FOT Lab Kit Fluoroptic Thermometer

User's Manual

For firmware version 2.80 and higher

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LUXTRON Corporation
3033 Scott Blvd.
Santa Clara, CA 95054-3316
Telephone (408) 727-1600
FAX (408) 727-1677
E-mail info@luxtron.com
support@luxtron.com
Website http://www.luxtron.com

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Preface

This document describes the FOT Lab Kit Fluoroptic® thermometer and is organized into the following sections.

- Chapter 1, “Introduction’’, provides an overview of the LUXTRON FOT Lab Kit and Luxtron’s Fluoroptic® technology.
- Chapter 2, “System Components’’, describes the various parts and components that make up a complete Fluoroptic® thermometry system.
- Chapter 3, “System Operation’’, provides general instructions on how to operate and use the FOT Lab Kit.
- Chapter 4, “User Interface Commands’’, provides a detailed description of all user interface commands and user selectable parameters.
- Chapter 5, “Temperature Data Reporting’’, describes the type and format of data reported by the instrument.
- Appendix A, “Calibration Procedure’’, describes the procedure used to calibrate the instrument.
- Appendix B, “Warranty and Service’’, provides warranty and service information.

1 Introduction

The FOT Lab Kit is a fiber optic thermometry system that allows users to measure temperature where conventional sensors fail. Luxtron's unique technology, called Fluoroptic® Thermometry (FOT), offers probes that are totally immune to electromagnetic interference (EMI) and of entirely non-metallic construction. These qualities make FOT probes perfectly suited for measuring temperatures in harsh environments, such as high voltages and strong radio frequencies (RF), often encountered during research or in industrial processes.

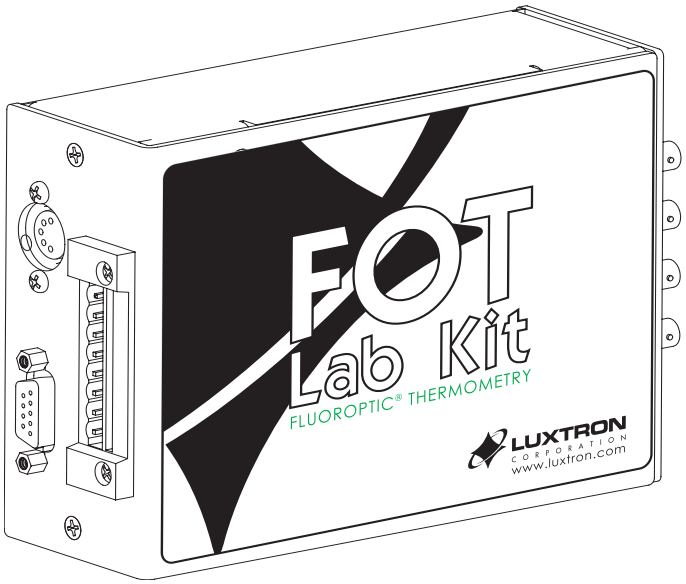
Applications include:

- **Medical treatment and research**
  MRI, microwave, laser, hyperthermia, RF ablation, cryogenic treatments
- **Semiconductor equipment**
  Electrostatic chucks, etch and deposition chambers, Rapid Thermal Process chambers
- **Industrial applications**
  RF and microwave drying, and harsh chemistries
- **Utility equipment**
  Transformer windings and high voltage transmission lines

FOT Lab Kit Contents

The FOT Lab Kit includes a four-channel Fluoroptic® thermometry instrument shielded in a rugged steel enclosure, a universal power supply, an RS-232 cable, and a user's manual; all within a compact carrying case.

Figure 1-1 FOT Lab Kit Instrument



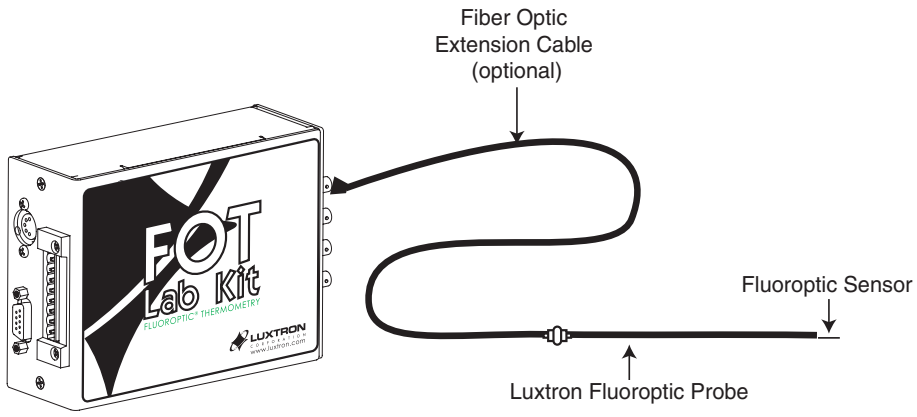
The FOT Lab Kit Instrument uses an RS-232 serial interface for command input and data output. The unit communicates at 9,600 bps using an 8-N-1 data format. In addition, it includes a 0-10 volt analog output for each measurement channel.

The user interface may be accessed through standard terminal emulation software e.g. HyperTerminal, ProComm Plus, etc. through a customer-supplied control application, or through LUXTRON's Windows®-based TrueTemp™ software. Compatible with Windows® 95/98, Windows® NT or higher, the TrueTemp™ software offers full-featured data acquisition, graphing, and analysis.

System Overview

A complete FOT system consists of an instrument and probe. Optional accessories include fiber optic extension cables, vacuum feedthroughs, and PC acquisition and graphing software (see Figure 1-2).

Figure 1-2 Fluoroptic® Thermometry System Includes an Instrument, Probes, and Optional Accessories.



Instrument

The FOT Lab Kit Instrument is a four channel system that includes 0 to 10V analog outputs for each channel as well as an RS-232 interface.

Probes

Luxtron offers standard fiber optic probes for use with the FOT Lab Kit. The probes are designed to suite a variety of applications. Some are designed to measure the bulk temperature of an object (immersion probes) while other are designed to measure the surface temperature of an object (surface and non-contact probes). These probes are available in standard lengths of 2, 5, and 10 meters (see Figure 2-1, on page 2-2 for details).

LUXTRON specializes in developing custom probes to meet the unique circumstances of OEM applications. Non-metallic and electrically non-conductive, the Fluoroptic® probes are immune to EMI and high voltages that adversely affect conventional sensors

such as thermocouples, RTDs and thermistors. Call a LUXTRON applications engineer to discuss development of a custom probe for your specific OEM application. To see examples of custom probes, visit LUXTRON's website at www.luxtron.com.

Accessories

The most common accessory is a fiber optic extension. The extension allows flexible mounting or locating of the instrument with respect to the point of measurement. Standard extension lengths are available in 2, 5, and 10 meters.

The other category of accessories is vacuum feedthroughs. These allow either a probe or a fiber optic extension to enter vacuum chambers through NPT fittings or Conflat™ flanges.

Fluoroptic® Technology Overview

The FOT Lab Kit uses LUXTRON's patented Fluoroptic® technology, based on a temperature sensitive phosphorescent sensor attached to the end of an optical fiber. Pulses of light transmitted down the fiber optic probe cause the sensor to be excited and fluoresce. The DSP-based electronics of the FOT Lab Kit Instrument detect and calculate the decay time of this fluorescence after each pulse. This decay time varies precisely with the temperature of the sensor, providing the basis for accurate temperature measurement. The FOT Lab Kit Instrument achieves accuracy better than 0.5 ^{o}C and a measurement range of -100 to +330 ^{o}C.

Below is a plot representation of the method used to extract the florescence decay time (τ) of the phosphor sensor. A mathematical curve fit correlates individual data points with stored values of (τ). The measured value of (τ) is then conditioned with the values in a calibration table to determine temperature.

