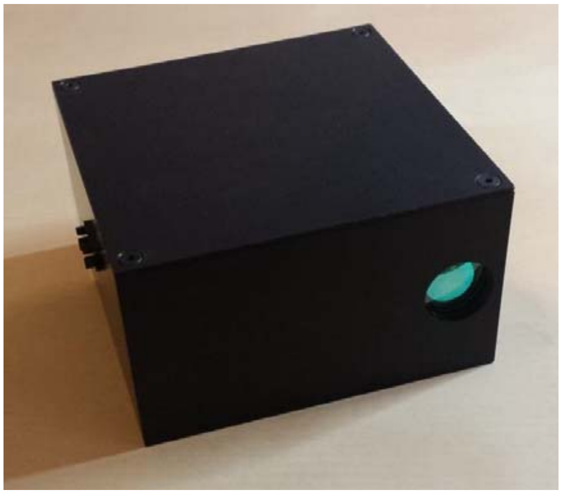
Argus 2000 IR Spectrometer



Owner's Manual

Document Number	Issue
OG274001	Release 1.03

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Release Notes

Issue	Revisions	Date
1.01	Draft for release.	1 December 2017
1.02	Revised, corrected and enlarged	16 March 2018
1.03	Revised	15 August 2018

1 Product Key

The product code format for the Argus instruments described in this manual is:

ARGUS2000XYZ-NN.

The code descriptions are as follows:

Table 1: X Letter Code Key

Letter Code	Description
A	Aluminum optics
G	Gold optics
S	Space certified
N	UAV grade

Table 2: Y Letter Code Key

Letter Code	Description
U	Unit only (kit excluded)
K	Kit included

Table 3: Z Letter Code Key

Letter Code	Description
L	Standard range
E	Extended range

Table 4: NN Number Code Key

Number Code	Description
01	700 nm – 1150 nm range
02	1000 nm –1650 nm range
03	1240 nm – 2000 nm extended range
04	1730 nm – 2200 nm extended range

2 Purpose

The purpose of this guide is to provide explanations and procedures for installing, operating, maintaining and troubleshooting the Argus 2000 IR Spectrometer.

3 Scope

This document provides safety guidelines, setup information, operating instructions, troubleshooting procedures and interface and technical specifications for the Argus 2000 IR Spectrometer.

4 Symbols Used

The following symbols are used in this document.

CAUTION

Cautions identify conditions or practices that could result in damage to the instrument or other equipment.

5 Trademarks

Argus is a registered trademark of Thoth Technology Inc.

6 Important Safety Instructions

CAUTION

This guide contains important safety instructions that should be followed during handling, installation and operation of this product. Be sure to read and understand these safety instructions prior to handling.

- Before installing or using this product, read all instructions and cautionary markings located in this guide.
- The instrument should be handled with gloves in a suitable clean room environment. Care should be taken not to contact optical surfaces or instrument corners.
- Do not attempt to open or unseal the unit. This product contains no serviceable parts.
- The instrument shall be accommodated in a temperature and humidity controlled clean room of cleanliness class no worse than 100,000 during handling, assembly, integration and test.
- Anti-static grounding procedures must be observed when handling the instrument or interface electronics. Care should be taken to align connector keys prior to insertion of instrument interface.
- Do not shock the instrument physically or expose this unit to liquids of any type.

7 Package Contents

The Argus instrument and GSE Kit includes the items shown in Figure 1 and itemized in Table 5.

Figure 1: Argus Instrument and GSE Kit.

Table 5: Argus GSE Kit Contents

Item	Location (Figure 1)	Description
1	Center	Argus unit
2	Top left	Shipping case
3	Top right	Argus ground test display laptop
4	Bottom Left	Argus power and communications interface cable, example electrical and mechanical mounting hardware.
5	Bottom Center	Laptop serial interface USB adapter
6	Bottom Center Right	Argus power USB adapter (5V)
7	Bottom Center Left	Laptop power module
8	Bottom Right	Laptop mains power cable (NEMA 5-15)

8 Product Features

The Argus spectrometer operates in the near infrared band in the standard range or in extended range versions. For instrument spectral variations please see the product key. Argus features a surface resolution of approximately 1.6 km when deployed in Low Earth Orbit (LEO). The device uses a detector array of 1x256 elements that is actively cooled. Each pixel has a native radiometric resolution of 10-bits. For models with numbers 01-03 resolution may be enhanced to

13-bit performance by utilizing the integrations setting to co-add successive spectra. The device includes a microcontroller, which controls the instrument's components. The device operates typically in a continuous single-pixel scanning mode with approximately 100 illuminated spectral channels.

8.1 Specifications

The technical specifications for Argus 2000 are summarized in Table 6, below.

Table 6: Technical Specifications, Argus 2000 Spectrometer

Argus 2000	Specification
1. Type	Grating spectrometer
2. Configuration	Single aperture spectrometer
3. Field of View	0.15º viewing angle around centered camera boresight with 15mm fore-optics
4. Mass	~280 g
5. Accommodation	46 mm x 80 mm x 80 mm
6. Operating Temp.	-20ºC to +40ºC operating temperature
7. Survival Temp.	-25ºC to + 50ºC survival temperature
8. Detector	InGaAs diode arrays with Peltier cooler
9. Grating	300 g/mm
10. Electronics	microprocessor controlled 10-bit ADC (co-adding feature to enhance precision to 13-bit, models 01-03), 3.6-4.2V input rail 250mA-1500mA (375mA typical)
11. Operational Modes	–Continuous cycle, constant integration time with co-adding feature –Adaptive Exposure mode
12. Data Delivery	Fixed length parity striped packets of single or co-added spectra with sequence number, temperature, array temperature and operating parameters
13. Interface	Serial interface RS232 protocol
14. Spectral Channels	100 (typical)
15. Integration Time	500 μs to 4.096 sec
16. Handling	Shipped by courier in ruggedized carrying case

8.2 Detector System

A linear gallium arsenide (InGaAs) photodiode array with high-quantum efficiency pixels in the infrared detect radiation emitted for a 1.5 km^2 surface tile, assuming LEO orbit altitude of 600 km, that has been divided spectrally by the grating optics. The array is a hybrid InGaAs and CMOS acitve-pixel readout electronics in which the photo-current is buffered, amplified and stored. Channels are differentially sampled as a form of double correlated sampling. Two values of feedback capacitor may be selected (the HIGH setting enhances dynamic range, the LOW setting increases sensitivity). Typical device quantum efficiencies are shown in the figures below.

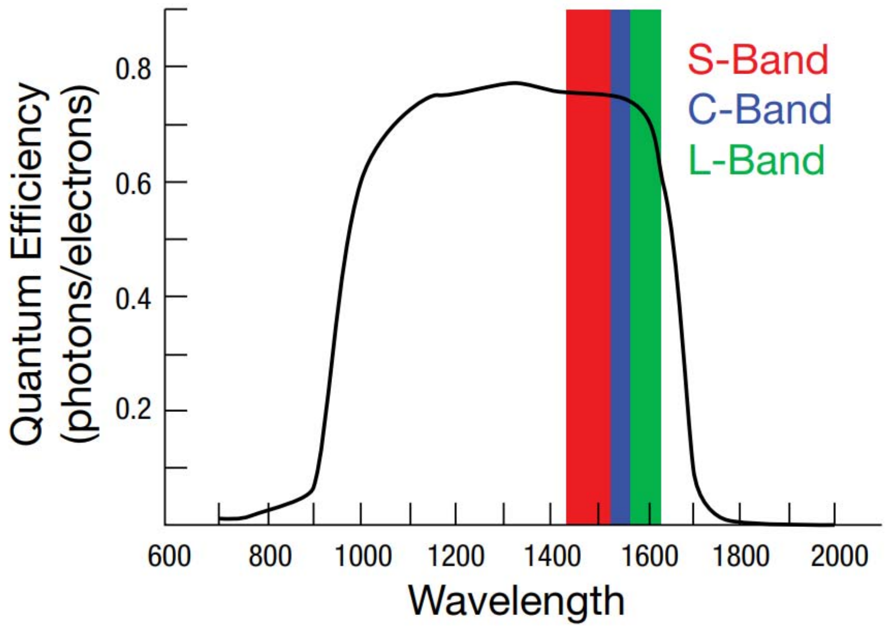


Figure 2: Detector Quantum Efficiency (1.7μm device).

