on/off controls. One is for instrument control, the other for manual blackbody (BB) control. The current state of each control has the dot filled in. The initial settings are Instrument control ON, Blackbody control OFF. To change these, use the mouse, or use the Tab key to select the control, then the cursor key to change it to a new setting. All new settings will take effect when Enter is pressed, or the OK button is activated. Selecting Cancel will reload the previous settings.

Display Menu

The **Display** menu has 3 items in its submenu, selected by mouse, arrow key, or underlined letter. They are:

Plot Type Display Units Plot Scales

Menu Selections

Plot Type specifies what type of display to use for data. The choices are:

<u>I</u>nterferogram	displays the interferogram full screen in one window
<u>S</u>pectrum	displays the spectrum full screen in one window
<u>B</u>oth	displays the interferogram in one window at the top of the screen, and the spectrum in a separate window at the bottom of the screen.

Selecting this item brings up a dialog box with three choices. The current selection will be marked with a dot. To change the plot type, use the mouse to click on it, or cursor keys plus Enter to select a new setting. The submenu closes, and the existing data will be re-plotted. If

there is no data, no re-plot will be done.

Display Units is used to set the X and Y axis units for all displays. There are three choices for the X units:

<u>M</u> icrometers	The X scale is displayed and exported in micrometers (μm)
<u>N</u> anometers	The X scale is displayed and exported in nanometers (nm)
<u>W</u> avenumbers	The X scale is displayed and exported in wavenumbers (cm^{-1})

It should be noted that the X, or wavelength, scale is not linear, i.e. having unequal delta X values. Any plot or further processing of ASCII exported data should use the wavelength scale included in the X, Y data.

The Y units are those for raw data only. Processed data is either dimensionless or expressed in calibrated units of physical properties. At present, there is only one choice for raw data units:

Volts per FFT component	The Y scale is detector volts per spectral element.
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The currently selected units for each axis are marked with a dot. To change units, click on the new setting with the mouse, or use the arrow keys or Tab to highlight the new choice. The dot will indicate the new selection. Then choose OK to finish the process, and the new scales will take effect. Choose Cancel to leave without changing the units.

Display Scales is used to set the display limits for interferogram and spectral plots. When this item is activated, a dialog box appears to select Spectrum or Interferogram scales to set. Choosing one of these brings up another dialog box containing settings for the X scale and Y scale. For the X scale, a low and high limit can be set, or there is a choice for All X points to be displayed. These are mutually exclusive choices. When displaying a plot, the F8 function key can be used to toggle between All X and the manual limits set here. For the Y scale, a low and high limit can be set, or Auto scaling. These, too, are mutually exclusive choices. When displaying a plot, the F9 function key can be used to toggle between Y-axis auto scaling and the manual limits set here. Once the limits are set up, choosing OK sets the new limits, or Cancel leaves them unchanged. It should be noted here that the manual scale settings are altered when using the cursor arrow keys to zoom and pan on a plot being displayed. To get back to specific manual scale settings, this screen will have to be used.

Process Menu

The Process menu normally has 1 item in its submenu, selected by mouse, arrow key, or underlined letter. If Radiance or Emissivity math is selected, a second item to calibrate a sample appears. Once a sample has been calibrated, a third item to fit a Planck function to a calibrated radiance appears. If a Planck function has been fitted to a calibrated radiance, a fourth menu item appears to remove the Planck function. The four functions are:

<u>M</u> ath	(<u>C</u> alibrate Instrument)	(<u>F</u> it Planck to Radiance)	(<u>R</u> emove Planck Plot)
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Menu Selections

Math is used to set which math, if any, is to be done on acquired or restored data files. The choice of Math function also determines what types of data will be acquired or restored when any of those functions are used. When the Math item is selected, a dialog box appears with a choice of none, or six different math operations. They are:

None		no math performed, raw data displayed
Ratio	Sam/Ref	the Sample file is divided by the Reference file
Difference	Sam-Ref	the Reference file is subtracted from the Sample file
Difference	Ref-Sam	the Sample file is subtracted from the Reference file
Inverse	1-Sam/Ref	the ratio function is subtracted from 1
Absorbance	-log (Sam/Ref)	the logarithm of the ratio is calculated and negated
Radiance	f (cbb,wbb,sam)	calibrated Radiance in (Watts/(m ² *microns*sr))
Emissivity	f (cbb,wbb,dwr,sam)	a calibrated radiance is corrected for sky reflected energy and divided by a Planck at the estimated sample temperature

The current math function being used will be indicated with a filled in dot when the Math function is selected. To change the function, click on the new one with the mouse, or arrow to it and press Enter. The menu will close, and, if the data is available, the plot with the new function will be calculated and displayed. To leave the Math function without changing anything, press ESC or Cancel.

