INFRARED SYSTEMS DEVELOPMENT CORPORATION

OPERATORS MANUAL

BLACKBODY REFERENCE SOURCE

MODEL: IR-574 / 301

7319 SANDSCOVE CT. #4 Φ WINTER PARK, FL 32792
(TEL) 407-679-5101 Φ (FAX) 407-679-5520
SALES@INFRAREDSYSTEMS.COM HTTP://WWW.INFRAREDSYSTEMS.COM

WARRANTY

IR-574/301 BLACKBODIES

This Infrared Systems Development Corporation (ISDC) instrument is warranted to the original purchaser for a period of one (1) year from the date of shipment. The instrument is warranted against defective materials and workmanship. Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective.

This warranty is void if, in the opinion of ISDC, the instrument has been damaged by accident or unreasonable use, neglect, improper service or other causes not arising out of defects in materials or workmanship.

This Warranty supercedes any and all expressed or implied warranties, including, but not limited to, warranties of implied merchantability and fitness for a particular application. Before use, the user shall determine the suitability of the product for its intended use, and the user shall assume all risk and liability in connection therewith.

Infrared Systems Development (Infrared Industries) shall not be liable for any loss of use of the instrument or other incidental or consequential costs, expenses or damages whatsoever incurred by the purchaser.

If a problem should occur, contact your representative or the factory:

Infrared Systems Development Corporation
7319 Sandscove Court
Suite 4
Winter Park, Florida 32792
(407) 679-5101
sales@infraredsystems.com

If it is necessary to return the instrument, notify your representative or the factory, package your instrument carefully, return the complete instrument with freight prepaid and include any observations of the malfunction.

Repaired instruments will carry the balance of the original warranty period or 90 days of new warranty on replaced or repaired parts and service, whichever is greater. The balance of the original warranty shall be defined as one (1) year from the original date of shipment.

WARNING

DO NOT OPERATE THE SYSTEM IN MANUAL MODE FOR ANY REASON!!! IF THE SYSTEM DISPLAYS MANUAL MODE, DO NOT OPERATE THE SYSTEM AND CONTACT US IMMEDIATELY. EXTENSIVE DAMAGE WILL OCCUR IF OPERATED IN MANUAL MODE!

CAUTION

DO NOT PLACE OBJECTS, SUCH AS THERMOCOUPLES, IN CONTACT WITH THE HEATER SURFACE WHILE THE INSTRUMENT IS HOT! DAMAGE TO THE CAVITY, FOREIGN OBJECT, OR PERSONAL INJURY MAY OCCUR.

WARNING

NO PARAMETER CHANGES SHOULD BE MADE WITHOUT READING ALL NOTES AND CAUTIONS THAT PERTAIN, AND THEN ONLY BY QUALIFIED PERSONNEL. THE EFFECT THE PARAMETER HAS ON THE SYSTEM MUST BE UNDERSTOOD PRIOR TO ANY ALTERATIONS.

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1.0 SPECIFICATIONS

Specifications: IR-574 Source	
Temperature Range:	50 – 1200 C
Emittance Watts/Cm^2 (Watts):	26.68 (684)
Wavelength Range:	0.5 - 99um
Emissivity:	>0.99
Emitter Size: in (mm)	2.25" (57)
Source Type:	Cavity
Temperature Resolution:	0.1 C
Calibration Accuracy:	+/- 0.2 C to NIST Standard
Stability: Short (Long) Term:	+/- 0.1 C (+/- 0.2C)
Response Time:	100-1200 <80 Minutes
Temperature Sensors:	Embedded 0.01% Matched Type S
Control Type:	Active Multi-Band P.I.D.
Line Voltage:	90 to 125 or 208-240 VAC 50-60 Hz
Power Requirements:	1400 Watts Max
Cable Length:	8 Feet (2.4 m)
Dimensions: in (mm) Source:	12.5” H x 20” D x 10” W (317x508x254)
Controller:	5.1"H x 13.4"D x 12"W (130x340x304)
Warranty:	1 Year
Standard Apertures:	2.0" (50.8); optional 5 position Motorized Aperture Wheel
Aperture Temperature:	Less than 60ºC above amb. At 1200ºC
Housing Temperature:	Lees than 25ºC above amb. At 1200ºC
Remote Interface:	RS-232, RS-485 or IEEE-488/GPIB

Specifications: IR-301 Controller	
Resolution:	1ºC or 0.1ºC Selectable
Control:	PID dual Zero voltage firing state power relays
Readout:	Dual display: BB Temp is shown on upper LED display; Set Point and Parameters are shown on lower LCD Display
Sample Rate:	Cavity Temp is updated 10 times per second; digitally filtered to eliminate noise
ºF/ºC	Selected at Factory. Standard is ºC
Alarms:	5.0 amps at 120 VAC, 2.5 amps at 230 VAC
Operating Environment:	0 to 40ºC ambient temp with relative humidity less than 95% non-condensing
Power Requirement:	105-125 Volts, 50-60 Hz., 500 Watts Max
Dimensions (HxWxL):	5.1" x 13.4" x 12" (130x340x304) (Rackmounted 5.25” x 19” x 14.4”
Weight:	9 lbs. (Rackmounted 10bs.) (Shipping Weight: 13 lbs. 17lbs.)

2.0 INTRODUCTION

2.1 MODEL IR-574 RADIATION SOURCE

The INFRARED SYSTEMS DEVELOPMENT CORPORATION (ISDC) Radiation Source provides an accurate, stable source of infrared radiation of known flux and spectral distribution. It can be used as a standard radiation source for the calibration of other laboratory sources, detectors, or other infrared devices requiring calibration against a standard.

As figure 1 illustrates, the major functional components of the Blackbody Radiation Source are the Cavity, Heater and Dual Thermocouples. The cavity is a 20º Recessed Conical design, manufactured from special stainless steel and processed to have a uniform, high emissivity coating. The high surface emissivity and the geometrical form of the cavity combine to produce an effective emissivity very near unity. The cavity is heated by means of a resistive-heating element designed to provide uniform heating of the entire cavity. Heater power is supplied and controlled by the microprocessor-based Model IR-301 Blackbody Temperature Controller. A continuous indication of Cavity Temperature is fed back to the controller for display and control by a 0.01% error Type “S” (Platinum/Platinum 10% Rhodium) Thermocouple inserted next to the cavity apex. A second Type “S” calibration thermocouple inserted into the cavity is provided for calibration and external monitoring as a standard feature.

2.2 MODEL IR-301 DIGITAL TEMPERATURE CONTROLLER

The IR-301 controller is a microprocessor based PID (Proportional, Integral and Derivative) system for regulating the Blackbody’s Radiating Surface. At Infrared Systems Development, we have taken a leap forward from the standard PID Controller types of past years. We do this by utilizing five (5) independent PID parameter groups, each for a specific temperature range, internally selected based on the Setpoint.

To control stability, the Standard Proportional Band with Automatic Reset and Derivative method is utilized. Unlike standard PID control, these parameters are totally dedicated to control stability only. This allows us to reduce the Proportional Band, creating a much more stable Blackbody system.

To control warm-up characteristics, we start with an independent Proportional Band, much wider than the stability Proportional Band. We then take the operational span and divide it into five smaller spans. Each of these spans is assigned a factory-selected range of PID Parameters values. Selecting a set temperature automatically loads the proper warm-

up parameters into memory for that specific temperature. This process practically eliminates the need for continuous reactionary parameter changes as required by standard PID.

For applications requiring one, a Blackbody Radiance Display (WATTS/CM²/STERADIAN) of actual temperature can be monitored at from the front panel LCD display BBRD.