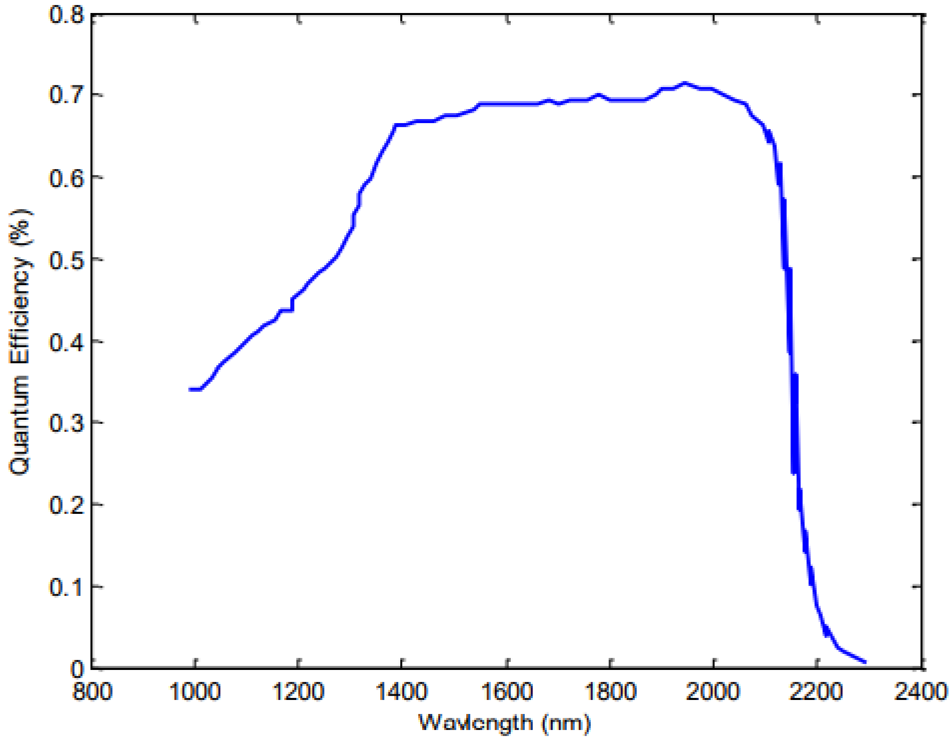


Figure 3: Detector Quantum Efficiency (2.2 μm device).

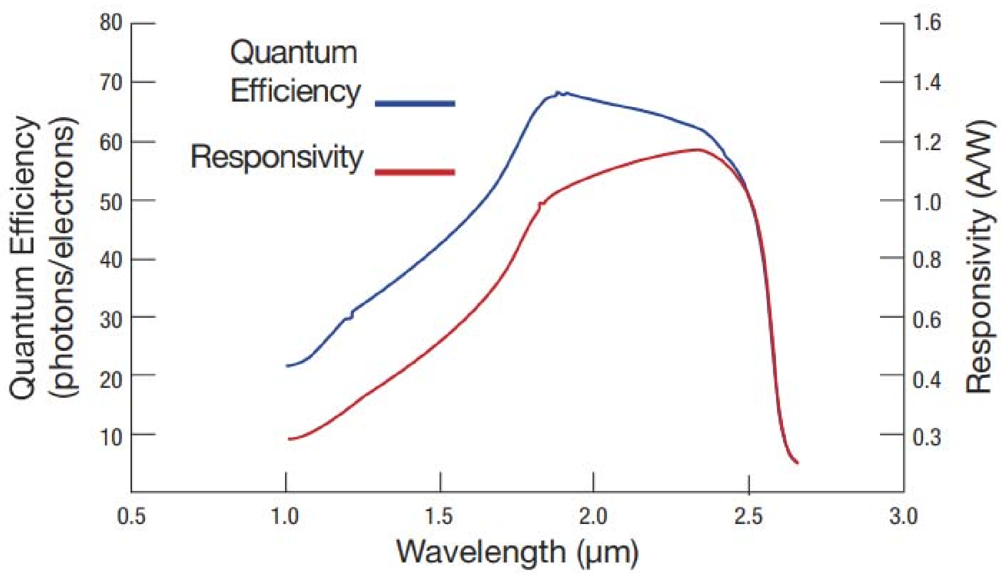


Figure 4: Quantum efficiency of 2.6µm detector measured at 20°C

8.3 Optical Design

The instrument is a single-scan pixel type observing a square surface tile and deriving simultaneous independent measurements of the surface spectral emission. The fore optics comprises a telescope lens system, field stop and mirror to provide a collimated image of the surface tile onto the reflective grating. The reflective grating reflects a spectrally divided image (in the vertical plane) onto another mirror that focuses the first spectral order of the surface tile image onto the detector. The particular optical configuration is determined by Thoth's custom design tool. Spectrometers may be customized for particular spectral ranges or resolution by choice of grating type and optical element placement.

8.4 Optical Efficiency

The typical optical efficiency of Argus is shown in Figure 5 as a function of wavelength against a NIST traceable source. The variation arises because of the device's approximately constant quantum efficiency over this wavelength range. Argus instruments require assembly to high tolerances and are individually tuned to optimize performance. Consequently, the absolute radiometric calibration will vary from instrument to instrument. Instruments can be ground calibrated for absolute radiance by using a calibrated light source viewed from a range of at least

12 meters and a 5 Degree of Freedom (DOF) kinematic mount. However, it is our experience is that due to alignment difficulties and variation between test lamps and solar insolation that results are only accurate to approximately 10%. Characteristic space radiance data is given in section 8.8.1.

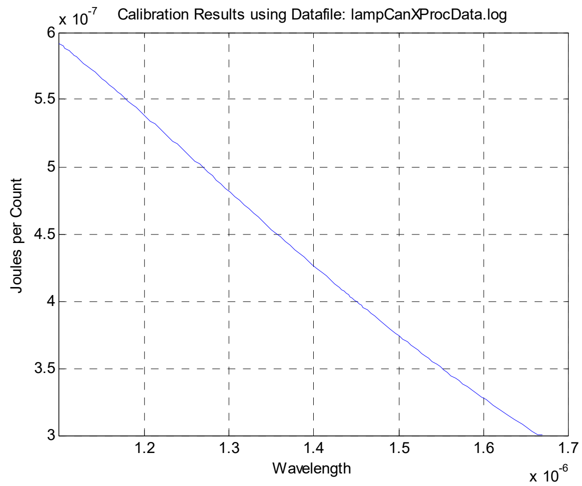


Figure 5: Spectrometer Energy Conversion Efficiency (1.6 ms exposure) against NIST traceable standard screen and source (typical results).

8.5 Angular Sensitivity

The angular sensitivity in response to a 1523 nm collimated gas laser is shown in Figure 6 for the standard grade Argus instrument. The full-width-half-maximum is estimated at 0.15°. At a typical LEO orbital height of 600 km, this corresponds to a surface tile of length 1.57 km.