Figure 1-3 Plot Representation of LUXTRON's Fluoroptic® Thermometry Technique

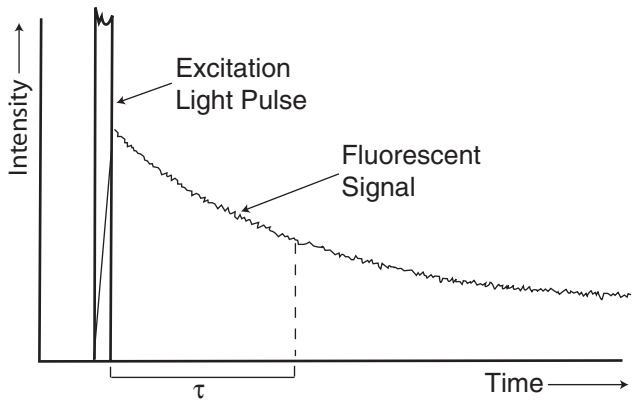


Table 1-1 FOT Lab Kit Performance Specifications

Number of Channels	4
Temperature Range	-100 through +330 °C, depending upon probe specification
Electrical Interference	Probes are immune to EMI and RF
Accuracy	
Uncalibrated	1% of full scale
Calibrated	±0.5 °C within ±50 °C of calibration
Repeatability	±0.5 °C RMS at 8 samples per measurement
Temperature Resolution	
RS-232 Output	0.01 °C
Analog Output	0.01 °C
Short Term Drift	<0.2 °C / hour
Long Term Drift	<0.5 °C / 10 days
Output Format	°K, °C, °F (user selectable)
Self-diagnostic	Self diagnosis and probe error indications available through RS-232 interface
Input Power	Universal power supply
Serial Output	RS-232 serial interface at 9,600 bps, N-8-1, no handshake
Analog Output	0.0 - 10.0VDC
Dimensions	184mm x 144mm x 51mm
Storage Temperature	-55 to +75 °C
Operating Temperature	10 to 50 °C
Maximum Humidity	80%, non-condensing

2 System Components

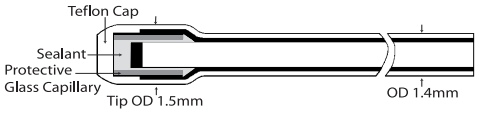
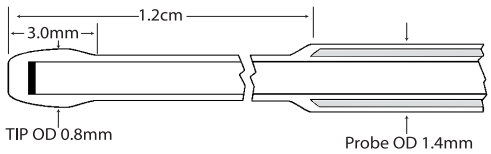
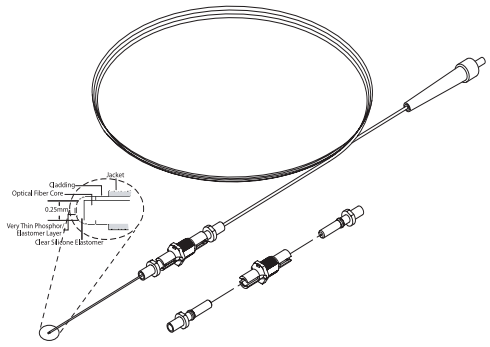
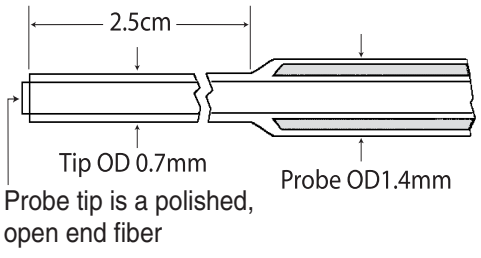
The FOT Lab Kit is designed to function with a variety of standard probes and accessories produced by LUXTRON Corporation. The various probes are designed for different applications and are described in Figure 2-1, “Standard Probes for Use with FOT Lab Kit,” on page 2-2. Visit LUXTRON’s website or contact the LUXTRON Sales Department for more detailed information.

Probes

Standard Probes

Fluoroptic probes are non-metallic and immune to EMI and radio-frequency noise. The standard probes generally consist of a fiber-optic cable with LUXTRON's temperature sensitive phosphor affixed to the probing end and a fiber optic ST-style connector on the other end for connection to the FOT Lab Kit.

Figure 2-1 Standard Probes for Use with FOT Lab Kit

Picture	Description	Luxtron Part Number
	**STM Probe** Application: General Purpose Immersion Temp Range: 0 to 250 °C Response Time: 5s in still air 0.7s in stirred water	00-13244-XX
	**STF Probe** Application: Fast Response Immersion Temp Range: 0 to 295 °C Response Time: 1.25s in still air 0.25s in stirred water	00-13737-XX
	**STS Probe** Application: Surface Contact Temp Range: -25 to 200 °C Response Time: 25ms	00-13738-XX
	**STR Probe Kit** Application: Non-contact Remote Temp Range: -25 to 330°C Includes: 0.1 gm Luxtron's Alpha phosphor sensor powder 1mL 150°C silicon binder 1mL 250°C silicon binder 1mL 450°C silicon binder 2m STP probe blank (see image at left) Remote Sensing User's Guide	06-13740-01

Custom Probes

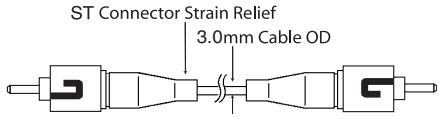
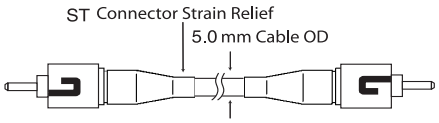
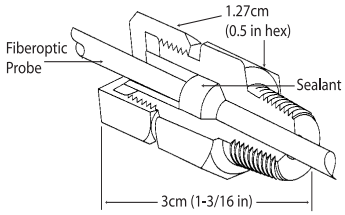
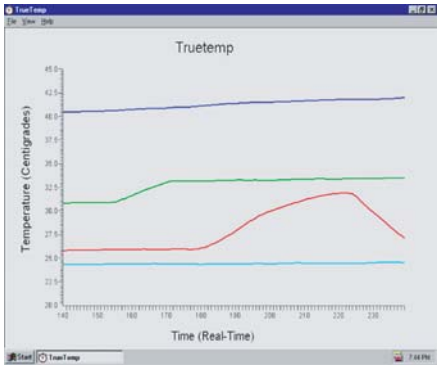
In addition to the standard probes, LUXTRON offers a custom development program to design and integrate probes to meet the needs of OEM applications. Custom probes have been developed for a wide range of temperatures (from cryogenic to over 400°C), vacuum specifications (down to $1e^{-10}$ torr), materials and mechanical specifications to survive various hostile environments. Examples of some custom designs can be seen on LUXTRON's website at www.luxtron.com.

Standard Options and Accessories

LUXTRON offers standard accessories for use with the FOT Lab Kit. The most common accessory is a fiber optic extension cable. The extension allows flexible mounting or locating of the instrument with respect to the target being measured. Standard extension cables are available in 2, 5 and 10 meter lengths.

Other accessories include vacuum fittings and PC data acquisition and graphing software. See Table 2-1 below for a description of standard accessories.

Table 2-1 Standard Accessories for Use with FOT Lab Kit

	**SST Extension** Application: General purpose fiber optic extension cable Connector: ST, both ends	00-13743-XX
	**HST Extension** Application: Heavy duty fiber optic extension cable Connector: ST, both ends	00-13744-XX
	**Compression Gland Feedthrough** Temp Range: -20 to 230 °C Maximum Vacuum Pressure: 5e10-6 Torr Maximum Pressure 3,000 psi Compatible with STM, STF, and STR probes	90-1462
	**TrueTemp PC Data Acquisition and Graphing Software**	00-12790-01

3 System Operation

The FOT Lab Kit is a fiber optic temperature measurement system. All standard probes and fiber optic accessories for use with the FOT Lab Kit have ST-style fiber optic connectors.

Getting Started

This "Getting Started" section will enable you to start basic measurements, using default setups, with your FOT Lab Kit. For more details on how to tailor the instrument to your specific needs, please refer to the user interface details described in Chapter 4, "User Interface Commands'' and Chapter 5, "Temperature Data Reporting''.

Host Control

To access the full features and interface of the FOT Lab Kit, you will need a PC or host device to communicate via RS-232. If you are using LUXTRON's TrueTemp Software, we recommend you install this software first, before connecting the instrument.

Connecting and Installing the System

The FOT Lab Kit includes various cables and accessories for connection. Follow the steps below and refer to Figure 3-1 to setup the system for operation:

a. Connect the 9-pin male D-sub connector to the RS-232 port on the instrument.

b. Connect the RS-232 female connector to your computer's serial COM port.

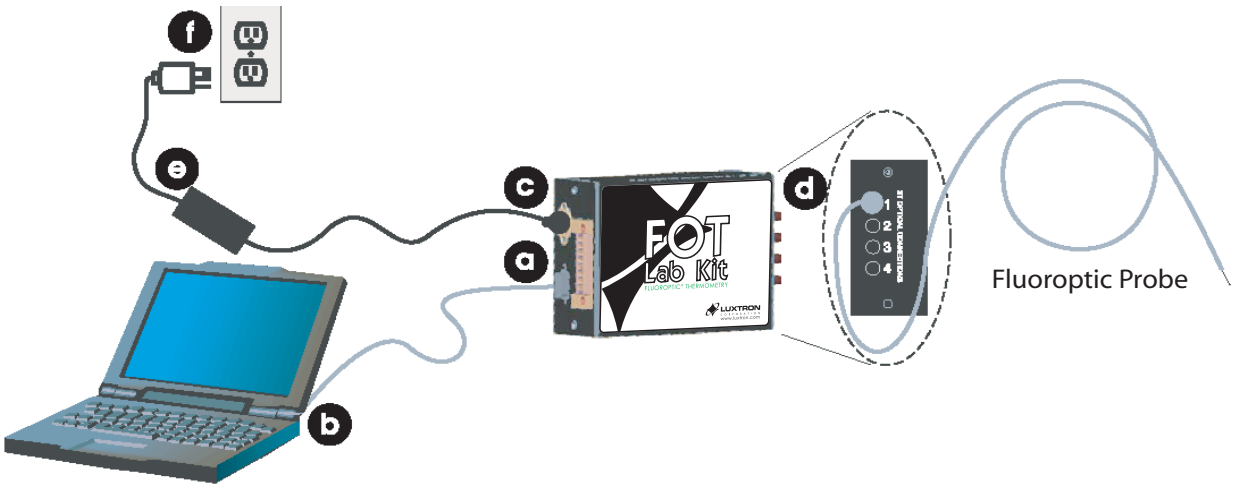
c. Connect the power supply's DIN connector to instrument's power inlet.

d. Remove the black dust cap(s) from the instrument's ST optical connection(s) and remove the clear protective cap from your Fluoroptic® probe(s). Connect the probe(s) to the instrument by aligning the polarized connector on the probe to the optical port and gently push in. Turn clockwise to lock the connection.

e. Plug power cord into the power supply

f. Plug power supply to a grounded power outlet.