All adjustments, parameters and indications are accessible from the front panel or via one of the communication options. The front panel contains 7 LEDs for visual indication of pertinent controller activity plus a Large LED display of Blackbody Temperature, and an interactive LCD menu display for presentation and changing of Parameters. All control parameters, selections and calibration procedures are accomplished through simple MENU selections using the four front panel buttons (▲▼►◄). These MENU selections are organized into Sections. Each Section presents a specific set of related functions. EXAMPLE: SP1 (SETPOINT) Move the indicator on the LCD Display (►) to SP1 and press the NEXT (►) Button to enter the Setpoint adjustment screen, and use the UP▲ and DOWN ▼ Buttons to adjust the Setpoint to the desired temperature, then press the NEXT ►Button to enter the new Setpoint and return tot the Main Display.

Internally the IR-301 was designed for maximum accuracy while maintaining our trademark reliability and quality. As is apparent with the use of redundant solid-state (zero-voltage switching) power relays, RFI filters and an entire temperature sensor feedback loop; wire, cable, pins and connectors, being manufactured from special thermocouple alloys to eliminate the effects of ambient temperature change. The Thermocouple Cold Junction is mounted to a high precision RTD sensor to accurately monitor the CJC to provide compensation for ambient temperature variations.

All connections are made from the rear for true rackmount capabilities. The IR-301 contains its own power supply which requires the standard 120 VAC 50-60 HZ line power. A 220 VAC option is available.

2.3 OPTIONAL ACCESSORIES

2.3.1 THERMOCOUPLE REFERENCE PROBE P/N 54386

The IR-574 Blackbody comes standard with a Type "S" calibration thermocouple inserted into the cavity and terminating to a mini T/C connector at rear of the Blackbody. The optional "Ice Bath" Reference Probe is designed to work in conjunction with the internal calibration T/C to verify the accuracy of the sensor feedback loop and the IR-301 Controller. One lead of the reference probe contains the mating mini T/C connector; the other is terminated with spade terminals. With the probe portion inserted into an ice and water bath, the reference probe will supply a direct millivolt output of temperature, accurate to a fraction of a degree.

2.3.2 220 VAC KIT P/N 54566

The IR-574/301 Temperature Controller was designed from the start to have the ability for 220 VAC operation. The 220 VAC Kit installs internally with just 4 bolts and 2 connectors into pre-drilled holes and pre-positioned wire harness connectors.

2.3.3 IR-301 RACKMOUNT KIT P/N 54565

The IR-301 Rackmount Kit is a standard 19" rack with a height limited to 5.25". The rack is installed by reversing the controller cover and mounting the rack to the controller face with 4 pre-positioned screws.

2.3.4 RS-232 COMMUNICATION KIT P/N: 54618

2.3.5 IEEE-488/GPIB COMPUTER INTERFACE P/N: 54616

2.3.5 VARIABLE SPEED ENERGY MODULATORS P/N: 54386/54367

The IR-860/860-1 Energy Modulators consist of a mechanical modulator assembly containing the motor–driven chopper disk, and a remote cable connected electronic control unit. The 860 modulator head is specifically configured for direct mounting to 560 series Blackbody Sources. The 860-1 is a stand-up tabletop version. With the choice of 10 chopping blades, the 860 series has a frequency range from 1.25 Hz to 45,000 Hz. The price of the modulator system includes the customer's choice of one blade.