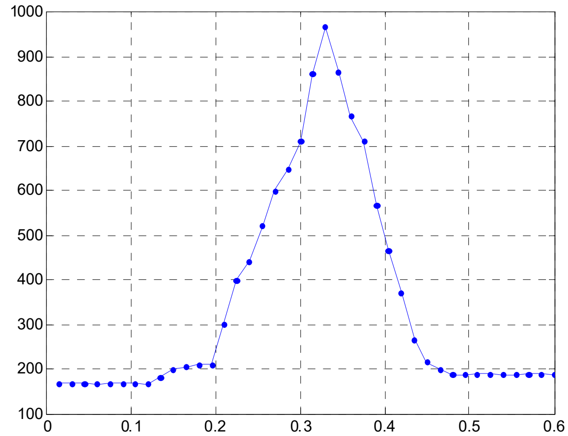


Figure 6: Angular Response in Counts *vs.* Angle in Degrees for a standard Argus unit (1.6 ms exposure to 1523 nm laser. FWHM estimated as 0.15°).

8.6 Response to Collimated Monochromatic Laser Source

Figure 7 shows a typical instrument response to a 1050 nm collimated laser source.

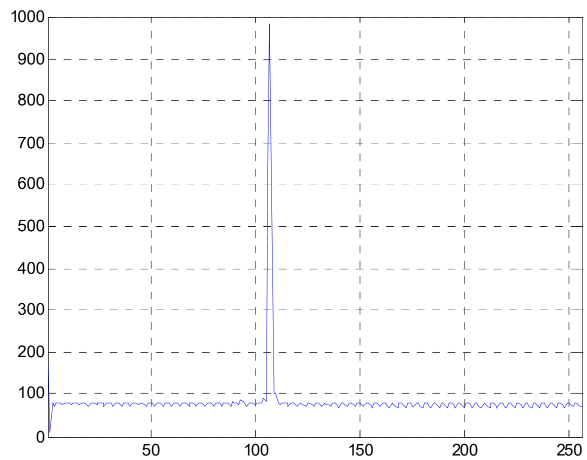


Figure 7: Response to Laser Source in Counts (1.6 ms exposure to 1050 nm laser, standard Argus).

8.7 Functional Design

The system utilizes a microprocessor for the sequencing and processing of spectra. A functional diagram for the instrument is provided in Figure 8.

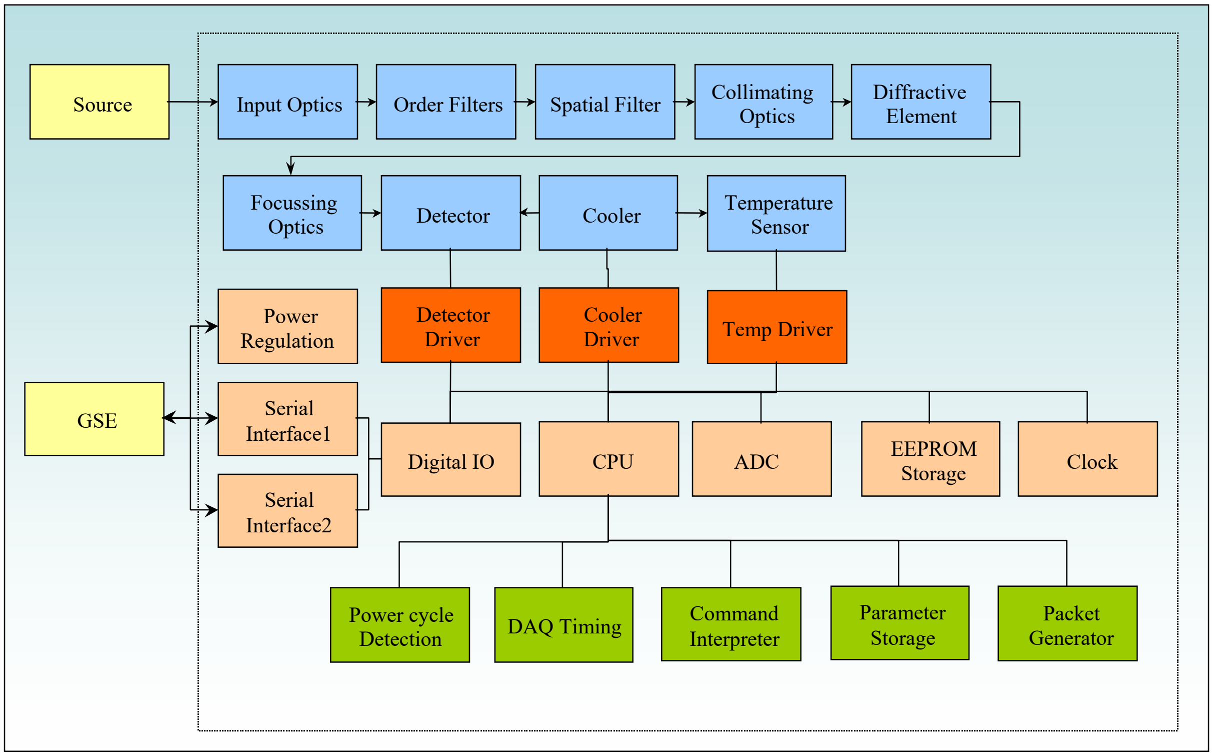


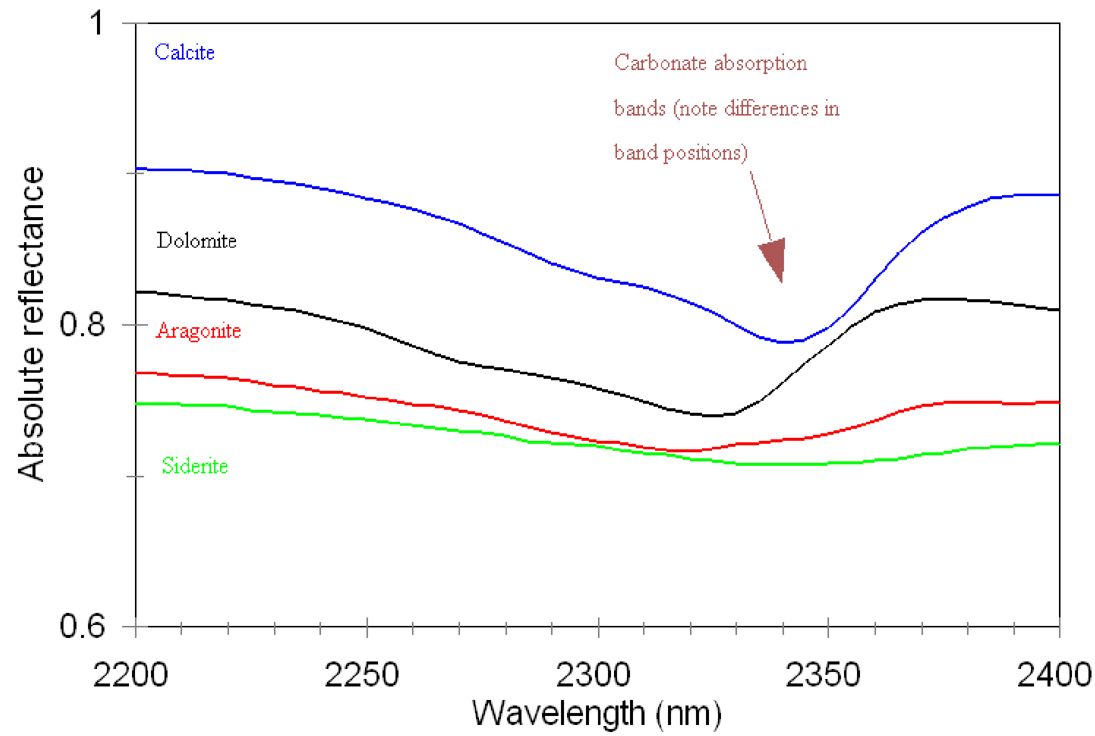
Figure 8: Argus Functional Diagram (optical train shown in blue; cooler components in red, electronics in brown and software functions in green; optional secondary serial interface illustrated).

8.8 Applications

8.8.1 Observing atmospheric gas and mineral species

Figure 9: Industrial Greenhouse Gas Emitters.