Figure 3-1 Connecting the FOT Lab Kit Components



Making Temperature Measurement

With default factory settings, the FOT instrument will automatically start making temperature measurements approximately one minute after power up. To start or stop measurements, use "Action Commands (One-Letter) in Chapter 4, "User Interface Commands''. To adjust measurement rates, analog output values, and other settings, refer to the "Parameter Commands (Two-Letter)'', also in Chapter 4

NOTE *Keep the protective black vinyl caps on the unused instrument probe ports. This prevents ambient light from entering the system, which could adversely affect the accuracy of temperature measurements from the remaining active probe(s).*

Probe Table Settings

The FOT Lab Kit is designed to work with many different probe types. There are four standard industrial probes (shown earlier in Table 2-1 on page 2-4) and some specific industry probes, for example, medical and power transformer probes. To guarantee system operation within specifications, the FOT Lab Kit must be configured to operate with your specific probe type. This is done by selecting the correct lookup table. See Table 3-1 below to lookup the correct calibration table for your probe type.

Table 3-1 List of Correct Lookup Tables for Various Probe Types

Probe Type	Description	Look Up Table
STF	Fast Response Immersion Probe	T1
STR	Non-contact, Remote Sensing Kit	T1
WTS	Power Transformer Winding Hot Spot Probe	T1
STS	Surface Contact Probe	T2
STB	Medical, 0.5mm Diameter Probe	T2
MRC	Medical, Core Temperature	T2
MRR	Medical, Skin and Core Temperature	T2
MRS	Medical, Skin Temperature	T2
STM	General Purpose Immersion Probe	T3

The FOT Lab Kit's default lookup table is T1. A simple command is used to change the lookup table. For example, to change the instrument to operate with table T2, the user sends the following command: <ESC> T2. Further details of this command are described in Chapter 4, Page 4-23.

Analog Outputs

The FOT Lab Kit includes a 0-10V analog output for each of the four measurement channels. There is a positive (+) and Negative (–) screw terminal contact for each channel. Connections should be made with shielded 22 AWG wire and a circuit impedance of >1kOhm.

The FOT Lab Kit can be used with LabVIEW sofware after loading drivers available on www.luxtron.com.

The analog outputs scaling and offset are programmable. These settings are adjusted using the AS and AO parameter commands. For a description and examples of how to use these commands please see the detailed command definitions on pages 4-7 and 4-8.

User Interface

The FOT Lab Kit communicates through a standard RS-232 serial interface. The connection is a 2-wire interface: Transmit, Receive and Ground which can be connected to a standard PC equipped with a 65550 or equivalent UART device. The PC host software may be a standard terminal emulation application such as HyperTerminal™ or a custom device-control program communicating through the RS-232 interface.

The user interface is described in detail in Chapter 4 and Chapter 5 of this manual.

NOTE *The serial interface is the main conduit through which the FOT Lab Kit communicates with the user. The instrument communicates at 9,600 bits-per-second (sometimes erroneously referred to as 9,600 Baud). The bit protocol is 8 data bits, one stop bit and no parity (8-N-1). The instrument does not use a handshaking protocol.*

Calibration

Basic temperature calibration is performed at the factory, however to achieve the highest level of accuracy, it will be necessary to perform a simple calibration to adjust for the type and positioning of the temperature probe used. Please refer to Appendix A, “Calibration Procedure’’, for details on performing this calibration.

Temperature Measurement Range

The range of temperatures that may be measured by the FOT Lab Kit is limited by the type of probe used. Under no circumstances should the maximum temperature rating of a probe be exceeded. Check documentation of your probe or with a LUXTRON Applications Engineer to determine the specified temperature limits of your Fluoroptic® probe.

WARNING ***Exceeding the maximum temperature rating of the probe may destroy the probe!***

Probes

LUXTRON's Fluoroptic® technology uses fiber optic probes incorporating patented phosphor compounds encapsulated at the sensing end of the probe. These probes are immune to EMI and radio-frequency noise, are much more robust that thermocouples and are ideally suited for hostile environments.

Temperature data are collected by exciting the probe's phosphor with a burst of light sent through the fiber optic cable. The decaying light signal returns through the fiber to the instrument where it is processed by converting the analog signal into a digital value which is then converted into a calibrated and corrected temperature. The measured temperature is reported through the RS-232 interface and the analog outputs.

Operational Note

Whenever a probe is disconnected from the device or from a fiber optic extension cable always install the provided vinyl cap over the FOT Lab Kit instrument's optical port. This prevents random ambient light from entering the system which would adversely affect the accuracy of the temperature measurements from the remaining probes.

If you experience unexpected resets of the device during initial installation and setup, it is likely that the power supply is improperly grounded. A code is provided in the startup message indicating the cause of the most recent reset. This code is found at the end of the first line of the startup message and may be requested by your Customer Service representative while assisting you with your installation. The code may be any one of the following:

(POR) Power On Reset	**(WDR)** Watchdog Timer	**(BOR)** Brown Out Reset
(CXR) Ctrl+X Reset	**(WKR)** Wakeup Reset	**(CLR)** MCLR Reset

Example: "Luxtron Corp. Copyright 2002" (POR)

4 User Interface Commands

The primary user interface with the FOT Lab Kit is through a standard RS-232 serial interface. The host may be a standard terminal emulation application software such as HyperTerminal™ or a custom device-control program communicating through the RS-232 interface. LUXTRON also offers a Windows-based graphing and data-acquisition program for PCs called TrueTemp™.

The instrument communicates at 9,600 bits-per-second. The bit protocol is 8 data bits, one stop bit and no parity (8-N-1). The instrument does not use a handshaking protocol. The details of the communication protocol are defined in this chapter and Chapter 5, “Temperature Data Reporting” .

User interface commands fall into two general categories:

1. Parameter Commands: Two-letter command codes with required or optional arguments.

2. Action Commands: One-letter character command codes consisting of the Control key plus one letter key.

For a summary of the Parameter Commands, see Table 4-1 on page 4-5. For a summary of the Action Commands, see Table 4-2 on page 4-5.

Parameter Commands (Two-Letter)

The Parameter Commands are used to adjust user-selectable parameters and to query the instrument to report a current parameter setting.

The Parameter Command code consist of the Escape character (1Bh) followed by two ASCII characters defining the command with optional arguments for retrieving information or setting system parameters. Commands are not case sensitive.

White space (spaces/tabs) is allowed but is ignored except where it is necessary for separation of arguments.

All commands must be terminated by a carriage-return character **CR** (0Dh) optionally followed by a line feed character **LF** (0Ah).

These parameter commands are used in either of two ways: information requests or parameter modification.

Information Requests

This command format consists of the Escape character followed by a two-letter command followed by a question mark and carriage return/line feed.

Example Query: **<Esc>AA ? <CRLF>**

Information Request	
Character	**Hexidecimal**
Escape	1Bh
A	41h
A	41h
Space (optional)	20h
?	3Fh
Carriage Return	0Dh
Line feed	0Ah

Informational output data packets consist of echoing the command code in upper case characters followed by an equal sign (=) followed by the requested information. The **Escape** character is not echoed.

White space is consistently applied with exactly one (1) space character between each pair of arguments.

Informational output data is always terminated by a carriage-return/ line feed pair (**CRLF**).

Example Response: **AA = INFO**

Information Request	
Character	**Hexidecimal**
A	41h
A	41h
Space	20h
=	3Dh
Space	20h
I	--
N	--
F	--
O	--
Carriage Return	0Dh
Line Feed	0Ah

If the command is unrecognized or the command syntax is incorrect the system responds with the request as typed with the addition of a question mark '**?**' followed by a **CRLF** pair.

The system responds to the information request as described, although certain exceptions exist; e.g. multi-line responses. Refer to the descriptions of the individual commands for additional details.

Parameter Modification

This command format consists of the Escape character followed by a two-letter command followed by an equal sign ('=') and the new parameter value(s) and ending with a carriage return/line feed.

These commands provide the mechanism for modification of setup parameters or for initiation of an event or sequence of events.