Calibrate Instrument appears under the Process menu if either Radiance or Emissivity is chosen as the Math function. This operation requires two blackbody data files (a Cold and a Warm) to be acquired or restored. The calibration function generates a slope and offset correction at each wavelength, which is then used to take out the instrument function when displaying sample Radiance or Emissivity. The units of Radiance will be in [Watts/m²*um*sr]. The generation or regeneration of these corrections takes place automatically whenever any blackbody is acquired or restored. At least one Cold and one Warm blackbody are needed for a valid calibration. As soon as one of each is loaded, the calibration function is generated. This is indicated by the "Instrument Calibrated" message in the lower left part of the bottom of the screen. Subsequent acquisition or restoring of any blackbody data will automatically trigger a re-calibration to occur. The calibration will be valid even if other math functions are selected and other types of data collected.

Selecting this menu item brings up a submenu with three choices:

Use Internal BB	to acquire new BB data using a D&P BB
Use External BB	to acquire new BB data using an external BB
Open BB Files and Calibrate	to use stored BB data

Selecting the first option, **Use Internal BB**, will open a dialog box for the Auto Calibrate function. From this screen, the instrument's blackbody can be controlled, data acquired, and instrument calibration performed. There are 5 choices on this screen:

Set Cold BB	selects the cold setting for blackbody, highlighted if selected
Set Warm BB	selects the warm setting for blackbody, highlighted if selected

Acquire	acquires the cold or warm blackbody data when at temperature
BB Off	used to turn the blackbody controller off after collecting data
Close(X)	closes the Auto Calibrate screen

The **Set Cold BB** and **Set Warm BB** choices each have the current set point for each printed underneath the selection box. These are preset by the user under the Instrument-Temperature menu item. The **Acquire** box has a note under it as to the current state of the BB control. It will indicate whether the BB control is Off, or display the set point when Cold or Warm is selected. **BB Off** is used to manually turn off the blackbody after all data has been collected. The instrument calibration will be updated automatically after a new BB file is loaded or acquired, even if the Math function is changed.

Once the choice of cold or warm blackbody has been made, the blackbody will be turned on and start slewing to the set point. It may take a few minutes for the blackbody to reach the set point. The actual blackbody temperature is indicated on the status display at the top of the screen as "Tbb". When it has stabilized at the new set point, the acquisition can be started. Activating the **Acquire** function starts the scan and acquires the data. The instrument scan will be turned on, then acquire the number of coadds presently set, then prompt for the data to be saved or not. Saving will bring up the File Dialog box, described under the File Menu description. The blackbody temperature will be read and saved with the data for use later in the calibration. After that, control returns back to the Auto Calibrate screen. From there, blackbody data can be taken or re-taken, the blackbody turned off, or the Auto Calibrate screen can be closed.

Selecting the second option, **Use External BB**, will bring up the External Blackbody Temperature dialog box. The temperature of the external blackbody should be entered in degrees C as XX.X in the data field, then the data should be tagged as either Cbb or Wbb, by selecting the proper type at the bottom of the dialog box. Selecting OK will then acquire the data, Cancel will exit the function. After the data is acquired, a prompt will appear to Save it or Cancel. Saving will bring up the File Dialog box, described under the File Menu description. The external blackbody temperature entered at the beginning of the sequence will be stored with the data for use later in the calibration process.

Selecting the third option, **Open BB Files and Calibrate**, will open the File Dialog box, which is described under the File Menu description. Using the File Dialog box, choices are made for a previously stored Cold, then Warm blackbody files. These are loaded into memory one at a time when they are selected, the instrument is re-calibrated, and the menu closed.