Argus can be utilized to map the spatial variation of greenhouse gases and to identify rocks and minerals with known reflectance spectra. Measurement interpretation requires spacecraft attitude information for an accurate geolocation of the spectrometer surface pixel, application of a radiative transfer retrieval algorithm and knowledge of surface cloud conditions and topography. Utilizing a near nadir-pointing configuration, the spectrometer can record infrared radiation emitted from the Earth's surface and atmosphere to space. By application of optical absorption spectroscopy, absorption and, consequently the column densities of particular atmospheric gas species may be obtained. The simplest methods such as differential optical absorption spectroscopy (DOAS) are similar to computing the intensity ratio between closely spectrally associated absorption and non-absorption features. For mineralogical survey and by application of reflectance spectroscopy, different rock and mineral types may be identified where the atmosphere. Reflectance spectroscopy has found application in space exploration and is used routinely on Earth for detection and characterization of organic molecules in the laboratory. For biological exploration, organic molecules containing aliphatic O-H, C-H, and C-O groups exhibit absorption bands in the 1700 and 2400 nm regions. Detection limits for these types of organic compounds in laboratory equipment are on the order of a few tenths of one percent. Figure 10 shows reflectance spectra for typical rock types. Iron content may be inferred from the strong absorption feature in the lower wavelength region. The absorption of infrared radiation by carbonates has a distinct signature that varies with rock type, enabling classification.



Carbonates: calcite, siderite, dolomite, aragonite (5 nm resolution).

Figure 10: Reflectance spectra of four types of carbonates.

Space flight experience with a standard Argus indicates that the instrument acquires excellent nadir spectra of reflected sunlight from a 1030 sun synchronous orbit with an exposure time of approximately 150 ms. Other orbital options can be utilized; however, variation in nadir and solar angles or spacecraft altitude can effect the scene significantly and increase retrieval complexity. The instrument's integration time is programmable. This enables integration times to be adjusted for observation conditions, scene altitude and orbital parameters. For good signal-to-noise it is advantageous to set the integration time to ensure that the spectral features to be observed correspond to instrument counts of approximately two thirds of the dynamic range of the instrument.

Table 7, below, lists the atmospheric gas species have absorption features in the spectral interval 1000 nm - 2.4 μm). In this spectral region water vapor dominates the spectra and, consequently, the radiative forcing and radiation budget. Carbon dioxide is visible and well isolated at 1.57 and

1.61 μm and is clearly observable in space data. At these wavelengths absorption by carbon dioxide is approximately one hundred times greater than that of water vapour and a number of spectral pixels are well correlated with CO2 absorption. Data from the first spaceflight of Argus indicate that CO2 absorption that is stronger significantly than predicted by a linear radiative path and assuming a single-surface reflection. CO2 absorption is also enhanced by the presence of clouds and aerosols. Retrievals to invert column absorption of CO2 to CO2 atmospheric concentration must account for topographical effects in addition to enhanced absorption forcing by clouds and aerosols.

Oxygen can also be observed; however, a shorter integration time is required than for carbon-dioxide observation. Carbon Monoxide (CO) and Hydrogen Fluoride (HF) is not detected in spectra because of feature contamination by other absorbing gases (water vapor). There is some evidence of methane (CH_4) absorption at 1.63 μm; however, it is contaminated with carbon-dioxide features. The extended range detector is recommended for the observation of methane (CH_4) features at 2.25 μm. The integrated intensity is highly correlated with surface albedo. Spectra contaminated by cloud cover show typically reduced gas absorption, a blackbody-like response and increased intensity. Results of spectra acquired over Canada in 2008 are shown below in Figure 11. We estimate that the peak radiance observed in this scene is equivalent to 0.04 $Wm^{2}\ sr^{-1}\ nm^{-1}$.

Table 7: Absorbing Species

Gas	Absorption Strength
Oxygen (O_2)	1.25µm (10^{-24} mol.cm^{-2})
Carbon Dioxide (CO_2)	1.57µm (10^{-23} mol.cm^{-2}) 1.61µm (10^{-22} mol.cm^{-2}) 2.05µm (10^{-21} mol.cm^{-2})
Water (H_2O)	900 nm (10^{-21} mol.cm^{-2}) 1.2µm (10^{-21} mol.cm^{-2}) 1.4µm (10^{-19} mol.cm^{-2})
Carbon Monoxide (CO)	1.63µm (10^{-22} mol.cm^{-2})
Methane (CH_4)	1.67µm (10^{-20} mol.cm^{-2}) 2.25µm (10^{-20} mol.cm^{-2})
Hydrogen Fluoride (HF)	1.265µm (10^{-19} mol.cm^{-2})

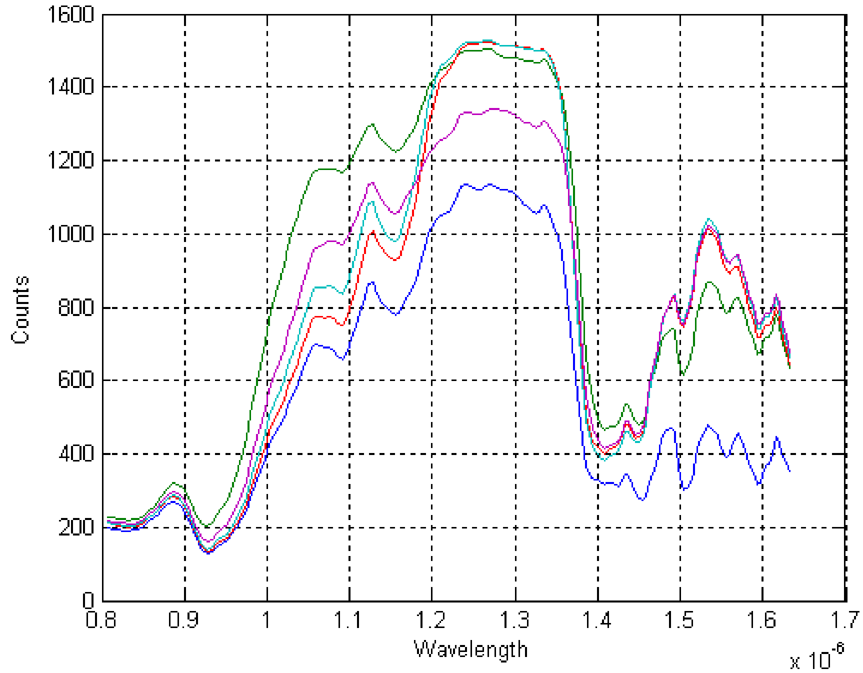


Figure 11: Data Acquired (successive spectra, smoothed features) from Argus 1000 on CanX-2 platform over Ontario, Canada, December 2008.

9 Ground System Electronics Setup

Referring to Figure 1 for item identification:

1. Setup the Argus Laptop Display Terminal and power it up.
2. Connect the USB converter to left (single) USB port on the laptop. Note if left port is used, serial port will mount as COM3 rather than COM4 or COM5 that require manual selection when launching 'Argus GSE'.
3. Place or mount the instrument unit in a safe condition.
4. Align the connector key on the USB converter the DF-11 plug with the instrument.
5. From the start menu, select and run the 'Argus GSE' application.
6. After correct setup Argus GSE application will report instrument spectra and green parity indicator shows successful instrument communications (bottom left of window).

The interface and cable setups are configured for a particular Argus GSE and instrument and are not designed to be interchangeable with other Argus instruments. For reliable operation and as a condition of warranty it is not recommended that the Argus GSE laptop terminal be connected to the internet either wirelessly or by LAN connection or that other applications be installed or operated on the Argus GSE laptop. The display terminal should be dedicated solely to instrument operation.

10 Argus GSE Test Application

Software for the operation of Argus is provided on the ground station laptop. Launch the "Argus GSE" application from the start menu or by shortcut to access a data display terminal developed for testing purposes. This terminal is not intended for data analysis but provides a means to command the instrument and check basic functionality.