Example Command: **<Esc>AA = E <CRLF>**

Information Request	
Character	**Hexidecimal**
Escape	1Bh
A	41h
A	41h
Space (optional)	20h
=	3Dh
Space (optional)	20h
E	45h
Carriage Return	0Dh
Line feed	0Ah

If the command is successfully received, parsed and executed, the new parameter will immediately take effect. There will be no serial-data response from the device.

If the command is unrecognized or the command syntax or parameter value is incorrect the system responds with the request as typed with the addition of a question mark '?' followed by a **CRLF** pair.

Table 4-1 Summary Listing of Parameter Commands

Command Code	Command	Description
AE	Analog Output Enable	Enable/Disable Analog Outputs
AO	Analog Output	Set Analog-Output Temperature Offset Factor
AS	Analog Scaling Factor	Set Analog-Output Temperature Scaling Factor
CC	Calibration Correction	Enable/Disable Application of Calibration Factors
CT	Calibration	Set Calibration Temperature for Auto-Calibration Function
DF	Data Format	Set Serial Data Output Format
DS	Data String	Capture User Data Sequence
HL	High Temperature Limit	Set High Temperature Limit (obsolete, no longer supported)
ID	Information Display	Report Device ID and Current Parameter Settings
LL	Low Temperature Limit	Set Low Temperature Limit (obsolete, no longer supported)
MU	Measurement Update	Set Interval Between Temperature Measurement Reports
PS	Probe Select	Specify Active-Input List
SL	Signal Level	Report LED Light Source Intensity Level
SM	Sample Measurement	Set Number of Samples to be Retained Per Measurement
SN	Serial Number	Report Device's Serial Number
ST	STart up Mode	Select Startup Mode
SV	Save Parameters	Save Current User Parameters and Calibration Factors
TU	Table Selection	Reports the Currently Selected Look-up Table
UN	Output Units	Specify Output Units of Measure

Table 4-2 Summary Listing of Action Commands

Command Code	Command		Description
CTRL + A	Abort	(01h)	Abort calibration sequence in progress
CTRL + D	Disable	(04h)	Disable remote control of temperature reporting
CTRL + E	Enable	(05h)	Enable remote control of temperature reporting
CTRL + F	Flush	(06h)	Flush the measurement buffer
CTRL + I	Initiate	(09h)	Begin data sampling
CTRL + K	Calibrate	(0Bh)	Begin auto-calibration sequence
CTRL + Q	Report	(11h)	Report the most recent measurement / enable serial output
CTRL + S	Stop	(13h)	Disable serial data output
CTRL + T	Standby	(14h)	Enter standby mode
CTRL + X	Reset	(18h)	Reset the instrument

AE

Analog Output Activation

Enable all analog output channels which are attached to active inputs. For each input channel that has been enabled using the PS command, enable the corresponding analog output channel.

Information Request:

Syntax: <Esc>AE ? <CRLF>
Response: AE = ENABLED | DISABLED

Command Parameters:

Syntax: <Esc>AE = status <CRLF>
Range:

ENABLE	Enable the analog outputs for all active inputs
DISABLE	Disable all analog outputs

Examples: <Esc>AE = ENABLE <CRLF>
<Esc>AE = E <CRLF>
<Esc>AE = Disable <CRLF>
<Esc>AE = D <CRLF>

AO Analog Output Offset

Set the temperature offset (minimum reported temperature) for analog output voltage. Along with the Analog Scaling Factor (**AS** command) the **AO** command sets the parameters for the analog output voltage range.

The native range for analog output channels is 0.00 to 10.00V. The analog temperature offset is expressed in degrees (using the specified system units). By adjusting the temperature offset it is possible to set the floor of the analog output range i.e. the temperature corresponding to 0.00V output.

$$V_{out} = (AS/1000) * (T_{measured} - AO)$$

Where:

AO = **AnalogOffset** = Minimum analog output voltage corresponding to minimum reported temperature

AS = Analog Scaling Factor, mV/deg (see AS command, page 4-8)

V_{out} = Analog output voltage

$T_{measured}$ = Temperature measured at input

The default temperature offset value is equivalent to the minimum temperature supported by the device.

See examples in description of AS command, page 4-8.

Information Request:

Syntax: <Esc>AO ? <CRLF>

Response: AO = offset in degrees

Example: AO = -30°C

Command Parameters:

Syntax: <Esc>AO = offset <CRLF>

Range:

This value is not range checked. Use care in selection of parameter value.

AS

Analog Output Scaling

Set the scaling factor for analog output voltage. Along with the Analog Offset (**AO** command) the **AS** command sets the parameters for the analog output voltage range.

The native range for analog output channels is 0.00 to 10.00V. The scaling factor is expressed in millivolts per degree. By adjusting the scaling factor it is possible to adjust the working range of the analog outputs as they apply to the input temperature range.

$$\mathbf{V_{out} = (AS/1000) * (T_{measured} - AO)}$$

Where:

AO = **AnalogOffset** = Minimum analog output voltage corresponding to min. reported temperature (see AO command, page 4-7)

AS = Analog Scaling Factor (in millivolt per degree, mV/deg)

$\mathbf{V_{out}}$ = Analog output voltage

$\mathbf{T_{measured}}$ = Temperature measured at input

The default scaling factor value is based upon the temperature range supported by the device.

Example using standard-configuration defaults:

Minimum Input Temperature	Maximum Input Temperature	VOutput Scaling Factor	Temperature Offset	Minimum Output Voltage	Maximum Output Voltage	Output Voltage Range
-30°C	330°C	27.7778mV / °C	-30°C	0V	10.0V	10.0V

Information Request:

Syntax: **<Esc>AS ? <CRLF>**

Response: **AS = scaling factor in mV / degree**

Example: **AS = 27.7778**

Parameter Modification:

Syntax: **<Esc>AS = factor<CRLF>**

Range:

This value is not range checked. Use care in selection of parameter value.

Example using a temperature range of 0.00°C to 200°C:

Minimum Input Temperature	Maximum Input Temperature	VOutput Scaling Factor	Temperature Offset	Minimum Output Voltage	Maximum Output Voltage	Output Voltage Range
0°C	200 °C	50 mV / °C	0°C	0V	10.0V	10.0V

$$0V = (50mV / {}^{O}C * 1V/1000mV) * (0^{O}C - 0^{O}C)$$

$$5V = (50mV / {}^{O}C * 1V/1000mV) * (100^{O}C - 0^{O}C)$$

$$10V = (50mV / {}^{O}C * 1V/1000mV) * (200^{O}C - 0^{O}C)$$

CC

Calibration-Correction

The **CC** command is used to Enable or Disable application of the Calibration-Correction Factors. Each installed temperature input channel has associated calibration factors which are applied to the measured temperature before it is reported.

These factors are set to typical values at the factory but must be fine-tuned as needed to compensate for differences in probe type, probe length and signal attenuation factors such as positioning and optical fiber bend-radius inherent in your particular installation.

Please refer to Appendix A, "Calibration Procedure" for additional details.

Information Request:

Command Syntax: **<Esc>CC? <CRLF>**

Response Syntax: **CC = info**

ENABLE Application of the Calibration-Correction Factors is enabled.

DISABLE Application of the Calibration-Correction Factors is disabled.

Parameter Modification:

Syntax: **<Esc>CC=status <CRLF>**

Range:

ENABLE (default) Enables application of Calibration-Correction Factors

DISABLE Disables application of Calibration-Correction Factors

Example: **<Esc>CC = ENABLE <CRLF>**

<Esc>CC = E <CRLF>

CT

Calibration Temperature

The CT command is used to set the calibration reference temperature used during the automatic calibration-correction procedure.

Please refer to Appendix A, “Calibration Procedure” for additional details.

Information Request:

Syntax: <Esc>**CT ? <CRLF>**
Response: **CT = caltemp**
Example: **CT = 37.00 C**

Parameter Modification:

Syntax: **CT = caltemp <CRLF>**
Range: **caltemp** New calibration reference temperature

The new reference temperature is specified in degrees and hundredths of a degree within the working range of the device. Temperature units are assumed to be the units previously set using the **UN** command.

Value input is in "**nn.nn**" format. Do not include the units. If the reference temperature entered is of an ambiguous format e.g. "40" or "40.1" the system will correctly interpret the input as "40.00" and "40.10" respectively. It is recommended, however that values be entered in the standard format.

Example: **<Esc>CT = 95.50 <CRLF>**

DF Data Format

The **DF** command sets the serial-interface temperature output format, either full or abbreviated.

The format selected depends upon the use to which the captured data will be put. For visual clarity the abbreviated format is recommended for most circumstances.

Information Request:

Syntax: <ESC>**DF ? <CRLF>**
Response: **DF = format**
Returns the current data reporting format.

Parameter Modification:

Syntax: **DR = format <CRLF>**
Range: **FULL**

FULL
Output is formatted for all channels without regard to the number of active channels.

Examples:
All four input channels are active.

```
" 1:   20.42 C 2:   22.75 C 3:   21.25 C 4:   19.97 C"
```

Input channels 1 and 2 are active.

```
" 1:   20.42 C 2:   22.75 C 3:           4:          "
```

Input channels 1 and 3 are active.

```
" 1:   20.42 C  2:           3:   22.75 C 4:          "
```

ABBR
Output is compacted to display data for only active input channels.