Fit Planck to Radiance or **Find Sample Temperature** appears under the Process menu only if three operations have been performed:

- The Math function is set to Radiance or Emissivity
- The instrument has been calibrated with Cold and Warm blackbodies
- A sample has been acquired or restored

This function is used to fit a Planck function to a Calibrated Radiance spectrum or calculate an estimate of the Sample temperature for the Sample data loaded. Once selected, a dialog box appears to set the temperature to be used for the Planck. There are two choices for setting the Planck temperature:

<u>Manual-Input Planck Temperature</u>	allows user to set Planck temperature manually
<u>Auto-Fit Planck Temperature</u>	fits the Planck to the Calibrated Radiance

For the Manual input, a dialog box appears where a Planck temperature can be entered in degrees C as XX.X. A temperature can be typed into the prompt on the screen, followed by Enter. Activating the Compute function computes the Planck at the specified temperature and overlays it on the Calibrated Radiance spectrum. For this computation, the Planck emissivity is set to 1.0. The current Planck temperature is displayed in the upper left corner of the screen when this function is active. The Cancel box terminates the Planck Fit function.

The Auto-Fit function brings up a dialog box in which a wavelength interval, and a known emissivity value within that interval, can be specified. To continue, the lower and upper wavelengths of the interval are entered in their respective blocks, using the mouse or the Tab key. The Emissivity Value in that interval is typed into the third box. Selecting Compute will then try to match the Planck function to the present Calibrated Radiance, in the interval specified. That Planck will be overlaid on the Calibrated sample radiance to show how good the fit is. This can be performed repeatedly and alternately with the Manual fit to optimize the Planck fit to the Calibrated Radiance spectrum. The final Planck temperature will be used in the Emissivity calculation. The current Planck temperature is displayed in the upper left corner of the screen when this function is active. The Cancel box, again, terminates the Planck Fit function.

Remove Planck Plot is present on the process menu when a Planck function has been fit to a calibrated radiance curve. Activating this function will remove the fitted Planck and display the underlying calibrated radiance again.

Help Menu

The help menu has 1 option in its submenu, selected by mouse, arrow key, or underlined letter. They are:

About

About displays the current software revision level.

Function Keys

The function keys are linked to frequently used operations. There are 10 function key assignments listed across the top of the screen, just below the menu bar. Their assignments are:

F1-Acquire	starts the acquisition of a data set
F2-Open	brings up the File Dialog box to open a file (same as menu File-Open)
F3-Save As	brings up the File Dialog box to save a file (same as menu File-Save As)
F4-Refresh	used to refresh the screen after making changes
F5-Export	used to start the ASCII File export process
F6-	TBD
F7-Cursor	puts a cursor on interferogram or spectral plots

F8-X Scale	toggles the X scale between ALL X and USER X scales
F9-Y Scale	toggles the Y scale between AUTO Y and USER Y scales
F10-Status	brings up a status screen showing currently loaded files
<Alt>F9	turn off audible temperature alarm
<Alt>F10	Factory Setup, used to set up instrument operating parameters

F1-Acquire starts the data acquisition process from the spectrometer. The first dialog box is used to select a data type to acquire. The choices depend on which Math is selected under Process-Math. For math functions requiring one or two spectra, the choices are Sample or Reference. For Radiance math, Warm and Cold Blackbody (WBB and CBB), and Sample are offered as choices. For Emissivity math, the Downwelling Radiance (DWR) selection is added to those of Radiance. Once a file type is selected, the scan is turned on, and the number of coadds set under the Instrument-Coadd menu item are acquired and averaged. Each scan is displayed on the screen as it is acquired, with whatever math is set. The display will be the plot type set under the Display-Plot Type menu (Interferogram, Spectrum, or Both). After all data has been acquired, a prompt appears to Save or Continue. If Continue is chosen, the data will be in memory only, but not on disk. If Save is selected and Autaname is enabled, a prompt for annotation will appear, and the data will be saved with the next sequential filename, using the appropriate file extension for the data type chosen.

If Save is selected and Autaname is disabled, a prompt for annotation will appear, and then the File Dialog Box for File-Save appears with the appropriate file extension for the data type chosen. A name can then be entered in the File name section, with no extension. Alternatively, an existing file can be replaced with the current data by TABing to the section containing the file list, highlighting the name of the existing file, and selecting OK (a prompt to "Overwrite Y/N" will appear). The file is then saved into the currently selected directory, under the specified name, with the appropriate file extension. A full screen plot will then be updated, with the last acquired interferogram and/or the coadded spectrum displayed.