The application comprises two windows. The left pane shows the instrument status. The right pane shows the spectra as a function of counts against frequency number. A screenshot of the GSE application is shown below.

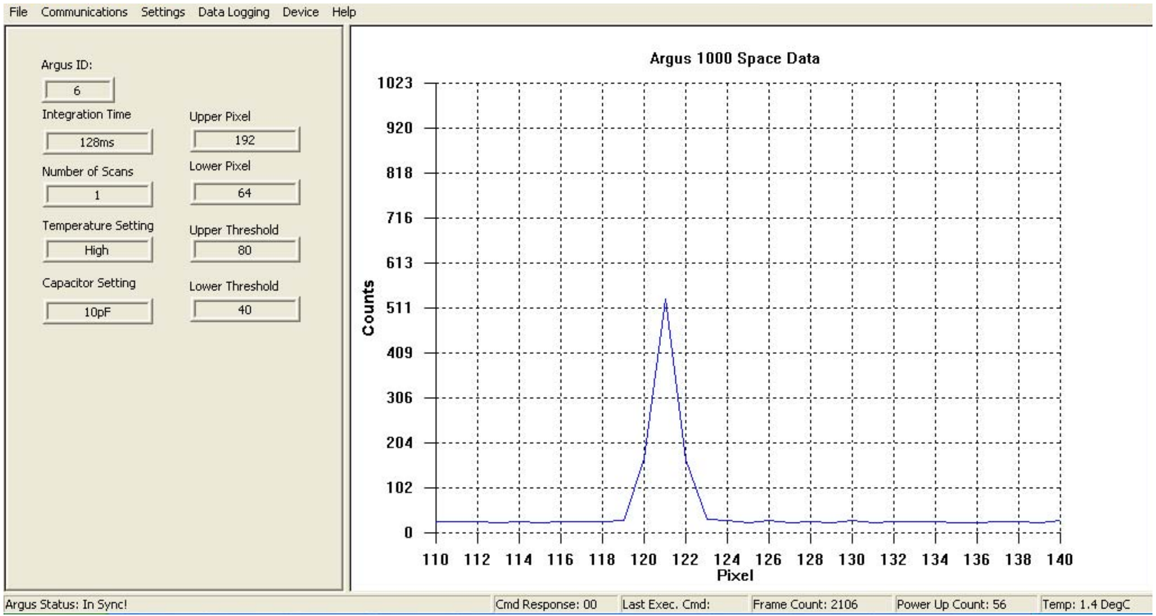


Fig 12: Argus GSE Screenshot (response to 1150 nm laser at range of 12 m).

10.1 Argus Status Message

The Argus Status message is displayed in the bottom left of the application window. "Argus Status: Lost Sync" occurs if Argus GSE has lost contact with Argus or is waiting for a frame with an integration time exceeding 0.5 seconds. "Argus Status: In Sync" is indicated when the Argus GSE application is in communication with the instrument.

10.2 Adjusting Spectrum Pixel Range

The spectral pixel range may be adjusted by right-clicking with the cursor on the spectral display pane. The upper pixel and lower pixel display range may be set using the increment buttons or by inserting a value between 0 and 255.

10.3 Commanding the Instrument Settings

The instrument may be commanded by selecting the settings tab. Note that the pane containing the Argus ID must be active (selected by the cursor) in order to command the instrument. Exposure time, Number of Scans, Capacitor, Temperature, Adaptive exposure and Load/Save Default settings may be programmed from the window menus.

10.4 Data Logging

The Argus GSE application may be used to log instrument data using the "Data Logging" tab. The data logging interval to create a new file with automatic time-stamped file name can be set as 1 min, 10 min or 60 min. Raw data is recorded, preceded by a windows standardized time stamp encoding the packet write time. Alternate serial port logging programs may be utilized if raw-only data is required.

10.5 Communications

The Argus GSE applications defaults to standard instrument communications settings on startup and utilizes a custom USB converter port on COM3. Other settings may be specified using the "communications" tab.

11 Integration

11.1 Power Interface

11.1.1.1 Argus requires a continuous input feed of 572 mA (375 mA typical) at 3.2 V DC to 4.6 V DC (nominally), while the instrument remains powered.

11.1.1.2 Argus provides current regulation over the specified input voltage ranges and typically draws 375 mA at standard temperature and pressure (STP) conditions. If the temperature and/or voltage are varied over the design range then Argus may draw up to 575 mA. Additionally, the instrument functions over a wider range of DC voltages however, this is not recommended. The power supplied to Argus should never exceed 5.0 V DC.

11.1.1.3 The power supplied to Argus may be switched on and off depending on whether Argus operation is required. Argus will power down automatically at approximately 3.0 V DC however this is not recommended.

11.1.1.4 The in-rush current (that occurs when the instrument is powered) may reach 1500 mA. In-rush current transients settle within 10 ms of Argus activation.

11.1.1.5 The Argus instrument casing shall be maintained at ground potential.

11.2 Communications Interface

11.2.1.1 The instrument features an asynchronous RS-232 serial port.

11.2.1.2 The serial port is connected and configured at 115,200 baud, 8 bits, one stop bit, no parity (data format 8N1).

11.2.1.3 The maximum data rate between the instrument is 230 kbps.

11.2.1.4 The payload electronics is designed to tolerate a constant logic high on its inputs, even when the unit is powered off.

11.3 Timing of Spectra Acquisition and Co-Adding Feature

11.3.1.1 The instrument shall acquire spectra for duration determined by the Integration_Time_Setting and then packetize and transmit this data in a subsequent 55 mS time slice. Where the Number_of_Scans_Setting setting is set to between n = 1 and 10, the instrument shall acquire n successive spectra co-adding them to a maximum precision of 16-bit before transmitting them in the last 55 mS timeslice according to the following example timing diagram:

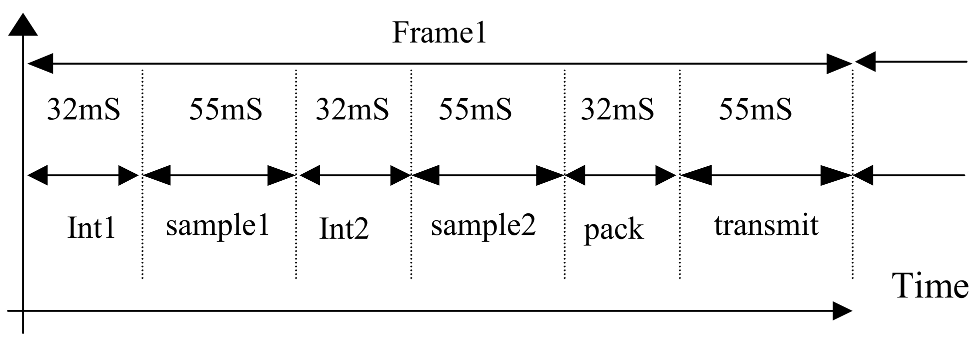


Figure 13: Spectra Acquisition Timing Example for 32 mS integration time and number of scans set to 2 resulting in a (32+55) * 3 = 261 mS total integration time at a resolution of 11-bit.

11.4 Data Packet Format

11.4.1.1 The spectrometer provides data over the serial communications interface to an Onboard Computer or listening device in fixed length unsigned 8-bit words. Data packets are transmitted continuously at a cycle period determined as (55mS+Integration_Time_Setting) * (Number_of_Scans_Setting). The packet format is shown in Table 8.