All four input channels are active.

```
" 1:   20.42 C  2:   22.75 C 3:   21.25 C 4:   19.97 C"
```

Input channels 1 and 2 are active.

```
" 1:   20.42 C2:   22.75 C"
```

Input channels 1 and 3 are active.

```
" 1:   20.42 C  3:   21.25 C"
```

DS

Display String

The **DS** command may be used by the OEM customer to enter a line of text to be displayed on startup. This text will also be displayed as part of the parameter dump (see example in description of ID command, page 4-14).

Information Request:

Syntax: **<Esc>DS ? <CRLF>**

Response: **DS = OEM display string**

Example: DS = XYZ Corp. Model SuperPro 5000

Parameter Modification:

Syntax: **<Esc>DS = OEM display string <CRLF>**

Range: Display string may be from 1 to 31 characters.

.

NOTE *Characters must be standard ASCII printing characters. If the first character after the '=' sign is a Space (20h) it will be discarded.*

To prevent display of this string enter an empty string i.e. press Enter key immediately after the Equal sign ('='): **<Esc>DS =<CR>**

Example Sign-On Message:

LUXTRON CORP.
Copyright 2002
M600 Fluoroptic Thermometer, Software Version 1.00
Serial # 12345
XYZ Corp. Model SuperPro 5000

ID

Identification Query

The **ID** command is used to report the device's identification string, firmware version, device serial number and current operating parameters. In essence this command combines the information requests of most other system commands into an inclusive report.

The **DS** and **SN** command data are incorporated into the header information. The **SL** command values, being dynamic are not included in the report.

Information Request:

Syntax: **<Esc>ID ? <CRLF>**

Response: **ID = info**

Example:

```
LUXTRON CORP. Copyright 2002
M600 Fluoroptic Thermometer, Software Version 1.00
Serial # 12345
XYZ Corp. Model SuperPro 5000
PS = 1,2,3,4
SM = 8
MU = 1 S
UN = CELSIUS
DF = ABBR
AE = ENABLE
AS = 27.7778
AO = -30.00 C
CC = ENABLE
CT = 75.00 C
MS = DISABLE
ST = ENABLE
```

Please refer to the descriptions of the individual commands related to the reported parameters for details on interpreting the information.

Parameter Modification:

n/a

MU

Report/Set Measurement Reporting Interval

The **MU** command specifies the interval between measurement reports. Another way of looking at it is that 1 / MU = reporting frequency.

Information Request:

Syntax: **<Esc>MU ? <CRLF>**
Response: **MU = interval**
Example: **MU = 4.5 S**

Parameter Modification:

Syntax: **<Esc>MU = interval <CRLF>**
Range: **C or** 'Continuous

Continuous mode reporting sets the reporting interval to the minimum practical value i.e. the sample interval times the number of active channels. Since the sample rate is 4 Hz the sample interval is then 250 milliseconds and the reporting interval will be 250mS * channels.

Examples:

If 4 channels are active **MU=C** would yield 250mS * 4 = **1.0 S.**
If 2 channels are active **MU=C** would yield 250mS * 2 = **0.5 S.**

0.25 - 600 S Interval may be specified in seconds
1 - 10 M Interval may also be specified in minutes

The minimum interval corresponds to the sample rate of 0.25 Seconds (4Hz).

The maximum interval is limited by the width of the timer (16 bits).

Examples:
<ESC> MU = C <CRLF>
<ESC> MU = 25 <CRLF>
<ESC> MU = IM <CRLF>

PS — Active Input Channels

The **PS** (**P**robe **S**elect) command specifies which input channels are to be activated.

It is recommended that unused inputs be disabled to provide the optimum number of samples per report for the active channels.

The number of active channels has a direct effect on the interpretation of the **MU** command parameter value '**C**' i.e. continuous reporting.

Information Request:

Syntax: **<Esc>PS ? <CRLF>**
Response: PS = active channel list
Example: **PS = 1,2,3,4**

Parameter Modification:

Syntax: **<Esc>PS = channel list <CRLF>**
Range: Any combination of installed channels may be specified, in any order with the channel numbers separated by commas. Additional spaces may be used but are ignored if present.
Examples: **PS = 1, 2, 3, 4**
PS = 2, 4
PS = 3, 1, 2

SL

Signal Level

The **SL** command reports the relative strength of the signal arriving at the photodetector. The signal is the intensity of light returned from the probe tip and is reported as a percentage of maximum.

This information is used primarily during probe testing and helps to determine whether the probe is functioning efficiently.

Information Request:

Syntax: **<Esc>SL ? <CRLF>**

Response: **SL = signal**

The signal data are returned in the same general format as a standard temperature report.

Example:

1: 1.81 % 2: 2.66 % 3: 5.10 % 4: 3.24 %

Parameter Modification:

n/a

SM

Samples per Measurement

The **SM** command is used to specify the number of ADC samples that will be averaged to create each measurement reported. Fewer samples mean faster response, more samples mean greater stability.

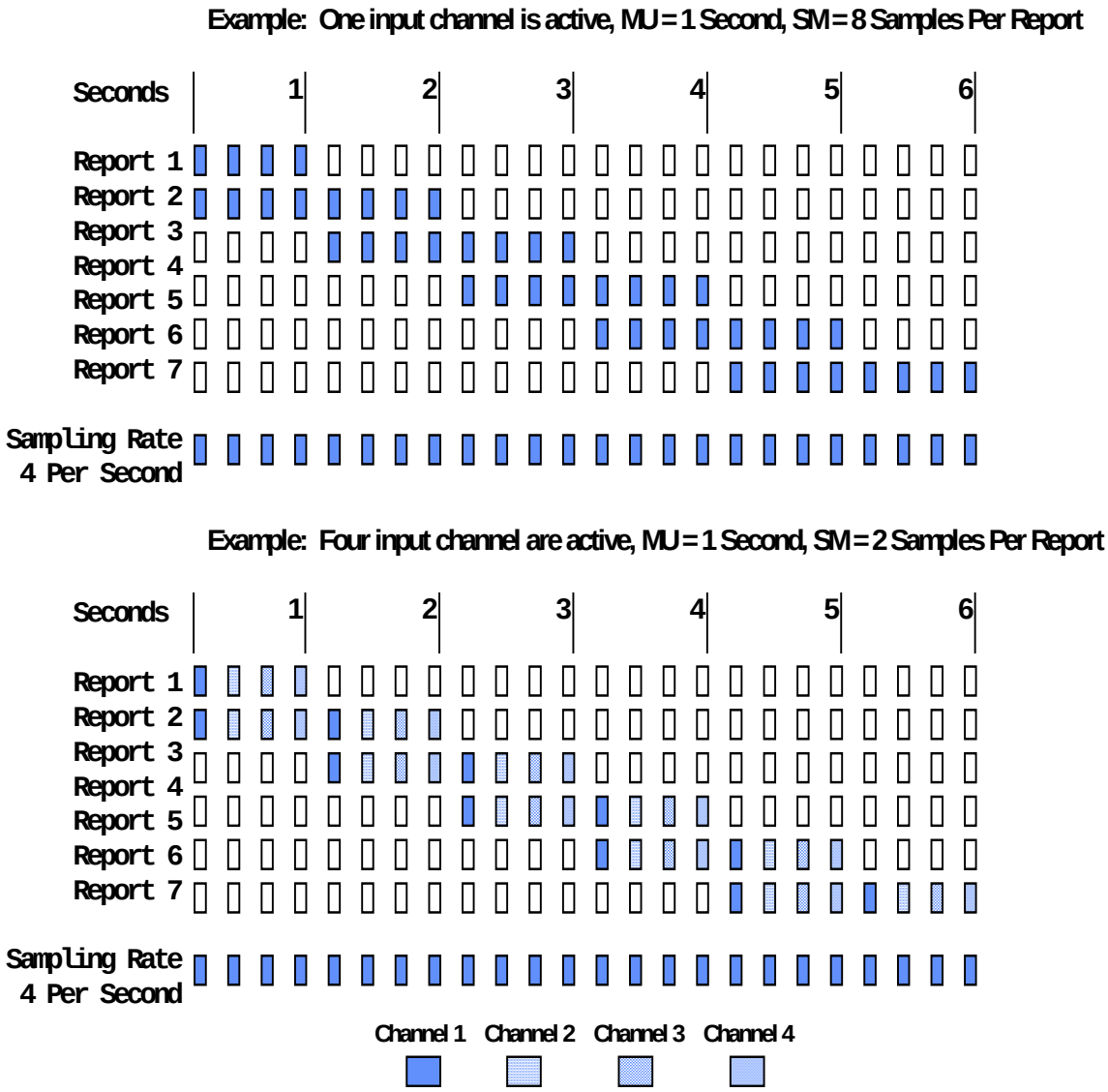
The FOT Lab Kit's internal timing is based upon a fixed 4Hz sampling rate. The number of samples per second per channel is 4Hz divided by the number of active channels.