3.0 DRAWINGS AND DIMENSIONS

3.1 MODEL 574 OUTLINE AND DIMENSIONS

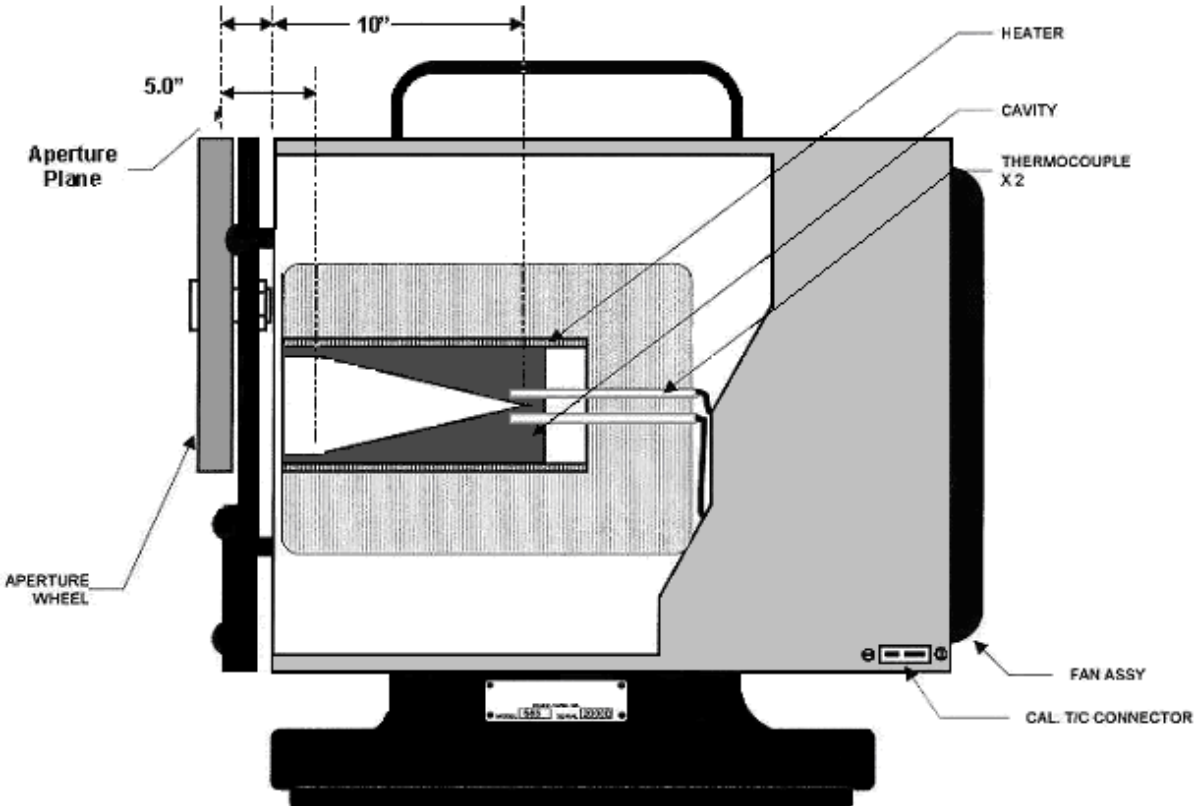


Figure 1

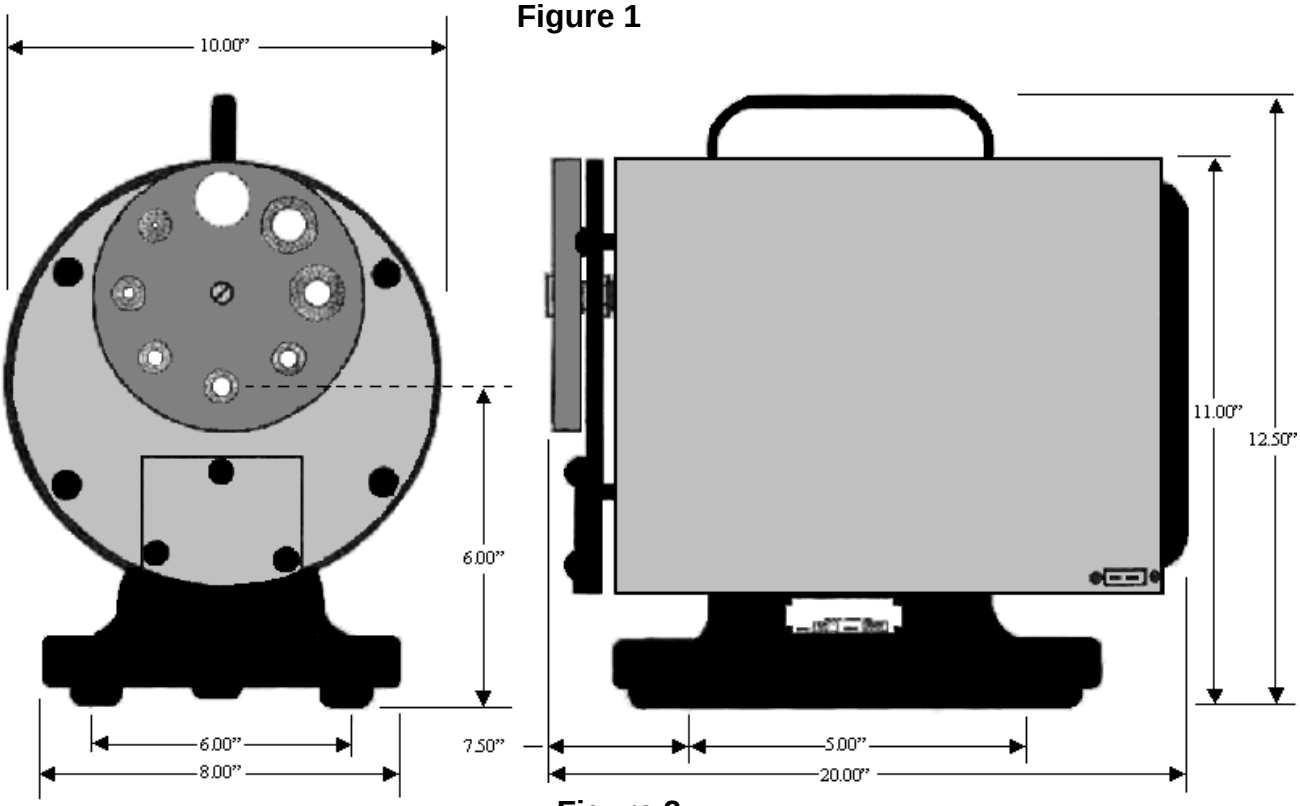


Figure 2

3.2 MODEL 301 TEMPERATURE CONTROLLER

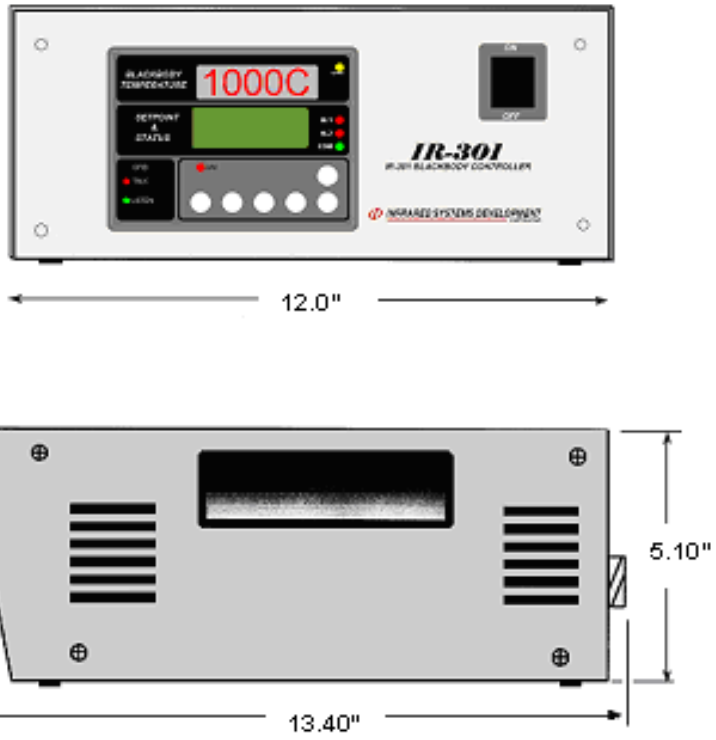
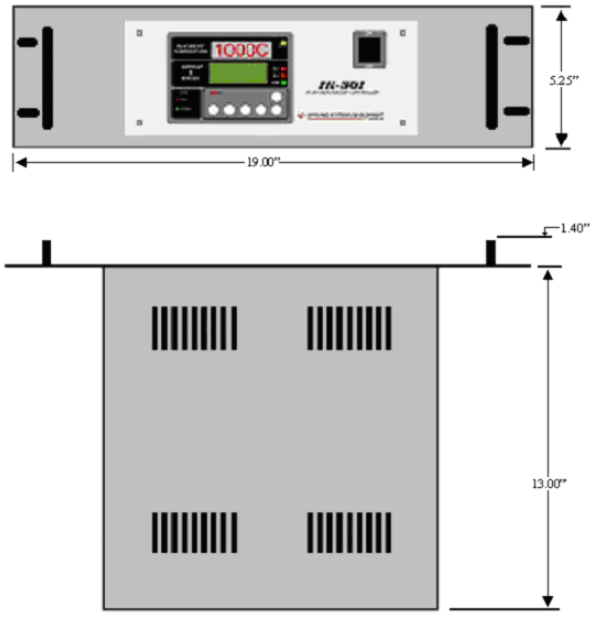


Figure 3



MODEL 301 CONTROLLER WITH RACKMOUNT ACCESSORY

Figure 4

4.0 INSTALLATION

4.1 INSPECTION AND UNPACKING

On receipt of your IR-574/301 Blackbody system, immediately make note of any visible damage to the shipment packaging and record this damage on the shipping documents. Unpack the system and carefully inspect it for obvious damage due to shipment. If the system will not be immediately installed and placed into operation, it should be stored in a cool, dry environment in its original protective packaging until time for installation and operation. Temperature extremes and excessive moisture can damage the instruments. IR recommends that the protective packaging be preserved and utilized for any future storage or shipping of Blackbody systems.

4.2 INSTALLATION

The design and construction of the IR-574 Blackbody and IR-301 Temperature Controller make our systems one of the most durable. However, the radiation source has numerous ceramic components susceptible to breakage from severe shock. To prevent premature component failure, avoid Blackbody Source movement. ESPECIALLY WHEN HOT!!

Connect radiation source to temperature controller by inserting the plug from the source into the rear mounted controller receptacle. Verify that the controller and source have matching serial numbers. (The IR-574/301 is a calibrated system and is serialized to reflect the same). If being used, hook-up alarm relay connections on rear, refer to PROGRAMMING for alarm configuration set-up. 5 AMP MAX. Insert line cord into the controller rear panel receptacle. Plug the line cords three-prong plug into an electric outlet that supplies 115 VAC, 50/60 Hz. (220 VAC available as a factory or field installed option).

CAUTION: DO NOT CONNECT TO POWER SOURCE OTHER THAN SPECIFIED ON DATA PLATE ON REAR OF CONTROLLER. DAMAGE WILL RESULT.

5.0 SETTING BLACKBODY TEMPERATURE:

The IR-301 Front Panel consists of the Blackbody Temperature Display, an LCD Status / Parameter Display, Status LED's, and Control pushbuttons. Please refer to Figure 5 below:

To change the Setpoint Temperature of the Blackbody Source, use the UP▲/DOWN ▼ Buttons to navigate the pointer on the Status LCD to indicate ► **SETPOINT**. This selects SETPOINT 1, which is the blackbody Setpoint. The Setpoint is the desired blackbody temperature, where the controller will set the blackbody.