Table 8a: Argus Data Packet Format (Models 01-03)

Byte Number	Description
0 – 1	Synchronization Characters '(' and ')' provided to indicate packet start.
2 – 3	Device ID identifies Argus Instrument serial number [2] [3].
4 – 5	Command acknowledgement and errors provided in two-character format: [4] [5]. (see section 12.1).
6 – 7	Last command received provided in two-character format [6] [7] (see section 12.1).
8 – 11	Time since power on in Seconds computed as: [8]x(60x60x24) + [9]x(60x60) + [10]x(60) + [11].
12	Integration Time for Exposure in Seconds computed as: 2^[12] x 0.00005.
13	Number of scans to co-added before data transmission.
14	8-bit binary word comprising: [14 Bit 0] Dynamic Range Setting 0 = High Sensitivity, 1 = High Dynamic Range. [14 Bit 1] Cooler Temperature Setting 0 = High Temp, 1 = Low Temp. [14 Bit 2] Auto-exposure time setting 0 = Mode OFF, 1 = Mode ON.
15 – 16	Detector Temperature (DT) computed in degrees Celsius as: V0=3.25*([15]*256 + [16])./1023; Rt=26.7e3*(3.22-V0)./(V0+1.78); DT=1/(1.289e-3 + 2.3561e-4 * ln(Rt) + 9.4272e-8 * (ln(Rt)^3));
17 – 18	Lifetime power ups computed as: [17]*256 + [18].
19 - 20	Adaptive exposure mode: pixel range for adaptive exposure defined as lower pixel number [20] to upper pixel number [19] to include.
21-22	Adaptive exposure mode: upper [21] and lower [22] thresholds to trigger changes in integration time expressed in percent of full dynamic range.
22 – 534	spectral data encoded as 512-bytes in repeating unsigned MSB and LSB 8-bit words [MSB]*256 + [LSB].
535	Parity word computed bitwise as: ∑ (I=1...534) XOR(byte_i, byte_i+1)

Table 8b: Argus Data Packet Format (Model 04)

Byte Number	Description
0 – 6	Synchronization Character string “[Thoth]” provided to indicate packet start.
7 – 8	Device ID identifies Argus Instrument & serial number [7] [8].
9 - 14	The last executed command, setting, and acknowledgement or errors provided in a six-byte format: [9] [14]. (see section 12.1).
15 – 18	Lifetime power up count: MSB[15] LSB[18].
19 – 22	Lifetime frame counter: MSB[19] LSB[22]
23 – 26	Time since power on in 0.01Sec.
27 - 28	Exposure in Seconds computed as: 2^[13] x 0.00005.
29	Number of scans to co-added before data transmission.
30 - 31	04 sensor Serial Register.
32	Cooler Temperature Setting 0 = Low Temp, 1 = High Temp.
33	01-03 sensors dynamic range. 0 = High Sensitivity, 1 = High Dynamic Range.
34	Adaptive exposure mode: 0 = Disabled, 1 = Enabled.
35 - 36	Detector Temperature (DT) computed in degrees Celsius as: V0=3.25*([16]*256 + [17])./1023; Rt=26.7e3*(3.22-V0)./(V0+1.78); DT=1/(1.289e-3 + 2.3561e-4 * ln(Rt) + 9.4272e-8 * (ln(Rt)^3));
37	Adaptive exposure mode upper pixel.
38	Adaptive exposure mode lower pixel.
39	Adaptive exposure mode upper threshold to trigger changes in integration time expressed in percent of full dynamic range.
40	Adaptive exposure mode lower threshold to trigger changes in integration time expressed in percent of full dynamic range.
41 - 44	Reserved.

46 - 557	Spectral data encoded as 512-bytes in repeating unsigned MSB and LSB 8-bit words [MSB]*256 + [LSB].
558	Parity word computed bitwise as: ∑ (I=1...534) XOR(byte_i, byte_i+1)

11.4.1.2 The electronics reads the detector thermistor resistance and records this data with every spectra. The thermistor reading will be conditioned to a temperature in ^{o}C according to the algorithm given in Table 8.

11.5 Connectors

11.5.1.1 The spacecraft shall provide all necessary external harnessing.

11.5.1.2 Connectors are located on the -Y face within the area indicated below:

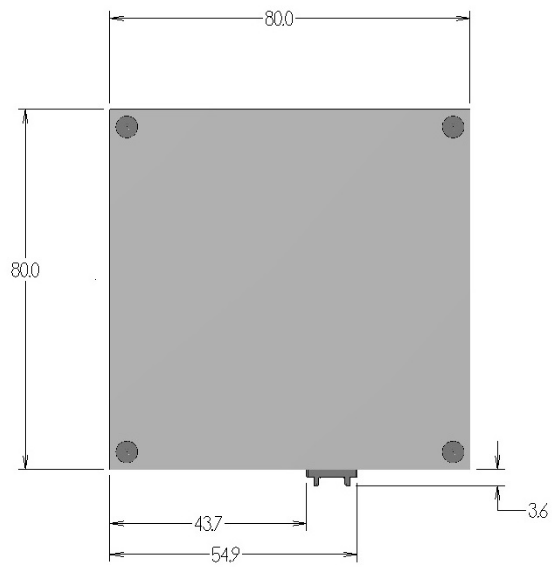


Figure 14: Argus 2000 Connector Mounting Location (top view).

Figure 15: Argus 2000 Connector Mounting Location (front view).

11.5.1.3 The instrument has a bulkhead mounted Hirose DF11 type connector with 6 pins. Hirose 6-pin DF-11 are required for mating to the instrument.

11.5.1.4 The pinouts are given in Table 9.

Table 9: Power Connector Pinouts

Signal Description	Pin No.	Description
COMMAND_RECEIVE1	1	Serial Data Receiving Port A
V_POS	2	Positive Power (may be switched)
COMMAND_RECEIVE2	3	Serial Data Receiving Port B (Option)
DATA_TX1	4	Serial Data Transmission Port A
GND	5	Ground
DATA_TX2	6	Serial Data Transmission Port B (Option)

11.6 Mechanical Interfaces

11.6.1.1 The instrument mechanical axes and dimensions are defined as follows:

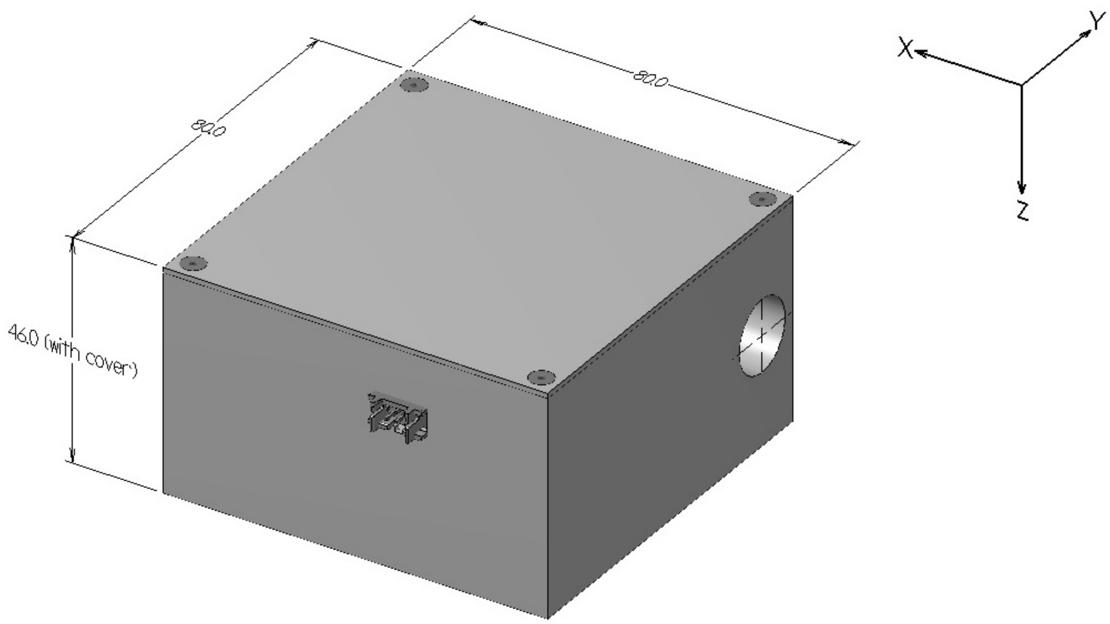


Figure 16: Argus 2000 Mechanical Axes and Dimensions

11.6.1.2 The instrument is mounted using 4-40 taped and helicoiled holes in the base of the instrument. WARNING: Mounting hardware must be sized so as to avoid exceeding the maximum thread depth of 5.0 mm. Example 4-40 threaded mounting hardware is included; however, actual hardware must be correctly sized for the depth of the mounting fixture and countersink (if applicable). The instrument should be retained by a minimum of six of the eight mounting points. The fastener torque requirement is fastener dependent but should never exceed 10 Nm. Do not over torque or exceed maximum thread depth as damage to instrument may result. The mounting-hole configuration is shown below. Note: center left hole has limited clearance due to optics, and its use is optional.