If Emissivity mode is active under Process-Math, a prompt will appear each time Downwelling Radiance data (.dwr) is acquired. The temperature and emissivity of the diffuse plate used to measure the downwelling radiance must be entered. This is needed to compute the emission from the plate and subtract it off the measurement, leaving only the reflected downwelling radiance. The gold diffuse plate supplied as an accessory typically has an emissivity of about .04. Also, when any new data is acquired in Emissivity mode, a prompt for the Planck fitting method will appear after the new data is acquired. Either the manual or auto fit can be specified. (See description under Process-Fit Planck to Radiance).

F2-Open is a shortcut for the File-Open menu item. See the description under the File menu section.

F3-Save As is a shortcut for the File-Save menu item. See the description under the File menu section.

F4-Refresh will recalculate and redisplay a plot at any time

F5-Export will generate an ASCII text file of a spectrum being displayed on screen. When it is activated, a dialog box appears to set the range of wavelengths to export. The beginning and ending wavelength is entered in whatever units are being used. Selecting OK will bring up a plot of the specified region to be exported. A dialog box then appears in the middle of the plot area on the screen, asking "Export This?", with YES, NO, and QUIT options. If the

region is incorrect, activating the NO box will bring up the previous dialog box for entering the wavelength range again. Selecting QUIT will terminate the ASCII export function.

If the plot region is correct and Autaname is enabled, selecting YES will save the ASCII file with the next sequential filename, and the appropriate file extension, as per the list for ASCII files under Software Operation. The filename used will be displayed in a dialog box on screen. ESC removes the dialog box.

If the plot region is correct and Autaname is not enabled, the File Dialog Box for File-Save appears with the appropriate file extension for the ASCII data type being displayed. A name can then be entered in the File name section of the File Dialog Box, with no extension. Alternatively, an existing file can be replaced with the current data by TABing to the section containing the file list, highlighting the name of the existing file, and selecting OK (a prompt to "Overwrite Y/N" will appear). The file is then saved into the currently selected directory, under the specified name, with the appropriate file extension. A full screen plot will then be updated, with the last acquired interferogram and/or the coadded spectrum displayed.

F6-TBD is not assigned yet.

F7-Cursor puts a crosshair cursor on a plot of interferogram or spectrum. Values at the cursor are read out in the top left of the screen. If both interferogram and spectrum are displayed, the cursor will be on the spectrum plot. This is a toggle function; pressing it once displays the cursor, pressing it again takes the cursor off the plot.

F8-(X Scale) is used to toggle between the User-X and All-X scales for the horizontal range to be displayed in a plot. The User scales are set in the Display-Scales menu, and are also affected by zooming and panning with the cursor keys. All-X will display the entire range of X points. This means all data points for an interferogram, and all spectral points between 1.6 and 25 microns.

F9-(Y Scale) is used to toggle between the User-Y and Auto-Y scales for the vertical range to be displayed in a plot. The User scales are set in the Display-Scales menu, and are also affected by zooming and panning with the cursor keys. Auto-Y will automatically fit the plot to the nearest whole units.

F10-Status brings up an overlay on the screen that shows the operating parameters and all currently loaded data for whatever math function is selected, and whether they are "Active". The operating parameters displayed at the bottom of the screen include Coadds, Resolution, Zero Fill, and Apodization.

The left side of the upper part of the overlay lists the data types required for the current math function. Next to each data type is the word "Active" if it is presently loaded. Just below it is the currently loaded file name. If nothing has been loaded for a data type, then the word "Active" will not appear, and no file name will be listed. If data has been acquired, but not stored, "Active" will appear, and the "File Name" will be "XXXX in memory", where XXXX is the data type (e.g. Sample, Reference, etc.). If the data acquired has been saved, or has been restored from disk, the "File Name", with path, of that data file will be shown, and "Active" will appear. Esc or OK will exit the Status screen.

<Alt>F9 will turn off the audible temperature alarm if the Ambient temperature exceeds the limits set in the Factory Setup screen

<Alt>F10 brings up the Factory Setup screen. From this screen, all instrument basic operating parameters can be set. Normally, these are not accessed by the user. They are :

Array Orientation (used only for multi-pixel systems)	Flip Horizontal
Dispersion Coefficients	Xm, Xb, Xc
Spectrometer Model	102, 402, etc.
Data Points to be Acquired	Number Points
Laser (microns)	Reference Wavelength
Double-sided or Single-sided Processing	Double, Single
Array (used only for multi-pixel systems)	Single Pixel, 1X4
Plot Window Size	Slider control
Ambient Temperature Alarm Limits	Enter temperatures (deg C)
Instrument Temperature Alarm Limits and Tolerance	Enter temperatures (deg C)
Scan Direction for acquiring data	0, 1, or Both