Press the Right Cursor button ►to enter the Setpoint Adjustment screen and use the UP▲/DOWN ▼ buttons to adjust the Setpoint value to the desired temperature. Holding the UP▲/DOWN ▼ buttons will accelerate the rate at which the value changes. When the desired temperature is set in the Setpoint Adjustment Screen, press the Left Cursor ◄ button to store the new Setpoint and return to the Main screen. The Main Screen will display the new setpoint value and the controller will begin to change the output power to

arrive at the new setpoint. The IR-301 Blackbody Controller will then control the power to the blackbody source to arrive at the new Setpoint as quickly as possible.

When changing temperatures, be sure to allow 30-40 minutes for optimum stabilization and uniformity. The large thermal mass of the blackbody requires this time to evenly distribute the power to the entire cavity assembly. The thermocouples in the system are placed very close to the apex of the core, and when heating, the thermocouples reach temperature after the heater. This requires that the system stabilize for 15-20 minutes after reaching temperature to ensure proper uniformity.

When the IR-301 has reached the setpoint temperature, and after stabilization, the controller may fluctuate $\pm$ 0.2 ºC. This is normal and should not be a cause for concern. The controller reacts to the changes in ambient temperature and ambient conditions, such as air currents. The IR-301 will compensate for these variations, which are usually slow acting changes. If extreme ambient condition changes are present, such as if a blower is switched on in front of the source, a momentary drop in temperature will occur while the controller responds to the new environment.

Should the power be removed, the controller will remember and return to the last set temperature upon power-up.

Allow the system to reach and stabilize at desired temperature prior to making any measurements. Even with the PID type control, some overshoot will occur and is normal.

For shutdown: turn “ON/OFF” switch to “OFF”. This removes power from the electronics and heating element, but allows the fan to continue operation.

5.1 FRONT PANEL PUSH BUTTONS AND INDICATIONS

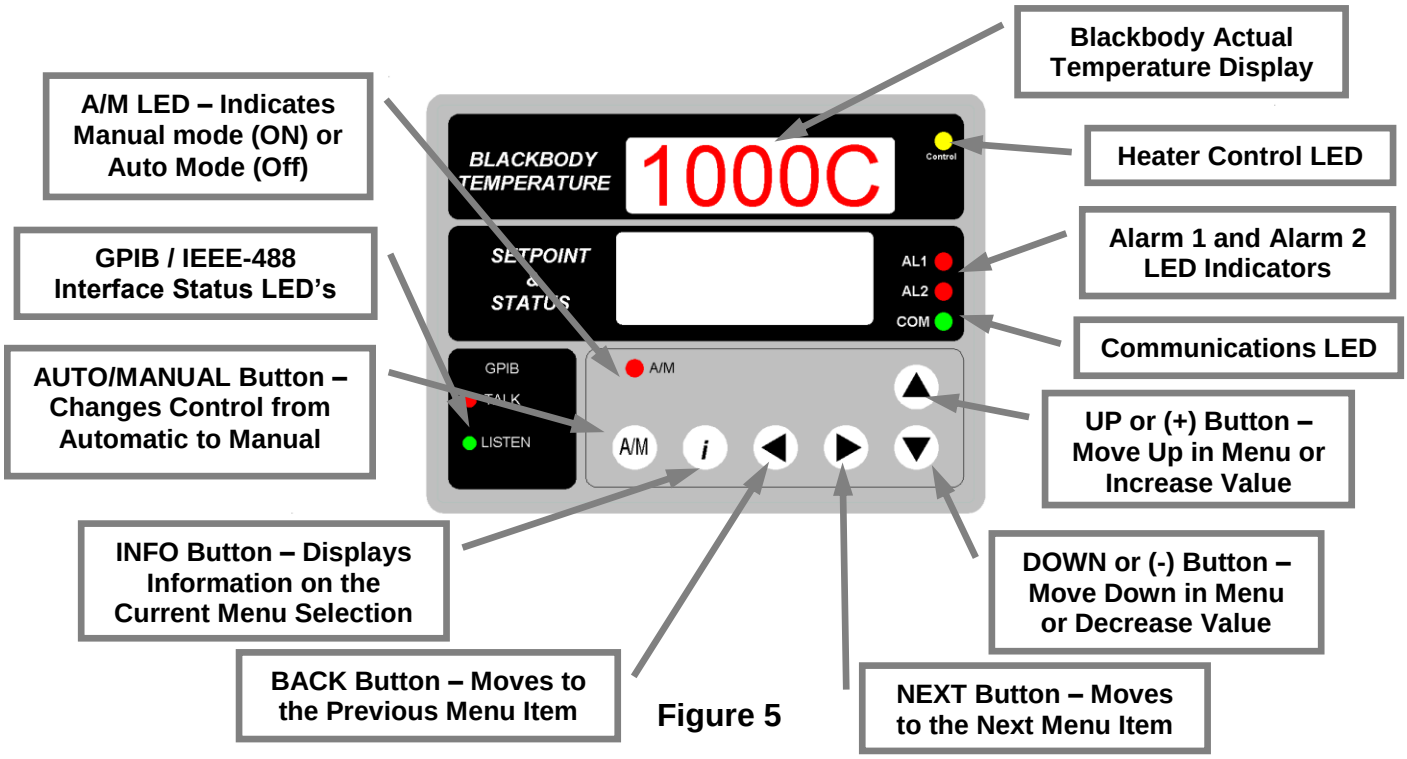


Figure 5

"ALARM 1/ALARM 2" LED's: Used to indicate alarm relay status.

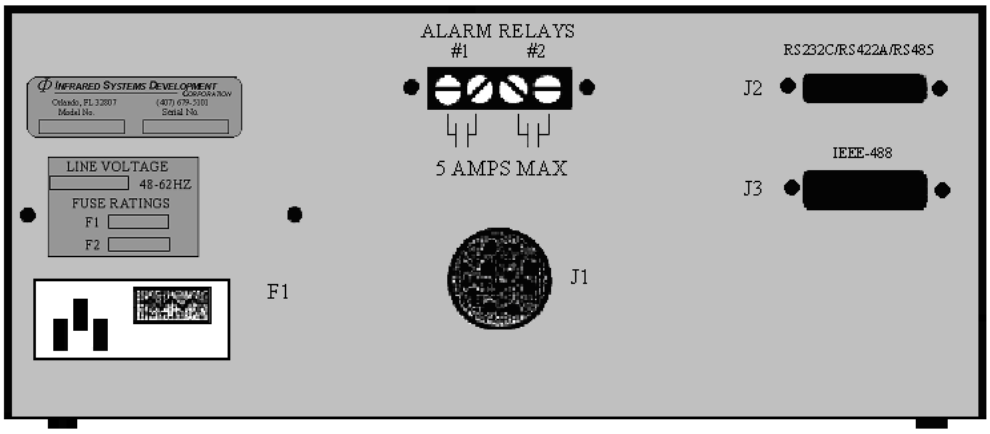
"ON/OFF SWITCH: Controls application of line voltage.

WARNING: ALWAYS UNPLUG VOLTAGE FROM CONTROLLER PRIOR TO ANY MAINTENANCE ON CONTROLLER OR BLACKBODY SOURCE.

Auto/Manual Button:

The A/M button is to return the controller to the automatic control mode. If the controller is turned on without the blackbody source attached, the mode will be switched to MANUAL by the controller. To resume normal operation, press the A/M button when the blackbody is attached. If the Automatic mode cannot be set and the controller remains in manual mode, this indicates an error or failure, please contact Infrared Systems Development at (407) 679-5101.