The Samples-per-Measurement command specifies the number of samples retained per channel which are then averaged to generate the temperature report. To put it another way, the specified number of samples will be averaged and used to create the temperature value to be reported.

NOTE *Please note also that the measurement update rate (**MU** command) has an impact upon averaging in that it determines the degree to which averaging occurs across measurements.*

Examples: In the first example only one input channel is active so all samples taken are for that channel. Each report (except the first) will include 8 samples. In the second example four channels are active so the samples taken are distributed evenly among the active channels. Each report (except the first) will then include 2 samples per channel.

Figure 4-1 Sampling Report



Information Request:

Syntax: **<Esc>SM ? <CRLF>**

Response: **SM = samples**

Example: **SM = 6**

(Six samples averaged into each reported value)

Parameter Modification:

Syntax: **<Esc>SM = samples <CRLF>**

Range: **1** through **50**

SN

Serial Number Query

The **SN** command is used to report the unit's internal serial number. A copy of this number may or may not also be affixed to the unit's case.

Information Request:

Syntax: **<Esc>SN ? <CRLF>**
Response: **SN = sernum**
Example: **SN = 123456**

In the unlikely event that the serial number saved in NvRam has been corrupted the message "**SN = Undefined**" will be returned.

Parameter Modification
n/a

ST

Startup Mode

The **ST** command is used to select the "startup mode" indicating to the device whether to power up into Standard mode or into Standby mode.

In Standard mode the input circuits are enabled and the device begins reporting temperatures as soon as data are ready.

In Standby mode the input circuits are idle i.e. samples are not being taken and no data reports will be generated. In this mode the user must explicitly enter Standard mode using the CTRL+R command to enable data sampling and reporting.

NOTE ***Do not issue the CTRL+R*** *command for at least 30 seconds after power-up which will allow the device time to complete its startup sequence.*

See also the descriptions of the **CTRL+T** and **CTRL+R** commands.

Information Request:

Syntax: **<ESC>ST ? <CRLF>**

Response: **ST = mode**

Examples:

ST = ENABLE	Temperature reporting starts automatically.
ST = DISABLE	Reporting must be started manually.
ST = E	Same as ST = Enable

Parameter Modification:

Syntax: **<ESC>ST = mode**

Range:	**ENABLE**	Begin reporting temperatures on power up.
	DISABLE	On startup wait for user to enable temperature reports.

SV

Save

The **SV** command is used to copy the currently active user parameter values and input-channel calibration factors to non-volatile (NvRam) storage for use in subsequent sessions.

When user parameters are changed or when the instrument is calibrated the resulting values are active only for the current session i.e. until the instrument is reset using the **CTRL+X** command or until the instrument is powered down. This allows you to experiment with different parameter combinations without affecting the stored parameters. If you wish to save the new calibration factors and user parameters for subsequent sessions you must explicitly save them using the SV command.

Information Request:
n/a

Parameter Modification:

Syntax:	**<Esc>SV <CRLF>**
Response:	none

TU

Table Selection

The TU query reports the currently selected "tau to temperature" lookup table. The FOT Lab Kit includes three such tables for use with different probe types.

Information Request:

Syntax: **<ESC> TU ? <CRLF>**
Response: **Using Table: 1**

Parameter Modification:

Syntax: **<ESC> T1 <CRLF>**
Response: **Set T1**
Syntax: **<ESC> T2 <CRLF>**
Response: **Set T2**
Syntax: **<ESC> T3 <CRLF>**
Response: **Set T3**

UN

Unit of Measure

The **UN** command is used to report or select the serial-interface data output units. Three units are currently supported: Kelvin, Celsius and Fahrenheit. The analog outputs are mapped directly from the serial output units.

NOTE *For legacy reasons it is important to select the output units first before adjusting any other system parameters. Units should not be changed after other parameters are set or after calibration has been performed. If you change units the device will need to be recalibrated.*

Information Request:

Syntax: **<Esc>UN ? <CRLF>**
Response: **UN = units**

Reports the current units/data type being transmitted through the user interface.

CELSIUS	Temperature in degrees Celsius
KELVIN	Temperature in degrees Kelvin
FAHRENHEIT	Temperature in degrees Fahrenheit

Parameter Modification:

Syntax: **<Esc>UN = units**
Range: **CELSIUS**
KELVIN
FAHRENHEIT
Examples: **<Esc>UN = KELVIN**
<Esc>UN = K

Action Commands (One-Letter)

Several commands which perform a simple function without the need of parameter data from the user are implemented as single-character commands. These commands consist of holding down the Control key (**CTRL**) and pressing one additional key. See the Summary of Commands below.

These commands are used to enable or disable an operation, initiate or terminate an event etc. If the command is successfully received and executed the character is echoed back.

NOTE *Many of these characters will not print through a terminal emulation application or may print as semi-graphic or garbage characters so it is sometimes difficult to determine whether the device has responded properly simply by looking. This, of course is not a problem when the device is under the control of a custom control program since in that case the character is not displayed, but is simply recognized as just another number.*

The FOT Lab Kit user interface includes eleven (11) one-letter Action Commands that instruct the instrument to perform a function or switch mode. Conceptually, there are four "modes" defined for the FOT Lab Kit device. A summary listing of these commands in Table 4-2 on page 4-5.

Modes of Operation

The FOT Lab Kit has four different operation modes. The Active Commands are used to switch from one mode to another, or to initiate specific events while the FOT Lab Kit is in a particular operational mode. The four modes are Standard, Remote control, Stand by, and Calibration.

Standard Mode

In Standard mode temperatures are reported periodically based upon the interval set using the MU command.

Remote Control Mode

In Remote Control mode temperatures are reported only when the PC host requests them.

Standby Mode

In Standby mode sampling and temperature reporting are disabled and the device simply waits for additional commands from the PC host.

Calibration Mode

In Calibration mode sampling and temperature calculation are still active but the temperatures, rather than being reported are used to calculate new calibration factors.

Of the one-letter codes described below some are valid only in certain operational modes or have different functionality in different modes. For this reason the sequence in which these commands are entered is significant. Please read the command descriptions carefully to obtain optimal results and avoid confusion.

Example of a typical Remote Control mode session:

- Place device into Standby mode using **CTRL+T.**
- Place device into Remote Control mode using **CTRL+E**.
- Send the Run command **CTRL+R**.
- Send the Initiate Measurement command **CTRL+I**. Wait for **CTRL+I** to be echoed.
- Send the Report Measurement command **CTRL+Q**. The report will be transmitted.
- Repeat steps 4 and 5 as desired.
- Return to from Remote Control mode to Standard mode using **CTRL+D**.
- Re-enable periodic temperature reporting using **CTRL+R.**

CTRL+A — Abort Calibration Sequence in Progress

When a calibration sequence has been initiated using the **CTRL+K** command the device will begin taking data from which to calculate the new calibration factors. The length of a calibration period is typically anywhere from 5 to 40 seconds. If the input data are invalid or cannot be properly integrated into the calibration algorithm the instrument will automatically abort the sequence after one minute. You may also abort the calibration sequence at any time using the **CTRL+A** command. If a calibration sequence is successfully aborted the **CTRL+A** character will be echoed back to the host, else there is no response.

NOTE *If the calibration sequence is aborted the previous calibration factors are not restored and the system will be left in an indeterminate state. You must then perform a successful calibration before using the device to capture calibrated temperature data. You may still operate the device in uncalibrated mode (**CC = DISABLE** command)*

CTRL+D — Exit Remote Control Mode

This command is valid ONLY when the device is in Remote Control mode (**CTRL+E** command).

Disable the Remote Control mode of temperature reporting and return to Standard Mode. If command is successfully executed the **CTRL+D** character will be echoed back to the host, else a question mark ('?') will be returned.

CTRL+E — Enable Remote Control Mode

This command is valid ONLY when the device is in Standby mode (**CTRL+T** command).

Exit Standby mode and enable Remote Control mode temperature reporting. In Remote Control mode temperature reports are created and transmitted only when the PC host requests them. If command is successfully executed the **CTRL+E** character will be echoed back to the host, else a question mark ('?') will be returned.

CTRL+F — Flush the Measurement Buffer

Discard any data currently stored in the measurement buffer. Use this command when you want to discard old data to prevent it from affecting new data. For example you may have just installed a new probe and want to discard any garbage data still in the input buffer. Old data will, of course cycle out on its own but may take several seconds depending upon the combination of system parameters you have selected. This command simply speeds up that process. The **CTRL+F** character will be echoed back to the host.

CTRL+I — Create a Data Report

This command is valid ONLY when the device is in Remote Control mode (**CTRL+E** command).

The **CTRL+I** command initiates data sampling and the creation of one temperature report. When the report is ready the device will echo the **CTRL+I** character. You may then request the report be transmitted using the **CTRL+Q** command.

CTRL+K — Initiate Auto-Calibration Sequence

This command is valid ONLY when the device is in Standard mode.