Dispersion Coefficients

The dispersion coefficients are used in the instrument dispersion correction. These values are determined by the type of optics used in the interferometer. There is a value for Offset (Xc), LogSlope (Xm), and LogOffset (Xb) in the equation:

$$X \text{ offset (cm}^{-1}\text{)} = \text{Offset (Xc)} + 10^{(\text{LogSlope (Xm)} * X + \text{LogOffset (Xb)})}$$

This is calculated for each value of X (in cm^{-1}) from the raw FFT, and added on to each value to generate a corrected wavelength scale. These do not require any adjustment under normal circumstances.

Spectrometer Model

Spectrometer Model is where the instrument model number is stored. Certain software options are determined by the Spectrometer Model setting.

Data Points to be Acquired

The Data Points to be Acquired. The number of data points is determined by the scan length of the interferometer and length of the Data Gate in the electronics. This must be a multiple of 512.

Laser(microns)

The reference Laser Wavelength determines the absolute accuracy of the wavelength scale. When laser diodes are used, each one has a slightly different wavelength, which is set here. This value is set at the factory, and does not normally require adjustment.

Double-sided or Single-sided Processing

Double Sided Processing or Single Sided Processing. This is set based on whether the

zero OPD centerburst is in the middle of the scan or off to one side.

Plot Window Size

This is a slider control to adjust the data plot size to different screens. It is set at the factory for the instrument, but may need to be used if the program is run on a different computer.

Ambient Temperature Alarm Limits

Limits to be used for setting off an over/under temperature alarm. 10 to 40 degrees recommended.

Instrument Temperature Alarm Limits

Limits to be used for setting off an over/under temperature alarm. 15 to 35 degrees recommended, with a 5 degree tolerance.

Scan Direction for acquiring data

Usually set to Both, can disable data in one scan direction, if desired.

Measuring Emissivity

The instrument has specialized software for the measurement of surface emissivity of targets in the field. For this, four raw data files are required; three are for calibration and one is the sample itself. Of the three calibration measurements, two are blackbodies and one is a measurement of downwelling radiance. The blackbodies are used to calibrate the target and downwelling radiances. The downwelling radiance sample is collected from a diffuse reflector placed in the field of view of the instrument. Samples are then placed in the same location as the diffuse reflector when they are measured. In this way, the reflected downwelling radiation off the target samples can be subtracted out to give the absolute emissivity.

The algorithm used to compute the emissivity is given by:

$$\varepsilon_s(\lambda) = [L_s(\lambda) - L_{dwr}(\lambda)] / [B(\lambda, T_s) - L_{dwr}(\lambda)] ; \text{ where}$$

$\varepsilon_s(\lambda)$ is the surface emissivity of the sample as a function of wavelength;

$L_s(\lambda)$ is the calibrated radiance of the sample;

$L_{dwr}(\lambda)$ is the calibrated radiance of the downwelling radiance;

$B(\lambda, T_s)$ is a Planck function at the sample temperature.

The downwelling radiance term must be corrected for the emissivity of the diffuse reflector and its temperature. These two parameters are prompted for as part of the data acquisition process for a downwelling radiance file. The sample temperature is derived by fitting a Planck function to the calibrated sample radiance. Two methods are provided in the software for doing this; a manual fit or an automatic fit. See the description under Process-Fit Planck to Radiance. The manual function simply inputs a temperature, computes the Planck, and overlays

it on the sample radiance curve. The temperature can be adjusted for a good visual fit. The automatic method requires knowledge of a spectral region of the sample radiance with a known emissivity. The interval from 7 to 7.5, with an emissivity of 1.0, is generally good for most samples. The automatic function allows the interval start and end points, and the known emissivity in that interval, to be entered. The Planck function is then fit to the sample radiance in that interval by a least square error algorithm, and overlaid on the sample radiance to see the quality of the fit. The temperature of that Planck function is displayed in the lower right corner of the status area of the screen.

When the proper Planck function is found, this is used in the computation and display of the final emissivity curve. For Emissivity math, a prompt is presented to select a method of Planck generation whenever any new file is acquired or restored. Either the manual or automatic function can be specified. The manual function will ask for a sample temperature, while the automatic function will ask for a wavelength interval and emissivity value in that interval. After inputting the values, a new emissivity plot will be generated and displayed. It should be noted here that emissivity is best measured outside, where there is less downwelling radiance. If measured inside, the downwelling radiance can swamp out the sample radiance unless the sample is heated above room temperature.