5.1.2 REAR PANEL LAY-OUT



5.2 OPERATING PROCEDURES

5.2.1 GENERAL

Once the Temperature Controller and matching serialized Blackbody Source are interconnected, proceed as follows:

Turn “ON/OFF” switch to the “ON” position. The lower display will flash the startup screen and load parameters from internal memory. The upper display will then indicate the current actual blackbody temperature. This is an indication that the IR-301 Controller has performed its self-test routine, and is ready for operation. The last set temperature will be the SETPOINT and the IR-301 controller will bring the blackbody to this temperature.

NOTE: REFER TO THE TROUBLESHOOTING SECTION IF ANY ERROR MESSAGES ARE DISPLAYED.

WARNING: ALWAYS UNPLUG VOLTAGE FROM CONTROLLER PRIOR TO ANY MAINTAINANCE ON CONTROLLER OR BLACKBODY SOURCE.

5.2.2 SECURITY

To prevent unqualified personnel from altering control parameters, the IR-301 is equipped with a security system. The security code is not available to customers and is for factory calibration use only. The security code will be given to customers who waive the warranty.

> ***WARNING: NO PARAMETER CHANGES SHOULD BE MADE WITHOUT READING ALL NOTES AND CAUTIONS THAT PERTAIN. AND THEN ONLY BY QUALIFIED PERSONNEL. THE EFFECT THE PARAMETER HAS ON THE SYSTEM MUST BE UNDERSTOOD PRIOR TO ANY ALTERATIONS.***

5.2.3 ALARMS

The IR-301 Temperature Controller has two alarm relays with terminals mounted on the rear panel of the chassis. The two normally open contacts are rated at 5.0 amps at 120 VAC, 2.5 amps at 230 VAC. The alarms are setup as DEVIATION alarms, where the setpoints are the degrees above and below the setpoint that will cause an alarm to set. The default settings are 1ºC for alarm 1, and 10 ºC for

alarm 2. Other alarm modes are available, please contact the factory. The IR-301 is equipped with two front panel mounted LED's to provide a visual indication that one or both relays are actuated, and the alarms will appear on the LCD display when set.

6.0 PROGRAMMING

6.1 GENERAL

WARNING: QUALIFIED PERSONNEL SHOULD ONLY MAKE PARAMETER CHANGES AFTER READING ALL NOTES AND CAUTIONS THAT PERTAIN. THE EFFECT THE PARAMETER HAS ON THE SYSTEM MUST BE UNDERSTOOD PRIOR TO ANY ALTERATIONS.

Software for operation of the IR-301 through a standard Serial Port, RS-485, or RS-422 can be performed. The system is organized using the AB MODBUS interface protocol.

6.2 ALARM RELAYS

There are two alarms provided with the IR-301 Temperature Controller. Each of these alarms may be set to close the relay contacts on the rear panel when the temperature of the blackbody has deviated from the setpoint by the amount set in the ALARM setup.

+/- Deviation Alarm: This deviation alarm is actuated whenever the Blackbody temperature deviates from the "SET TEMP" more than the predetermined (Alarm Set Point) amount in either a positive or negative direction.

With deviation alarms, the Alarm Set Point determines at what point above and below the "SET TEMP" the alarm will actuate.

The default settings are:

ALARM 1	± DEVIATION	1ºC	HYSTERESIS	0.1ºC
ALARM 2	± DEVIATION	10ºC	HYSTERESIS	0.1ºC

To set the alarm setpoints, use the UP▲/DOWN ▼ Buttons to navigate the pointer on the Status LCD to indicate ► **Go To Operations**. Press the Right Cursor button ►to enter the operations menu, and use the UP▲/DOWN ▼ Buttons to navigate the pointer on the Status LCD to indicate ► **Alarm Setpoints**. Press the Right Cursor button ►to enter the Alarm Setpoints menu.

Use the UP▲/DOWN ▼ Buttons to navigate the pointer on the Status LCD to indicate ► **ALARM1** or **ALARM 2**. Press the Right Cursor button ►to enter the selected alarm menu. Use the UP▲/DOWN ▼ Buttons to change the **ALARM LOW DEVIATION** value, and press the Next ► button to accept the new value and move the HIGH DEVIATION menu. Use the UP▲/DOWN ▼ Buttons to change the **ALARM HIGH DEVIATION** value, and press the Next ► button to accept the new value and return to the **Alarm Setpoints** menu. Press the press the Left Cursor ◄ button twice to store the new Alarm Setpoints and return to the Main screen.

INFRARED SYSTEMS DEVELOPMENT CORPORATION

IR-301 Blackbody Controller Communications Reference

(REV M March 2011)

RS-232
GPIB IEEE-488
(MODBUS Reference)

7.0 IR-301 BLACKBODY CONTROLLER COMMUNICATIONS REFERENCE

7.1 CONVENTION

In this document, numbers in the format 0x00 represent values in hexadecimal. Numbers in the format 0 represent values in decimal and finally, numbers in the format 00000000 represent values in binary unless stated otherwise

7.2 INTERFACE STANDARDS

An interface is a means for electronic systems to interact. It's a specific kind of electrical wiring configuration.

EIA-232 (Full Duplex) (IR-301 Default Configuration)
An EIA-232 (formerly RS-232) interface uses three wires: a single transmit wire; a single receive wire; and a common line. Only two devices can use an EIA-232 interface. A -3 to -24 volt signal indicates a 1 and a +3 to +24 volt signal indicates a 0. The EIA-232 signal is referenced to the common line rather than to a separate wire, as in EIA-485 and EIA-422. An EIA-232 cable is limited to 50 feet, due to noise susceptibility.

EIA-485 (Half Duplex)(ONLY Available at special request)
An EIA-485 interface uses three wires: a T+/R+, a T-/R- and a common line. A -5-volt signal is interpreted as a 1, a +5-volt signal as a 0. As many as 32 remote devices can be connected to a master on a multi-drop network up to 4,000 feet long.

7.3 WIRING

Most PCs and some PLCs have a standard EIA-232 port (usually referred to as RS-232, Serial Port, COM Port). Use a standard straight thru Serial Cable DB9M to DB9F.
You may use an interface converter to connect to EIA-485. This interface standard (485) is required to have a multi-drop system (more than one controller on the bus). See the Appendix for connector pin-outs.

7.4 MODBUS REMOTE TERMINAL UNIT (RTU)

Modicon Corporation, now AEG Schneider, created a serial protocol known as Modbus for controlling industrial process control systems. The Modbus protocol is an extremely reliable protocol for exchanging data in noisy industrial applications. The Modbus protocol is a packet exchange protocol where the controller receives a response to each packet that it sends to a device.
Each packet contains the address of the controller that is to receive the information, a command field that says what to do with the data fields and a CRC (Cyclic Redundancy Checksum) field that is used to validate the packet.

The Modbus protocol uses two coding schemes, ASCII or HEX characters. The HEX character format is known as the RTU protocol and it is the protocol supported by the IR-301 Controllers. Modbus devices pass data and commands through addressable

registers. Each register has a different function as defined by the device designer, i.e. temperature setpoint, alarm settings, etc. The registers may be read only, write only or read-write.

7.5 WRITING A MODBUS APPLICATION

Modbus is a protocol that enables a computer or PLC to read and write directly to registers containing the controller's parameters.

Do not use Windows Hyperterminal for command debugging.

Use a RAW serial terminal or other programming environment such as LabView, C, C++, Basic, etc.

This document explains the functionality of addressing registers through commands.

1. You need to code messages in eight-bit bytes, with no parity bit, one stop bit (8, n, 1).

2. **Negative parameter values must be written in twos' complement format.** Parameters are stored in two-byte registers accessed with read and write commands.