The **CTRL+K** command invokes the auto-calibration sequence for all active inputs. When the sequence is complete the device will report the status of the operation as shown with the status indicator immediately following the colon (':') and the calibration temperature. Please see Appendix A, “Calibration Procedure” for further details.

```
1:C 348.15 K    2:C 348.15 K    3:C 348.15 K    4:C 348.15 K
```

CTRL+Q — Report the Most Recent Measurement

When in Remote Control mode periodic reporting of temperature through the serial interface is disabled even though sampling and creation of temperature reports can be invoked as background tasks (**CTRL+I** command). The **CTRL+Q** command instructs the device to report the most recent measurement created for each active input. The format of the report is exactly the same as when in automatic-reporting mode except that it is preceded by the echo of the **CTRL+Q** character. Under normal circumstances the user would alternate between **CTRL+I** (create report) and **CTRL+Q** (transmit report). If you transmit **CTRL+Q** twice without an intervening **CTRL+I**, you will receive a copy of the old report created by the most recent **CTRL+I** command.

When used in Standard mode the **CTRL+Q** command simply enables RS-232 serial data output previously inhibited by the **CTRL+S** command.

CTRL+R — Exit Standby Mode / Run

This command is valid ONLY when the device is in Standby mode (**CTRL+T** command) or Remote Control mode (**CTRL+E** command).

When in Standby mode **CTRL+R** instructs the device to return to Standard-mode operation.

When in Remote Control mode **CTRL+R** enables, but does not initiate data sampling.

If command is successfully executed the **CTRL+R** character will be echoed back to the host, else a question mark ('?') will be returned.

CTRL+S — Disable Serial Data Output

This command is valid ONLY when the device is in Standard mode.

Use **CTRL+S** to temporarily disable periodic reporting of temperature data. A common reason for doing this is to prevent the data you are looking at from scrolling off the screen. Use **CTRL+Q** to restart periodic reporting.

CTRL+T — Enter Standby Mode

This command is valid ONLY when the device is in Standard mode (**CTRL+R** command) or Remote Control mode (**CTRL+E** command).

The **CTRL+T** command causes the device to enter Standby mode (if not already in Standby). Standby mode can be thought of as a low-power mode in that the lamps are turned off and temperature reporting disabled. If command is successfully executed the **CTRL+T** character will be echoed back to the host, else a question mark ('?') will be returned.

CTRL+X — Reset the Instrument

The **CTRL+X** command is used to perform a software reset of the FOT Lab Kit device. This software reset is exactly equivalent to cycling power to the unit.

All parameters will be loaded from NvRam exactly as they are on power up.

If the parameters in any section of NvRam have been corrupted, factory defaults will be loaded for that section and a message will be displayed informing the user which section(s) have received the factory default values.

5 Temperature Data Reporting

RS-232 Serial Interface Data Format

General Format Specification

Temperature data are reported for each active input channel. The temperature units are selected using the **UN** command. The format of the report is selected using the **DF** command.

The general format is to display the channel number followed by the temperature measurement for the channel followed by the units designator: **1: 245.71 K**

This general format is followed for each input channel from lowest to highest, concatenating the data and presenting it on a single output line.

- The data for each channel are presented in a fixed-length format.
- Each output line is terminated by a carriage return / linefeed pair.
- There are two basic formats for serial output: **FULL** and **ABBRIEVIATED**. This format is selected using the **DF** (**D**ata **F**ormat) command.

The following is an exact breakdown in both ASCII and hexidecimal of a report where input channels 1 and 2 are active and DF = ABBR. Space characters are replaced by the underscore character '_' for visual clarity.

```
_  _  1  :  _  _  2  2  4  .  3  9  _  C  _  _  2  :  _  _  2  2  4  .  5  1  _  C
20 20 31 3A 20 20 32 32 34 2E 33 39 20 43 20 20 32 3A 20 20 32 32 34 2E 35 31 20 43 0D 0A
```

1. The first two characters on the line are spaces.
2. The next character is the input channel number followed by a colon and one space.
3. The temperature value follows which is four places to the left of the decimal, the decimal point and two places to the right of the decimal. The value is right-justified with leading spaces as necessary.
4. The temperature is followed by one space and the units designator.
5. Items 1 - 4 are repeated for succeeding channels.
6. If the temperature units are Celsius or Fahrenheit the temperature may be below 0.00, in which case the minus character ('-') is displayed as the first digit of the channel's temperature value (e.g.__1:_-_41.50_C).
7. The line is terminated by the carriage-return / linefeed pair.

Example showing a report line with all four channels active.

```
1:  224.39 C2:  224.51 C3:  224.22 C4:  224.19 C
```

Example showing a report line with channels 1 and 2 active, then 1, 3 and 4 active with DF = FULL.

```
1:  224.39 C2:  224.51 C3:          4:

1:  224.39 C2:          3:  224.22 C4:  224.19 C
```

Example showing a report line with channels 1 and 2 active and DF = ABBR.

```
1:  224.39 C 2:  224.51 C
```

Error Reporting

The FOT Lab Kit device has a very simple error reporting mechanism. If a problem is detected the letters "**PE**" (**P**robe **E**rror) are inserted into the serial data stream following the data for the affected channel(s).

This error could be caused by a number of factors including, but not limited to:

1. Probe not attached to input
2. Improper probe type
3. Damaged probe
4. Input channel is not properly calibrated
5. Temperature of target is outside the device's measurement range
6. One or more inappropriate parameter settings
7. Failure of the capture hardware

When an error is detected on a given input channel the format includes the "**PE**" message as in the following example showing an error on channel 2:

```
1:  224.39 C  2:  224.51PE  3:  224.22 C  4:  224.19 C
```

Analog Output Data

The FOT Lab Kit includes a 0-10 volt analog output for each installed input channel. The analog outputs may be enabled and disabled using the **AE** command. The output voltage may be scaled using the **AS** and **AO** commands. Using these two commands you may scale the analog output to the working temperature range of your application.

When the instrument is in Standby mode the analog outputs are set to 0.00V. In Standard mode with analog outputs enabled (**AE** command) the outputs will track the measured temperature based upon the parameters set through the **AS** and **AO** commands. By properly scaling the outputs you can obtain optimal resolution throughout the selected temperature range.

A Calibration Procedure

Digital Temperature Output Calibration Procedure

A curve-fitted temperature calculation algorithm is used within the system firmware to provide calibrated temperature output. Although the user need not be concerned with the temperature calculation algorithm there are certain physical factors encountered during the system installation process which can affect the reported temperature.

- Type of temperature probe used. The probes used with the FOT Lab Kit device are LUXTRON Fluoroptic® probes. These probes are available in a variety of lengths and diameters with varying optical properties depending upon the type of optical fibers, lenses and filters used.
- The bend radius of the optical fiber connecting the probe to the device. Optical fiber is rated for a minimum bend radius (see probe documentation). Within its specified working range the actual bend radius of the fiber can affect signal attenuation.
- Proximity of the probe tip to the temperature source (immersion is strongly recommended).
- The degree to which the temperature source (liquid, air, etc) is of a homogeneous temperature.
- Ambient temperature surrounding the device. The FOT Lab Kit is nearly impervious to changes in ambient temperature within its working ambient range but care should be used when working at or near the limits of this range.

The FOT Lab Kit provides a set of calibration-correction factors for each input channel physically installed in the device. These factors are set to a nominal value at the factory before shipment to the customer. The items listed above, however may affect the calibration of a device within its specific working environment.

For this reason the user must adjust these calibration factors as needed during the installation procedure to ensure accurate temperature measurements. The calibration procedure is semi-automatic and should be straightforward and nearly foolproof if the instructions are followed carefully. Please refer also to the descriptions of the **CTRL+K** (Kalibrate) **CC** (Calibration Correction) and CT (Calibration Temperature) commands in Chapter 4, "User Interface Commands''.

Calibration of the device should be verified on a regular schedule.

If you are unable to successfully calibrate the device please contact LUXTRON Technical Support.

Automatic Calibration Correction

Automatic calibration correction for each channel is invoked using the **CTRL+K** command. When invoked this functionality captures several seconds' of data samples and compares the average of these samples to the calibration reference temperature (please refer to the description of the CT command, page 4-11).

Calibration Options

1. Self-Calibration – If the user has a stable temperature bath (i.e. ice water for 0°C), they can calibrate the instrument themselves using the instructions below.

NOTE *For best performance the user should calibrate with a stable temperature bath at the midpoint of the measurement range. For example, if the user's temperature range is 100°C to 150°C, the ideal calibration point would require a stable temperature bath at 125°C to calibrate the FOT instrument to achieve the best accuracy possible.*

2. Luxtron Calibration – Luxtron offers an initial and annual service to provide calibration of instruments, extensions and probes for customers who require a "Certificate of Calibration" with calibration temperatures traceable to the National Institute of Standards and Technology (NIST) temperature standards. Luxtron can perform standard calibrations from –25°C to 295°C, higher and lower temperatures are also available. Please refer to our Calibration page at www.luxtron.com/calibration for more information on this service.