Getting Data Off

The Model 102 can use a USB memory stick for loading software and transferring data. Insert the USB device into the USB plug, and wait for Windows to recognize it. Then use Explore to select the desired files and drag them to the USB drive letter. The LAN connection can also be used to connect a computer to the Model 102 and move data across the LAN connection.

Shipping Procedure

The Model 102 requires special handling during shipment. There are optical and electronic parts inside which can become dislodged if a sharp blow is transmitted from outside the box.

Our standard method of shipping the instrument is to first place it into a plastic bag for moisture protection. Then, it gets packed by itself into a medium sized box full of Styrofoam peanuts. This box is then packed into another, larger box, also full of Styrofoam peanuts. The instrument itself is about 14"X8"X9". The medium sized box for it should be at least 4" larger on all sides, or 22"X16"X16", filled in on all sides with Styrofoam peanuts. The outside box should be much larger, minimum 30"X24"X24", and also filled with Styrofoam peanuts. The Styrofoam peanuts provide the best shock absorption of any packing material. We have shipped this way to many customers, including overseas, and have never had a problem. As an aside, both solid foam and bubble wrap transmit shock quite well from the outside of the box, and thus are not recommended.

In addition to packing this way, we always insure each package for a minimum of \$10,000. This would not only make it somewhat easier to recover losses from damages that might occur, but sometimes gives the package special treatment by the carrier. We have observed that packages insured for \$10,000 and up may be put into separate staging areas at the shipper's depot. They are probably treated carefully all the way to their destination. Some shippers may require inspection of the packing inside the box, but this is a small price to pay for damage liability. In addition to this, there is also some recovery if the parcel is completely lost.

System Specifications

Spectral Range:	2 to 16 micrometers
Spectral resolution:	4, 8, and 16 cm^{-1} , adjustable
Spectral Accuracy:	+/- 1 cm^{-1} across the spectral range
Scan rate:	1 scan/second, nominal
Optical throughput:	0.016 cm^2 steradian
Sampling frequency:	5 KHz, nominal
Signal bandwidth:	2 KHz, nominal
Analog to Digital converter:	16 bits, +/-10 Volts Full Scale Range
FFT size:	1024 to 32,768 ⁽¹⁾
Computer type:	PC compatible, PC/104 buss
Processor/RAM:	AMD LX800 500 MHz/256 Mbytes
Hard Disk Size:	40 Gbytes, minimum
Operating system:	Windows XP™
Operating temperature range:	15 to 35 degrees C (instrument temperature)
Input voltage range:	12V DC +/- 10% (10.8 to 13.2 VDC)
Size:	14"L X 8"W X 9" H
Weight:	15 lbs.
Power:	50 Watts max., 18 Watts typ. ⁽²⁾

(1) Depends on spectral resolution selected, in conjunction with the Zero Fill function

(2) Maximum power is with all temperature controllers on at the same time, plus the computer and scan.

Troubleshooting

General

If the system fails to run at any time, the first place to look is the fuses. There is one main fuse (10 amp) located in the cigarette lighter plug of the main power cable. Unscrew the tip of the plug to remove it. If the AC supply is being used, it also has fuses. The green LED on the front panel of the AC supply indicates whether the DC output is working. One fuse for the AC supply (3 amp) is external, located behind the rectangular panel next to the AC input connector. The other (4 amp) is inside the case, on a PC board. **Disconnect AC power before opening the AC supply!** Remove the cover by taking out the two screws in the middle of the bottom of the case and sliding the cover up. The fuse is located near the front of the PC board, on the right side. Replacement fuses are supplied with the system.

The AC supply also will click on and off rapidly under an over-current condition. If this happens, try shutting off certain loads (instrument temperature control, blackbody, etc.) to correct the problem. One last fuse is a push-in type (15 amp) located in each battery cigarette lighter socket. This would be the last to blow in an over-current situation.