3. Messages are sent in packets that are separated by a pause at least as long as the time it takes to send 30 bits. To determine this time in seconds, divide 30 by your baud rate. *(30 bits/19200bits/sec = 1.56ms)*

7.6 COMMAND FORMAT

All command values in this section are hexadecimal.
Each message packet begins with a one-byte controller address, from 01 to F7.
(DEFAULT IR-301 ADDRESS IS 01)

The second byte in the message packet identifies the message command:
Read Single Register 03
Write Single Register 06

The next n bytes of the message packet contain register addresses and/or data.

The **last two bytes** in the message packet contain a two-byte Cyclical Redundancy Checksum (CRC) for error detection. See Appendix for CRC algorithm.

7.6.1 Read Single Register Command (03)

This command will read a parameter from a single register. The controller will return the registers value within a command packet.

Packet sent to controller:| 01 | 03 | | 0n nn | nn nn |

Controller address (one byte) (01) **(IR-301 Default address)**
Read command (03)
Register high byte
Register low byte
Number of Registers high byte (00)
Number of Registers low byte (01)
CRC low byte
CRC high byte

EXAMPLE: Read the controller's current set point (Register 300 = 0x012C)
Register: 300 Main > Status Information: Blackbody Setpoint (SP1) (value times 10)

Packet Sent to Controller: 0103 012C 0001 443F
Packet Returned from Controller: 0103 0200 FA38 07

Controller Address	01
Read Command	03
Number of bytes	02
Data high byte	00
Data low byte	FA ***(FA = 250 Decimal / 10 = 25.0 Deg C)***
CRC high	38
CRC low	07

7.6.2 Write Single Register Command (06)

This command writes a parameter to a single register. The controller will echo back the command. An attempt to write to a read-only parameter returns an illegal data address error (0x02). (See “Exception Responses,”)

Packet sent to controller:| 01 | 06 | 0n nn | nn nn | nn nn |

Controller address (one byte) (01) **(IR-301 Default address)**
Write command (06)
Register high byte
Register low byte
Data high byte
Data low byte
CRC low byte
CRC high byte

EXAMPLE: Write the controller’s current set point (Register 300 = 0x012C) to 150º C.
Register: 300 Main > Status Information: Blackbody Setpoint (SP1) (value times 10)

Packet Sent to Controller: 0106 012C 05DC 4B36
Packet Returned from Controller: 0106 012C 05DC 4B36

Controller Address	01
Write Command	06
Register high byte	01
Register low byte	2C
Data high byte	05
Data low byte	DC ***(05DC = 1500 Decimal / 10 = 150.0 Deg C)***
CRC high	4B
CRC low	36

7.6.3 Test: Read Model Number (03)

This command will read the internal PID controller's model number. The controller will return the model number value within a command packet. This example serves as a check for correct wiring and proper communications with the IR-301 controller.
All IR-301 controllers return 0x14A0 = 5280

EXAMPLE: Read the controller's Model Number (Register 0 = 0x0000)

Packet Sent to Controller:	0103 0000 0001 840A
Packet Returned from Controller:	0103 0214 A0B7 3C

Controller Address	01	
Read Command	03	
Number of bytes	02	
Data high byte	14	
Data low byte	A0	***(14A0 = 5280 Decimal)***
CRC high	B7	
CRC low	3C	

7.7 SPECIAL IR-301 MODBUS FUNCTIONS

Register 25 (Write ONLY), Save Changes to Non-volatile Memory (System EEPROM)

Register 25 is a special function register to save changes to the Non-Volatile memory. However, there is a limit to the number of times you can store information in the EPPROM.
PCs can quickly reach this limit if the set point is continually changed and saved, for example by using a PC as a ramping controller.

From the factory this 'feature' is disabled. A user can write as many changes as they wish to the controller's registers without risk of damage to the EEPROM.

Writing a "0" (zero) to register 25 saves all of the current settings of the controller to Non-Volatile Memory.

Any write commands written to the controller after this point (even after power is cycled) will not be saved in the Non-Volatile memory. When the power is reset all settings will default to the last values stored in the Non-Volatile memory before the "0" command was sent to register 25.

7.8 USER RESPONSIBILITY

Users must exercise caution when writing to registers that do not appear on the controller's front panel or listed in this manual. For example, if a valid command

is sent to a register holding a calibration or power ramp parameter it could cause damage to the calibration or worse the equipment.

7.9 IR-301 MODBUS REGISTERS

Register Location/Parameter

0 **Model# (All IR-301's: 5280)**
3 **Software Revision (All IR-301's: 10)**
16 **Output 1A Type (All IR-301's: 3 Open Collector Output)**
17 **Output 1B Type (IR-2100 Series Only)**
25 **Save Changes to Non-volatile Memory (System EEPROM)**
100 **Current Blackbody Temperature (Value x10)**
101 **Error Status**
102 **Alarm 1 Status**
103 **% Power Sent to Blackbody**
104 **Cold Junction Sensor Value**
105 **Cold Junction Error Status**
106 **Alarm 2 Status**
200 **Operation Mode**
209 **System Error Status**
300 **Blackbody Set Point (SP1) (Value x10)**
302 Alarm Set Point > Alarm 1 > **Alarm Low Set Point**
303 **Alarm High Set Point**
321 Alarm Set Point > Alarm 2 > **Alarm Low Set Point**
322 **Alarm High Set Point**

7.10 OPTIONAL IEEE-488/GPIB INTERFACE

If your controller is equipped with both RS-232 and GPIB, the first interface to be used after power on will be the only interface available until power is turned off, then on again.

7.10.1 CONTROLLER OPERATION

The GPIB commands specify the slave device address, a read or write operation, a register number and data or the number of registers to be read. When the controller receives a read (R) or write (W) command, it converts the ASCII characters into HEX bytes, assembles the packet, adds the checksum and transmits it serially to the Modbus device.

When the packet is successfully received, the device will generate a response packet that either acknowledges receipt of the message or returns the requested data. The controller receives the response packet and checks it for a valid checksum and byte count. If the packet is a valid response to a read command, the returned data is held in the GPIB transmit buffer and outputted onto the GPIB bus the next time the controller is addressed to talk. If the packet is a command acknowledgment message, there is no further action. If the packet is invalid or contains a Modbus Exception Error code, then the code is placed in the Modbus Error Register.

The controller expects to receive a response packet within a preset time period or it declares a timeout error. The timeout period is programmable and is factory set to 100 milliseconds. Tests have shown that 300 milliseconds provide improved communications

with older PC's. If the received packet was not a valid packet, or was an exception message, then the controller sets the appropriate bit(s) in the Questionable Register and puts a decimal error value in the Modbus Error register. Both registers are part of the controller's IEEE-488.2 Status Reporting Structure. The controller can be programmed to generate an SRQ if an error occurs by setting the appropriate enable bits in the Status Reporting Structure. If an enabled error bit becomes set, the register's summary signal cascades into the Status Byte Register and generates a Service Request by asserting the SRQ line. The SRQ line stays asserted until the unit is serial polled or until the bits that caused the SRQ are reset.

7.10.2 GPIB COMMAND SET

Although the IR-301 is an IEEE-488.2 compatible device and incorporates a SCPI parser for their own functions, they have a very simple set of command.