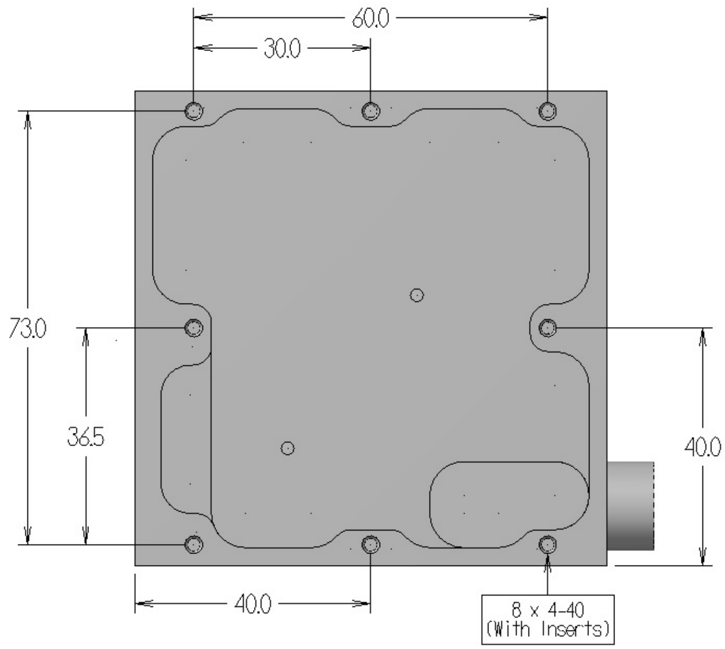


Figure 17: Spectrometer Mounting-hole Locations (ANSI/ASME 4-40 threads). Mounting hardware should not extend more than 5.0 mm into threads. Do not over torque. Input beam shown bottom right (clear space required).

11.6.1.3 The spectrometer entrance aperture is 15 mm diameter. The instrument has no outer protrusions (except the power connector) and should be mounted under the spacecraft skin, co-aligned with a 16 mm circular aperture to allow light entry. Optimally, the 16 mm circular aperture port should be between 10 mm and 50 mm from the front face of the instrument and should have blackened edges. Spectrometer faces other than the mounting face should have no physical contact with other spacecraft components. A minimum 2 mm gap on all external spectrometer faces is recommended.

11.7 Environment

11.7.1.1 The instrument core temperature should be maintained within tolerances for operation and survival specified in Table 6.

11.7.1.2 Argus type-S instruments are capable of surviving a vibration load of at least 12 g rms random and sinusoidal on all axes.

11.7.1.3 Argus type-S instruments contain no more than 0.1% collected volatile condensable material.

11.7.1.4 Argus type-S instruments should be accommodated in a clean room of cleanliness class no worse than 100,000 during assembly integration and test; class 10,000 recommended.

12 Operation

12.1 Command Format (Models 01-03)

12.1.1.1 The command string consists of five bytes arranged as follows:

Header	Header	Parameter	Setting	Parity

The header is two bytes in length and are the characters '(', ')'. The parity byte is the logical XOR of the bytes making up the command string, excluding the parity byte. As an example, the command to set the exposure time to 2048mS is as follows:

(	)	x	<	0x65? 0x45?

An acknowledgement of a command is normally returned by the instrument in the subsequent telemetry packet (see Section 11.4 for the message location in the data packet). If an error occurred during the command reception/execution process the system may respond with a data packet beginning with a different message. The message and corresponding codes that may be received are given in Table 10.

Table 10: System Messages (Models 01-03) (see Section 11.4 for message location in data packet).

Message Description	Packet Start Characters
NO STATUS MESSAGE TO COMMUNICATE	"00"
PARAMETERS LOADED SUCCESSFULLY	"PL"
POWER UP INITIATED	"PU"
COMMAND ACKNOWLEDGED	"AK"
RESET TO DEFAULT PROGRAM	"DP"
ERROR RX TIMEOUT	"EC"
ERROR EXPOSURE OUT OF RANGE	"XR"
ERROR BAD PARITY	"BP"
ERROR INVALID PARAMETER	"IP"
ERROR SCAN COUNT OUT OF RANGE	"SR"
ERROR CAP SELECT OUT OF RANGE	"CR"
ERROR COOLER SELECT OUT OF RANGE	"TR"

12.1.2 Command List

12.1.2.1 Exposure Time

Parameter: ‘x’

Setting:		
	‘0’	500uS
	‘1’	1.0mS
	‘2’	2.0mS
	‘3’	4.0mS
	‘4’	8.0mS
	‘5’	16.0mS
	‘6’	32mS
	‘7’	64mS
	‘8’	128mS
	‘9’	256mS
	‘:’	512mS
	‘;’	1024mS
	‘<’	2048mS
	‘=’	4096mS

12.1.2.2 Select Capacitor Setting

Parameter: ‘c’

Setting: ‘0’ High Sensitivity

‘1’ High Dynamic Range

12.1.2.3 Select Cooler Temperature Setting

Parameter: ‘t’

Setting: ‘0’ High temperature setting, (reduced current draw by 70 mA)

‘1’ Low temperature setting, (100mA cooler current draw)

12.1.2.4 Set Number of Scans to Count

Parameter: ‘s’

Setting: ‘1-9’ Number of spectra to co-add before data transmission.

12.1.2.5 Load Default Settings

Parameter: ‘d’
Setting: ‘l’

12.1.2.6 Save Current Settings as Default

Parameter: ‘d’
Setting: ‘s’

12.1.2.7 Set Adaptive Exposure Mode

Parameter: ‘a’
Setting: ‘0’ is OFF ‘1’ is ON.

12.1.2.8 Load Factory Parameters

Parameter: ‘i’
Setting: ‘0’

12.1.2.9 Set Adaptive Exposure Mode Upper Threshold

Parameter: ‘u’
Setting: Threshold value in percent (%).

12.1.2.10 Set Adaptive Exposure Mode Lower Threshold

Parameter: ‘l’
Setting: Threshold value in percent (%).

12.1.2.11 Set Adaptive Exposure Mode Upper Pixel

Parameter: ‘e’
Setting: Pixel Number.

12.1.2.12 Set Adaptive Exposure Mode Lower Pixel

Parameter: ‘b’
Setting: Pixel Number.

12.2 Command Format (Model 04)

12.2.1.1 The command string for Model 04 versions consists of eleven bytes arranged as follows:

Header							Parameter	Setting		Parity
0	1	2	3	4	5	6	7	8	9	10

The header is the seven-byte character string "[Thoth]". The parity byte is the logical XOR of the bytes making up the command string, excluding the parity byte. As an example, the command to set the exposure time to 2048mS is as follows:

[	T	h	o	t	h	]	1	12	0	0x44

An acknowledgement of a command is normally returned by the instrument in the subsequent telemetry packet (see Section 11.4 for the message location in the data packet). If an error occurred during the command reception/execution process the system may respond with a data packet beginning with a different message. The message and corresponding codes that may be received are given in Table 10.