Another source of problem is instrument temperature. The operating temperature range of the interferometer is 15 to 35 degrees C. The instrument temperature is internally controlled, and can be read off the top of the computer screen. Also, this spectrometer system is designed to run intermittently, not on a continuous basis. If the scan fails to start, and the "BOOST" switch fails to revive it, perhaps the interferometer is too hot, or has been run too long and needs to cool

down. Leave it off for an hour or so and try it again. Extreme cold is also problematic, as there is a lubricant inside that can become too stiff if the instrument temperature is below 15 degrees C.

If none of this corrects the problem, check all connections, disconnecting and reconnecting them. Check the battery voltages, and charge them if necessary. Try both the AC supply and battery. Cycle the scan power on and off a few times, using the "BOOST" switch also. Note the operation of the LEDs on the panel, under the keyboard. See the Electronic Subsystem section for details on these. The STBY LED should be on as soon as the power switch is turned on. The SCAN LED comes on when data is being acquired, and the DG LED flashes on and off during data acquisition, once every second for each scan. The ERROR LED is red, and should normally be off. During data acquisition, it indicates a loss of the reference laser signal, which is needed for any spectra to be acquired. The LD LED should come on briefly at power on, either red or green, then become dimmer. The INST LED comes on briefly when the program starts, either red or green, then goes dim. It will also glow brightly if the instrument set point is changed, until the new set point is reached. The BB LED is only on when the blackbody is turned on. It glows red when heating it, or green when cooling it, and dims when the set point is reached.

If the scan works, but no spectra or noisy spectra are seen on the screen, it may be that the detector has not been filled properly, or has run out of LN₂. Normally, the detector Dewar lasts for 12 hours from an initial fill. Refer to the Optical Subsystem section for detector filling instructions. Also, the Dewar needs to be re-pumped every few years to maintain its vacuum. The symptom of poor vacuum is shorter hold times and condensation on the outside of the Dewar. Listen for any unusual sounds, such as clunking or chattering. The normal running system will have a regular soft bumping sound at each turnaround, around once per second.

If the spectra are seen, but do not seem to be proper, check that the lever on the foreoptic eyepiece is pushed down. Also, note the min and max values of the interferogram, and their location in the data record. A properly working system should put out +/- 2-9 volts near the center of the data record, depending on the target temperature. This would be at around 2300 for a 4 cm⁻¹ system. The peak values should go up a little if a warm hand or blackbody is placed in front of the foreoptics. Voltage levels above 9.5 volts should be avoided, because the maximum voltage for the data converter is +/- 10 volts.

If an oscilloscope is available, check the LAS and DET signals on their respective BNCs on the panel, near the power input connector. The LAS signal should be a clipped sine wave, about 8-10 volts peak to peak, at around 5 kHz. The DET signal is a burst of about +/- 2-9 volts at zero OPD, once per scan.

CHECKLIST

Fuses: inside cigarette lighter plug, in front of AC supply, inside AC supply, in battery socket.

Try running on both AC supply and a freshly charged battery.

Check that the voltage on the LCD meter is between 10.8 and 13.2 volts.

Check all four temperatures at the top of the screen for the normal range of 15 to 35 C.

Make sure the detector is filled properly.

Check the system LED's for proper state, especially the red ERROR LED.

Make sure the lever for the viewer on the foreoptics is down.

If possible, check the signals on the LAS and DET BNCs.

Look at known good stored data to compare with acquired data.

Listen for unusual noise, or lack of fan noise.

System Computer

The system computer is normally very robust, but can act strangely under extreme heat or cold. Usually the screen will fade or have low contrast under these conditions. If there seems to be problem at any time, (such as "hanging up") a warm boot (CTL-ALT-DEL buttons pressed simultaneously) will usually solve it. If not, use the computer RESET switch on the panel just behind the keyboard on the right side to restart the operating system and reset all operating parameters. The computer has its own battery for time and date backup, which should last for 5 years.

If the program ever fails to load, or acts strangely, it may be due to a corrupted file, called WINFT.INI, in the C:\FTIR\PROGRAM subdirectory. It must be deleted to solve the problem. To do this, exit the program, or reset the computer to the Windows desktop. Using Explore, delete the WINFT.INI file from the \FTIR\PROGRAM subdirectory.