The 'R' command reads a Modbus register. The 'W' command writes a value to a Modbus register. The register numbers and functions come from the table in this manual. Some examples:

R 100,1 'Reads current temperature in Degrees C (x10, 1000 = 100.0 C)
W 300,1250 'Sets Blackbody Set Point to 125.0 □C

GPIB COMMANDS

L[?]	w	Loopback Command. Writes a 16-bit word, w, out to a Modbus device and returns a single response word to the GPIB bus. The question mark is optional. Value for *w* is 0 to65535.
R[?]	reg, num	Read Register Command. Reads one or multiple Modbus device registers. User specifies starting register *reg* and number of registers to be read *nu*m. The [?] is an optional symbol so programs like ICS's GPIBKybd program can recognize the command as a query and automatically read the response. Values for *reg* are 0 to 32767. Values for *num* are 1 to 64. Responses are returned as 16-bit decimal or HEX values separated by commas. Output format selected with the Format command. i.e. R? 0,1 reads IR-301 Model Number. Response is 5280
W	reg, w	Write Register Command. Writes a 16-bit value, *w* to a single Modbus device register, *re*g. Values for reg are 0 to 32767. Values for *w* are 0 to 65535. An example is: W 300, 550 writes the decimal value 55.0 to register 300.
D	time 100	Timeout Command. Sets timeout value of Modbus response message in milliseconds. Timeout is the total time for the message to be received by the 4899 or 4809. Value for *time* is 1 to 65,535 milliseconds. Default is 100.
D?		Queries the current timeout setting.
E?		Read Error Command. Reads and clears the Modbus Error Register and bit 6 in the Event Status Register. Returns an error code whose value is 0 to 255. Error values are: 0 No errors present 1 Exception Code 1 2 Exception Code 2 3 Exception Code 3 100 CRC Error 101 Timeout Error indicates no characters received 2nn Partial or corrupted message nn is number of received bytes.

Notes:
1. All values are in decimal. To enter HEX values, use #h value.

2. Response parameter format set by SCPI FORMat command.
3. Negative values start with a minus '-' sign.
4. Separate multiple values by a comma

7.11 APPENDIX:

7.11.1 CRC (Cyclical Redundancy Checksum)

This C routine, calc_crc(), calculates the cyclical redundancy checksum for a string of characters. The CRC is the result of dividing the string by 0xA001. Modbus applications calculate the packet's CRC then append it to the packet.

```
#define POLYNOMIAL 0xA001;
unsigned int calc_crc(unsigned char
*start_of_packet, unsigned char
*end_of_packet)
{
unsigned int crc;
unsigned char bit_count;
unsigned char *char_ptr;
/* Start at the beginning of the packet */
char_ptr = start_of_packet;
/* Initialize CRC */
crc = 0xffff;
/* Loop through the entire packet */
do{
/* Exclusive-OR the byte with the CRC */
crc ^= (unsigned int)*char_ptr;
/* Loop through all 8 data bits */
bit_count = 0;
do{
/* If the LSB is 1, shift the CRC and XOR
the polynomial mask with the CRC */
if(crc & 0x0001){
crc >>= 1;
crc ^= POLYNOMIAL;
}
/* If the LSB is 0, shift the CRC only */
else{
crc >>= 1;
}
} while(bit_count++ < 7);
} while(char_ptr++ < end_of_packet);
return(crc);
}.
```

7.11.2 RS-232 SERIAL INTERFACE

IR-301 Modbus Slave Address 1

Serial signals conform to EIA Specifications for RS-232 signals.
J2 (RS-232) is a DTE type interface with DTR and RTS signals pulled to +V.

Signals Txd,Rxd,Gnd
Baud Rates: 19.2 Kbaud

Data Bits: 8 bits
Parity: None
Stop Bits: 1
J2 Port: (DB9 - Female)

DB-9S Rear Panel Connector Signals

1	DCD	Not required
2	RxD	Receive Data
3	TxD	Transmit Data
4	DTR	Not required
5	Gnd	Signal Ground
6	DSR	Not required
7	RTS	Not required
8	CTS	Not required
9	----	Not required

7.11.3 GPIB Interface

IR-301 GPIB address is set to 4

J3: Rear Panel Connector Signals

Signal	Pin#	Color	Bit (Weights)
GROUND	1	BRN	1
ADSW5	2	RED	1 16 (MSB)
T SW	3	ORG	1 not used
L SW	4	YEL	1 not used
ADSW4	5	GRN	1 8
SI SW	6	BLU	1 not used
ADSW1	7	VIO	1 1 (LSB)
ADSW3	8	GRY	1 4
ADSW2	9	WHT	1 2
NRFD	10	BLK	1 GPIB Signals
REN	11	BRN	2
DAV	12	RED	2
IFC	13	ORG	2
NDAC	14	YEL	2
EOI	15	GRN	2
ATN	16	BLU	2
SRQ	17	VIO	2
DIO1	18	GRY	2
DIO2	19	WHT	2
DIO3	20	BLK	2
DIO4	21	BRN	3
DIO5	22	RED	3
DIO6	23	ORG	3
DIO7	24	YEL	3
DIO8	25	GRN	3
GROUND	26	BLU	3 GPIB Signals

GPIB SRQ GENERATION

SRQs are generated per the IEEE-488.2 specification when the unit is not addressed to talk and an enabled bit in the ESR,Questionable or Conditional register becomes set.ESR bits are:

Modbus Error Register set
Serial Buffer full
Command error
Serial error
Execution error
Query error
Power on

GPIB COMMON COMMANDS

*CLS	*IDN?	*SAV	*TST?
*ESE	*OPC	*SRE	*WAI
*ESE?	*OPC?	*SRE?	
*ESR?	*RST	*STB	

GPIB EVENT STATUS REGISTER

The Event Status Register reports events that are common to all 488.2 devices. This includes events such as self-test errors, command errors, execution errors, power on and operation complete. The Power-on event occurs at power turn-on and can be used to signal a power off-on occurrence. The Event Status Register is read with the ***ESR?** query. Use the ***ESE** commands to set the Event Status Enable Register as shown in the following example:

***ESE 60** 'Enables error bits 2 through 5 for errors
***ESE 124** 'Enables error bits 2 through 5
***ESE?** 'Queries the enabling register setting

GPIB STATUS BYTE REGISTER

The IR-301 generates a service request (SRQ) whenever any of the enabled bits in the Status Byte Register become true and the IR-301 is not addressed as a talker. The Status Byte Register may be read by a Serial Poll or with the ***STB?** query. A Serial Poll resets the RQS bit; the ***STB?** query does not change the bit. The Status Byte Register is enabled by setting the corresponding bits in the Service Request Enable Register with the ***SRE** command. e.g.

***SRE 160** 'Sets the SRE Register to 1010 0000 which enables just the Event Status and Questionable summary bits to generate SRQs.

8.0 TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	CORRECTION
Power applied, front panel does not light and controller does not function	1. No power applied 2. Power loss transient	1. Check power wiring 2. Check F1 3. Power down and re-power up
Display reads SEnLo or SEnHi	1. Open control PRT loop 2. Severe Calibration error	1. Check Ω between pins 9 and 11 (<5Ω)
Fuse F1 blows	1. Shorted heater element	1. Check Ω between pins 4 and 7 (10±4Ω)
Blackbody does not heat up	1. Open heater element 2. Open power relay 3. Incorrect control parameters	1. Check Ω between pins 4 and 7 (10±4Ω)
Erratic operation	1. Incorrect control parameters 2. Not tuned correctly 3. Controller failure (internal electronics)	1. Switch control T/C with Cal. T/C 2. Contact factory

9.0 CALIBRATION

All ISDC Blackbody Systems are factory calibrated and supplied with a Certificate of Calibration, prior to shipment, therefore it is not necessary to calibrate when you receive and install it. Calibration adjustments should not be required under normal operating conditions. Six-month Calibration Verification checks are recommended.