Table 11: System Messages (Model 04) (see Section 11.4 for message location in data packet).

Error Code (hex)	**Type**	**Message Description**
0x01	Error	Exposure setting is out of range.
0x02	Error	Bad parity.
0x03	Error	Invalid command.
0x04	Error	Programming default settings.
0x05	Error	Loading default settings.
0x06	Error	Default setting verification.
0x07	Error	Integration limit exceeded.
0x08	Error	LCS Invalid bandwidth capacitor.

0x09	Error	LCS Invalid feedback capacitor.
0x0A	Error	Cooler setting out of range.
0x0B	Error	Invalid default command.
0x0C	Error	Programming already initiated.
0x0D	Error	Invalid Auto Exposure mode.
0x0E	Error	Auto Exposure upper limit exceeded.
0x0F	Error	Auto Exposure lower limit exceeded.
0x10	Error	Auto Exposure lower pixel out of range.
0x11	Error	Auto Exposure lower pixel out of range.
0x12	n/a	Reserved.
0x13	n/a	Reserved.
0x14	Error	LCS Antiblooming setting out of range.
0x15	Error	Reserved.
0x16	Error	LSB Dynamic range setting out of range.
0x17	Error	LCS sensor reset.
0x18	Msg	Command acknowledgement.
0x19	Msg	Power up.
0x1A	Msg	Frame counter programmed.
0x1B	Msg	Default settings programmed.
0x1C	Msg	Command executed.
0x1D	Msg	Zero counters.
0x1E	Msg	Device ID programmed.
0x1F	Msg	Parameters loaded.

0x20	Msg	Current settings saved as default.
0x21	Msg	Reserved.
0x22	Msg	Reserved.
0x23	Msg	LCS Antiblooming mode set.
0x24	Msg	LCS Autozero mode set.
0x25	Msg	Integration set.
0x26	Msg	Cooler set.
0x27	Msg	LCS bandwidth capacitor set.
0x28	Msg	LCS feedback capacitor set.
0x29	Msg	Auto Exposure set.
0x2A	Msg	Auto Exposure upper threshold set.
0x2B	Msg	Auto exposure lower threshold set.
0x2C	Msg	Auto Exposure upper pixel set.
0x2D	Msg	Auto Exposure lower pixel set.
0x2E	n/a	Reserved.
0x2F	Msg	LSB dynamic range set.
0x30	Msg	LCS sensor reset.
0x31	Msg	Factory settings loaded.

12.2.2 Command List Model 04

Table 12: Command List (Model 04).

Command	Description	Setting			
0x01	Set exposure.	Setting	Time	Setting	Time
		0	500uS	7	64mS
		1	1mS	8	128mS
		2	2mS	8	256mS
		3	4mS	10	512mS
		4	8mS	11	1024mS
		5	16mS	12	2046mS
		6	32mS	13	4096mS
0x02	Set LCS feedback capacitor	Setting	Capacitance (pF)		
		0	0.1		
		1	1.0		
		2	20.0		
		3	10.0		
0x03	Set LCS bandwidth capacitor.	Setting	Capacitance (pF)		
		0	1.5		
		1	3.0		
		2	50.5		
		3	10.5		
0x04	Set LSB dynamic range.	0	High Sensitivity		

		1	High Dynamic Range
0x05	Set cooler setting.	0	High (30mA)
		1	Low (100mA)
0x06	Set integrations	*1 <= integrations <= 10*	
0x07	Set time stamp		
0x08	Load default settings	0	Load default settings.
0x09	Zero frame and power up counters.	0	Set both the frame counter and the power up counter to 0.
0x0A	Set device ID and serial number	MSB	LSB
		Serial number	Device ID
0x0B	Enable Auto Exposure	0	Disabled
		1	Enabled
0x0C	Set Auto Exposure lower limit	*10 < x < upper limit*	
0x0D	Set Auto Exposure upper limit	*lower limit < x < 95*	
0x0E	Set Auto Exposure upper pixel	*pixel > lower pixel*	
0x0F	Set Auto Exposure lower pixel	*pixel < upper pixel*	
0x10	Load Factory settings	0	Sets current scan settings to the factory settings.
0x11	Save current settings as default	0	Saves the current settings as the default settings. Defaults are loaded on power up.
0x12	Set Time and date.	n/a	
0x13	Reserved.	n/a	
0x14	Reserved.	n/a	

0x15	Reserved	n/a	
0x16	Reserved	n/a	
0x17	Enable LCS Antiblooming mode	0	Enabled
		1	Disabled
0x18	Enable LCS Autozero mode.	0	Enabled
		1	Disabled
0x19	Reset LCS sensor.	0	Resets the LCS registers.

13 Troubleshooting

The following table provides information on identifying and resolving possible problems when using an Argus 2000 Spectrometer.

Table 11: Troubleshooting Information.

Problem	Possible Cause	Solution
'Status: Lost Sync' reported by Argus GSE application.	Serial communications Not connected. Instrument not powered. Instrument interface not mated. Long Integration Time setting. Communication lost by Argus GSE.	Connect USB adapter. Connect USB adapter to Argus. Mate instrument interface. Wait for integration to complete. Restart Argus GSE application.
Argus Communication settings pop-up window appears when Argus GSE launched	Argus USB adapter not plugged in to laptop's left-hand USB port.	Move adapter to left port or select COM4: or COM5: to use adapter in other USB ports.
Settings menu inoperable (grayed out)	Argus Parameter Pane (Left Window) not active.	Select Instrument pane. Reselect from settings menu.

14 Warranty

This limited warranty is provided by Thoth Technology Inc. ("the Company") and covers product defects in your Argus IR Spectrometer. In case of delivery of faulty merchandise, especially faulty construction, defective material, or defective manufacture, the Company shall, at its reasonable discretion, repair or replace the merchandise provided that the Customer notifies the Company of faults in writing within thirty (30) days of delivery; in such cases, the faulty merchandise becomes the property of the Company and must be returned to the Company.

There shall be no warranty for damages arising from normal wear, improper use, improper handling, faulty installation or startup by the Customer or by a third party or for deficient building provisions, including but not limited to unsuitable electrical provisions, exposure to fire, exposure to water or other liquids, or other unsuitable site properties. If, on inspection by the Company of returned merchandise within the warranty period, it becomes apparent that a fault is due to improper handling or use by the Customer, the Company may offer to fix the merchandise, and the costs of repair shall be borne by the Customer.

Any repair or modification to the merchandise performed by the Customer or by a third party without the prior written permission of the Company invalidates any warranty for faulty merchandise.

14.1 Disclaimer

THIS LIMITED WARRANTY IS THE SOLE AND EXCLUSIVE WARRANTY PROVIDED BY THOTH TECHNOLOGY INC. IN CONNECTION WITH THE ARGUS IR SPECTROMETER AND IS, WHERE PERMITTED BY LAW, IN LIEU OF ALL OTHER WARRANTIES, CONDITIONS, GUARANTEES, REPRESENTATIONS, OBLIGATIONS AND LIABILITIES, EXPRESS OR IMPLIED, STATUTORY OR OTHERWISE IN CONNECTION WITH THE PRODUCT, HOWEVER ARISING (WHETHER BY CONTRACT, TORT, NEGLIGENCE, MANUFACTURER'S LIABILITY OR OTHERWISE) INCLUDING WITHOUT RESTRICTION ANY IMPLIED WARRANTY OR CONDITION OF QUALITY, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Company makes no warranty that the items described herein are suitable or fit for a particular purpose. The Company makes no representation as to condition or character of the merchandise and in no event will be liable for any special, direct, indirect, incidental or consequential damages, losses, costs or expenses however arising whether in contract or tort including without restriction any economic losses of any kind, any loss or damage to property, any personal injury, any damage or injury arising from or as a result of misuse or abuse, or the incorrect installation, integration or operation of this product. The company may vary product specifications, production methods, software and components without prior warning.