Please note that all factory setup operating parameters, including laser sampling wavelength under Factory Setup (alt-F10) will need to be restored after deleting the WINFT.INI file. The accuracy of the wavelength scale depends on the sampling wavelength being correct. In addition, the proper dispersion correction constants and number of points to acquire need to be reset. The proper values for this system are:

Dispersion Offset = 0.0
 Dispersion LogSlope = _____ (factory default 1.394e-4)
 Dispersion LogOffset = _____ (factory default 1.1616)
 Spectrometer Model = _____
 Data Points to Acquire= _____ (factory default 4608)
 Laser Wavelength = _____ (factory default .7850)

A backup CD is provided should it ever become necessary to restore the program to the system computer. To do this, first transfer the CD contents to the USB memory device. Then, with Windows running, insert the USB memory device into the USB port on the 102. After the device is recognized, transfer all the CD contents into the C:\FTIR subdirectory using Explore.

After this is done, the sampling wavelength and other factory setup parameters must be set to the correct values in the Factory Setup (alt-F10) menu. Please see the above instructions under System Computer for the proper values to enter.

CHECKLIST

Check for proper parameters under Factory Setup <alt>F10 screen.
 Try resetting the computer using the Computer Reset switch on the panel under the keyboard.
 Operating temperature of the computer is 0 to 50 C, which is greater than the instrument range.
 Delete the WINFT.INI file in the C:\FTIR directory, then re-enter factory setup parameters.
 Restore the program from the backup CD, then re-enter the factory setup parameters.

If none of the above solves the problem, then contact D&P Instruments in the USA at:

CT: (860) 658-0458 Phone/Msgs or (860) 651-0698 FAX
 e-mail: microfts@aol.com

It helps to have some diagnostic information when calling, as it is easier to diagnose problems with some data on problem history and present indicators. In addition, looking at old stored data may help in pointing out differences over time in spectral performance.

General Tips for using the Model 102 Spectrometer

General

The instrument temperature controller has a much easier time heating the instrument than cooling it. Consequently, when working outside, the best results are obtained by setting the instrument temperature to near the highest temperature expected for the day, then letting the instrument equilibrate at that temperature for at least one hour (overnight is better). This will achieve the dual goals of using the least amount of power, and maintaining the most accurate calibration. This temperature can be maintained on the way to the measurement site if a car cigarette lighter socket is available. Note that setting the instrument temperature more than 5 degrees above or below its current temperature will trigger a temperature alarm (see manual). This 5 degree limit may be exceeded during a pre-heating operation, but only when the set point is higher than the current temperature, and even then not by more than 10 degrees C. Cooling requires more power than heating, and the controller may overheat if the set point is more than 5 degrees C lower than the current temperature. Therefore, violating the 5 degree limit on the low side is not recommended.

Make sure to allow sufficient time after powering up the spectrometer for the laser diode reference to reach its set temperature, which is usually about 25 degrees C. The farther the temperature is from 25 C, the longer it may take to reach the set point. Generally, again, it takes less time to heat than to cool. Monitor the laser diode temperature on the screen.

It is always advisable to run the instrument a few times at the beginning of a session to warm up the interferometer and drive motor. A sequence of 4-5 coadds of 8-16 scans each should suffice.

It is best to turn off the blackbody when not in use, as it dissipates power unnecessarily.

Emissivity Measurement

Try to make emissivity measurements on clear days with little or no cloud cover. This will give the most accurate results because the downwelling radiance will not change much when multiple samples are measured. If this is not possible, take frequent downwelling radiance data, and use the closest one in time to each sample. Also, take blackbodies more frequently at the beginning of a measurement session, when the instrument calibration may be changing more. After an hour or so, less frequent blackbodies should be sufficient.

When making emissivity measurements, make sure that there are the same objects, including people, near the instrument's field of view for all sample and downwelling measurements. It is best to have no objects around the sample area, and to step away from the instrument about 6-8 feet or so while acquiring data. There is a delay before data acquisition, and

a beep will sound after data acquisition is complete. This allows the user time to get away at the beginning, and notifies the user to return at the end of data acquisition. This does not need to be done when acquiring blackbodies, as the instrument is not looking out at the scene.

The sky has a much lower apparent temperature than most samples. For best results in calibrating the downwelling radiance, use a lower temperature blackbody, such as 5-10 degrees C. The warm black body should be just above the estimated sample temperature. This is a compromise between obtaining a good sample temperature calibration and a good sky radiance calibration.

Measuring very low emissivity targets may result in erroneous readings. These include targets with low apparent temperatures, such as gas clouds, and highly reflective targets. Diffuse solid targets give the best results.

The sun should generally be on the front side of the instrument, so no shadows are cast on the sample area.

102F Setup Diagram