WARNING: ***UNQUALIFIED PERSONNEL SHOULD NOT ATTEMPT CALIBRATION OF THE BLACKBODY SYSTEM. SEVERE SYSTEM FAILURE COULD OCCUR. WE RECOMMEND RETURNING THE BLACKBODY AND CONTROLLER TO THE FACTORY FOR A COMPLETE CHECKOUT AND RECALIBRATION. IN THE EVENT THAT FIELD CALIBRATION IS NECESSARY, WE STRONGLY SUGGEST THAT ALL NOTES, WARNINGS AND PROCEEDURES BE UNDERSTOOD PRIOR TO ANY ATTEMPT.***

NOTE: ***THE TEMPERATURE CONTROLLER USES SOLID-STATE RELAYS TO CONTROL SURFACE HEATER POWER. WE RECOMMEND THAT, AS PART OF THE SIX-MONTH CALIBRATION CYCLE, THE RELAY BE CHECKED TO VERIFY THAT IT IS NOT SHORTED.***

With system power and cover removed, ohm between terminals #1 and #2 on the relay. Resistance should be greater than 1 MEG ohm. If the relay is shorted, then it must be replaced to ensure continued reliability.

10.0 APPLICATION NOTES

BASIC TERMS AND RELATIONSHIPS USED TO DEFINE THE CHARACTERISTICS OF INFRARED SOURCES

The following basic formulas are used to define an Infrared Source. They are particular to Blackbody Sources, but can be applied to most sources of Infrared Energy by using the proper emisivity values.

Radiant Emittance (W): Radiant flux emitted per unit area of an Infrared Source in watts per square centimeter (Watts/cm^2), defined as:

$$W = \varepsilon\sigma\,(T_S^4 - T_b^4) \qquad \text{where}$$

ε = Emissivity of the Source (For a Blackbody $\varepsilon = 1$)
σ = Stefan Boltzman constant (5.6697×10^{-12} W/cm^{2}K^{-4})
T_S = Temperature of the Infrared Source in Kelvins (K)
T_b = Temperature of the background in Kelvin (K)

Spectral Radiant Emittance (W_λ): Radiant emittance per unit area per unit wavelength in watts per square centimeter micron, defined as:

$$W_\lambda = \frac{C_1}{\lambda_5\,(e^{(C_2/\lambda T)}-1)} \qquad \text{where}$$

C_1 = First Radiation Constant (3.7415×10^4 W μ^4/cm^2)
λ = Wavelength in microns (μ)
C_2 = Second Radiation Constant (1.43879×10^4 μK)
T = Temperature in Kelvin
e = Naperian Base (2.7183…)

Wavelength of Peak Response (λ_m): The wavelength at which the Infrared Source has peak radiance, defined as:

$$\lambda_m = \frac{2897.8}{T}$$ **where T is Temperature in degrees Kelvin**

In some texts, λ_m may be written as λ_p. Both expressions are accepted.

Radiant Emittance at Peak Wavelength (W_p): The radiant emittance at the wavelength of peak response, defined as:

$$W_p = bT^5$$ **where**

b = 1.2862×10^{-15} W cm^{-2} μ^{-1} K^{-5}
T = Temperature of the Infrared Source in Kelvin

W_p can also be expressed as $W_{\lambda m}$. Both expressions are acceptable.

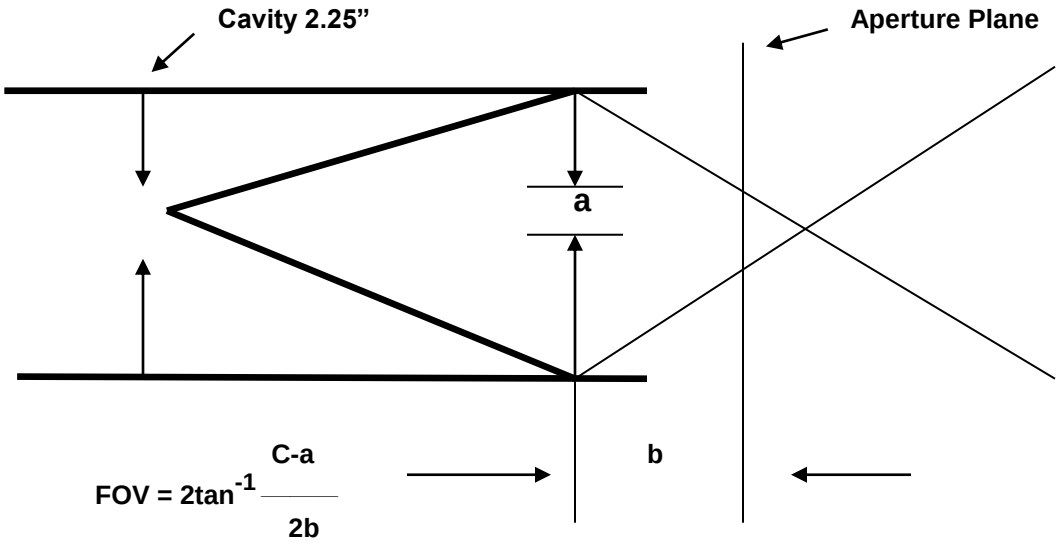
Irradiance (H): The amount of infrared energy incident on a Detector's sensing area, defined as:

$$H = WF \frac{a^2}{4d^2} t$$ **where**

W = Radiant emittance of the Infrared Source
F = RMS conversion factor of the Source (If NA, then 1)
a = Limiting aperture diameter
d = Distance from the aperture plane to the sensing area plane
t = Transmission of the optical path (0→1)

Emissivity (e): The ratio of the radiant emittance of a non-blackbody source when compared to the radiant emittance of a Blackbody. Normally the value of e varies from zero to one and is readily available from reference sources.

11.0 BLACKBODY FIELD OF VIEW (FOV)



			508	574
C	=	Maximum Cavity Diameter	0.250”	2.25”
b	=	Distance from the Aperture Plane to the innermost Maximum Width point	0.541”	5.00”
a	=	Aperture Diameter		

12.0 RADIOMETRIC TERMS

SYMBOL	TERM	DESCRIPTION	UNIT
W	Radiant Emittance	P Emitted / unit area	W/cm^2
Q	Radiant Photon Emittance	Number of photons emitted / second unit area	$photons/sec/cm^2$
J	Radiant Intensity	P / unit solid angle	W/Sr
N	Radiance	P / unit solid angle unit area	$W/cm^2/Sr$
H	Irradiance	P / incident / unit area	W/cm^2
Pλ	Spectral Radiant Flux	P / unit wavelength at wavelength	W/μ
Wλ	Spectral Radiant Emittance	W / unit wavelength at wavelength	$W/cm^2/μ$
Qλ	Spectral Radiant Photon Emittance	Q / unit wavelength at wavelength	$W/sec/μ/cm^2$
Jλ	Spectral Radiant Intensity	J / unit wavelength at wavelength	W/Sr/μ
Nλ	Spectral Radiance	N / unit wavelength at wavelength	$W/cm^2/Sr/μ$
Hλ	Spectral Irradiance	H / unit wavelength at wavelength	$W/cm^2/μ$
ε	Emissivity	Ratio of W of a source to a blackbody source	Numeric
α	Absorption	Ratio of absorbed P to incident P	Numeric
ρ	Reflectance	Ratio of reflected P to incident P	Numeric

NOTES: _____

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sales@infraredsystems.com

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Contact us for more information.

Infrared Systems Development Corporation
7319 Sandscove Court #4
Winter Park, FL 32792

Phone: 407-679-5101
Fax: 407-679-5520

Email: sales@infraredsystems.com
Visit us at: www.infraredsystems.com