Multi-temperature Calibration

Each fiber optic channel of the FOT instrument can be calibrated at a different temperature, if required, for applications where the user is measuring locations with distinctly different temperature ranges. A two temperature range example application is if one needed to measure water temperature from –10°C to 60°C and an oil system from 100°C to 200°C. In this application, the user may want to calibrate channel 1 at 35°C for the water temperature measurement and calibrate channel 2 at 150°C for the oil temperature measurement. This multi-temperature calibration can be performed for all channels on the instrument. Instructions are outlined below.

Calibration Instructions

For calibration, the instrument must be connected through a computer with HyperTerminal® or Luxtron's TrueTemp software. All commands are for terminal software.

One Temperature Calibration

1. Connect the extensions and probes to the appropriate channels .
2. Insert the probe or probes into the stable temperature bath, verified by a reliable, independent temperature measurement device.
3. Connect the FOT instrument to the computer and start the appropriate software.
4. Power up the FOT instrument.

5. Set the temperature units using the command <ESC> UN = “units” ENTER, where “units” is Celsius, Kelvin, or Fahrenheit. Depending on your FOT instrument, some of these units will not be available.

6. Set the calibration temperature to match the actual temperature of the temperature bath using the comment <ESC> CT = nn.nn ENTER, where “nn.nn” is the temperature in degrees and hundredths of degrees in the temperature units previously specified using the UN command.

7. Disable the calibrated output using the command <ESC> CC=D ENTER.

8. Allow the probe several minutes (5 to 15 minutes) to achieve thermal equilibrium with the temperature bath.

9. Start the automatic calibration sequence using the CTRL+K command. You may abort the procedure anytime by pressing CTRL+A command.

10. After a few seconds you will receive the following output, depending on the results of the calibration.

    a. 1: C 100.00F 2:C 100.00F – This indicates the calibration was successful on channels 1 and 2.

    b. 1: U 100.00F 2: C 100.00F – This indicates there was an unstable temperature variation on channel 1 but channel 2 was successful.

    c. 1: E 100.00F 2:C 100.00F – This indicates there was an error on channel 1 but channel 2 was successful. The error is due to the following two issues.

        i. Measured temperature differs from specified calibration temperature by more than eight degrees.

        ii. The calibration coefficient required is greater than 50% of the measured temperature.

After an "E" error, the FOT instrument will disable the channel with the error. To re-enable the channel, the user needs to disable the calibration with the command CC=D and then reselect the disabled channel and restart the calibration.

11. If all four channels are reading correctly, then save the setting with the following command <ESC> SV ENTER.

Multi-Temperature Calibration

If required, each channel of the instrument can be calibrated at a different temperature to achieve the highest accuracy over separate temperature ranges. The instructions below show how to calibrate a four-channel instrument with Channels 1 and 2 calibrated at 60°C and Channels 3 and 4 calibrated at 100°C.

1. Connect the extensions and probes to the appropriate channels.

2. Insert the probe or probes into the stable temperature bath, verified by a reliable, independent temperature measurement device.

3. Connect the instrument to the computer and start the appropriate software.

4. Power up the instrument.

5. Set the temperature units using the command <ESC> UN = “units” ENTER, where “units” is Celsius, Kelvin, or Fahrenheit. Depending on your FOT instrument, some of these units will not be available.

6. Disable channels 3 and 4 and enable channels 1 and 2 with the command <ESC> PS=1,2 ENTER.

7. After channels 3 and 4 are disabled, you can calibrate channel 1 and 2 at 60°C with the command <ESC> CT=60 ENTER.

8. Then, disable the calibration <ESC> CC=D ENTER.

9. Place the probes attached to channels 1 and 2 in the 60°C temperature bath and wait until the temperature is stable (5 to 15 minutes).

10. Start the automatic calibration sequence using the CTRL+K command. You may abort the procedure anytime by pressing CTRL+A command.

11. Wait for a few seconds for the calibration to complete, then review the output data for errors (see above).

12. After the unit has finished the calibration of channels 1 and 2, then calibrate channels 3 and 4 with the following sequence.

13. Disable channels 1 and 2 and enable 3 and 4 with the following command <ESC> PS=3,4 ENTER.

14. After you have enabled channels 3 and 4, disable the calibration again with the command <ESC> CC=D ENTER.

15. Place the probes attached to channels 3 and 4 in the 100°C temperature bath and wait until the temperature is stable (5 to 15 minutes).

16. Start the automatic calibration sequence using the CTRL+K command. You may abort the procedure anytime by pressing CTRL+A command.

17. Wait for a few seconds for the calibration to complete, then review the output data for errors (see above).

18. After the calibration of channels 3 and 4 is complete, enable all four channels at once with the command <ESC> PS=1,2,3,4 ENTER.

19. If all four channels are reading correctly, then save the setting with the following command <ESC> SV ENTER.

If there are no errors the new correction factors have been calculated and will take effect immediately.

NOTES Do not issue any commands to the device for at least 10 seconds after the calibration routine has finished. This allows the device time to reinitialize the data-sampling sequence.

If an error is encountered during the procedure and error message will be displayed for the failed channel(s). In this case revisit all steps of the setup and calibration to determine the cause of the error and run the procedure again.

Error Codes:

C **C**alibration Complete. No errors.

U **U**nstable Temperature error. Temperature variation too great. Could not get a stable reading.

E **E**rror. General error probably caused by one of the following:

a. Measured temperature differs from specified calibration temperature by more than eight (8) degrees.

b. The calibration coefficient required is greater that 50% of the measured temperature.

Example A: Success on all channels:

```
1:C 348.15 K   2:C 348.15 K   3:C 348.15 K   4:C 348.15 K
```

Example B: Unstable on channel 1 and general error on channel 2:

```
1:U 348.15 K   2:E 348.15 K   3:C 348.15 K   4:C 348.15 K
```

NOTE If a calibration error 'E' occurs on any input channel that input will be disabled to prevent the uncalibrated readings that would be reported for that channel from being interpreted as calibrated data. To attempt recalibration it will be necessary to re-enable the failed input(s). For example, if Channel 2 is reported to have an error as shown in Example B (above), then Channel 2 will be disabled. The user must disable calibration (CC=D) and reselect Channel 2 (and any other desired channels) to be active (PS=1,2,3,4).Note that the m600 will again operate in uncalibrated mode.. You may then re-enable the desired channels (see PS command, page 4-16) and restart the calibration sequence.

Analog Temperature Output Calibration

The FOT Lab Kit includes a 0-10V analog output for each installed input. Because the output voltage is tied directly to the digital temperature value it is unnecessary to calibrate the analog outputs.

The analog outputs may be scaled for the temperature range and voltage range desired. Please refer to the descriptions of the AS command, page 4-8 and AO command, page 4-7 for details.

B Warranty and Service

Limited Warranty

LUXTRON Corporation warrants each Fluoroptic® Thermometer to be free from defects in material and workmanship under normal use and service for the period of one year from date of shipment. This warranty extends only to the original purchaser. It does not apply to fuses, lamps, or probes, nor any products or parts that have been subject to misuse, neglect, accident or abnormal conditions of operation.

In the event of failure of the instrument covered by this warranty, LUXTRON Corporation will repair and calibrate the instrument if it is returned to LUXTRON within one year of the original shipment, provided LUXTRON's examination discloses that the product is defective. LUXTRON may, at it's option, replace the unit in lieu of repair. The repairs or replacement will be made without charge if the instrument is returned within one year of the original shipment date.

If the fault has been caused by misuse, neglect, accident or abnormal conditions of operation, repairs will be billed at current service rates. In such case, a purchase order number is required prior to the start of any repair. If requested, an estimate of the service charges will be given prior to the start of any repair.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE.

LUXTRON CORPORATION SHALL NOT BE LIABLE FOR ANY SPECIAL INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

Damage In Shipment for the Original Purchaser

The instrument should be thoroughly inspected immediately upon delivery to purchaser. All material in the container should be checked against the enclosed packing list. LUXTRON cannot be responsible for shortages against the packing list unless a claim is filed with the carrier immediately. Final claim and negotiations with the carrier must be completed by the customer.

What to do in Case of a Malfunction

Notify LUXTRON Customer Service giving details of the problem. Include the instrument model number and serial number. On receipt of this information, Customer Service will attempt to locate the fault and, if possible, solve the problem over the telephone.

If Service concludes that the instrument has to be returned to LUXTRON for repair, a Return Material Authorization Number (RMA) will be issued. Upon receipt of the RMA number, the instrument should be returned, transportation prepaid.

Shipments to LUXTRON for Repair

All shipments of LUXTRON instruments should be made prepaid and insured via United Parcel Service or Best Way. For overseas customers, units should be shipped air freight, priority one. The instrument must be shipped in the original packing container or its equivalent. LUXTRON is not responsible for freight damage to instruments that are improperly packed.

Shipping Address:

Luxtron Corporation
3033 Scott Blvd.
Santa Clara, CA 95054-3316, USA\
Telephone: (408) 727-1600