

<i>Title:</i> NEON Sensor Command, Control And Configuration – Digital Camera	<i>Author:</i> M. SanClements	<i>Date:</i> 09/24/2014
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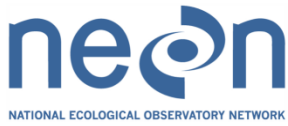
## NEON SENSOR COMMAND, CONTROL AND CONFIGURATION – DIGITAL CAMERA

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## 1 DESCRIPTION

### 1.1 Purpose

This document specifies the command, control, and configuration details for operating a NEON sensor used for instrumental observations. It includes a detailed discussion of all necessary requirements for operational control parameters, conditions/constraints, set points, and any necessary error handling. All Level 0 Data Products generated by the sensor are identified. The raw data are compensated by the DAS, but received at HQ for further processing as L0 unfiltered and uncorrected data product until its associated algorithms are applied to produce a QA/QC'd L1 data product in Standard Scientific Units.

### 1.2 Scope

The expectation is that the Stardot NetCam SC CAM-SEC5IR-B (NEON P/N: 0303510000; firmware version 1.1.78) and associated Compact Outdoor Enclosure Model: ENC-OUTD3 (NEON P/N 0333710000; no firmware required) will be used to capture digital images (AD [04]). The reference document for the Stardot NetCam SC CAM-SEC5IR-B is RD [03]. The reference document for the Compact Outdoor Enclosure Model: ENC-OUTD3 is RD [04].

This document specifies the command, control, and configuration that is needed for operating this sensor. It does not provide implementation details, except for cases where these stem directly from the sensor conditions as described here.

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## 2 RELATED DOCUMENTS AND ACRONYMS

### 2.1 Applicable Documents

AD [01]	NEON.DOC.000001	NEON Observatory Design (NOD) Requirements
AD [02]	NEON.DOC.000291	NEON Configured Sensor List
AD [03]	NEON.DOC.005003	NEON Scientific Data Products Catalog
AD [04]	NEON.DOC.005005	NEON Level 0 Data Products Catalog
AD [05]	NEON.DOC.XXXXXX	NEON Digital Camera ATBD (NEON.DOC.000809)
AD [06]	NEON.DOC.XXXXXX	NEON Digital Camera SOP (NEON.DOC.001882)

### 2.2 Reference Documents

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	StarDot Technologies (2010). NetCam SC User’s Manual 4-2. Indd. StarDot Technologies. 6820-H Orangethorpe Ave Buena Park, CA 90620 U.S.A.	
RD [04]	StarDot Technologies (2009). Enclosure and Mounts Sheet. StarDot Technologies. 6820-H Orangethorpe Ave Buena Park, CA 90620 U.S.A.	
RD [05]	Tierney, G., B. Mitchell, A. Miller-Rushing, J. Katz, E. Denny, C. Brauer, T. Donovan, A. D. Richardson, M. Toomey, A. Kozlowski, J. Weltzin, K. Gerst, E. Sharron, O. Sonnentag, F. Dieffenbach. 2013. Phenology monitoring protocol: Northeast Temperate Network. Natural Resource Report NPS/NETN//NRR—2013/681. National Park Service, Fort Collins, Colorado.	
RD [06]	Cory Teshera-Sterne, Elizabeth Felts, Stephen Klosterman, Andrew Richardson. Phenocam Installation Instructions. February 2013.	
RD [07]	Step-by-step instructions for obtaining back-to-back RGB-IR imagery from StarDot IR-enabled cameras. <a href="http://phenocam.sr.unh.edu/pdf/IR_Cam_instructions.pdf">http://phenocam.sr.unh.edu/pdf/IR_Cam_instructions.pdf</a> . Original instructions/scripts by Julian P. Jenkins, Complex Systems Research Center, University of New Hampshire, Oct. '09 Updated and expanded by Cory Teshera-Sterne, Richardson Lab, Harvard University, Apr. '11 Modified and simplified by Andrew Richardson, September '11 Updated by Elizabeth Felts and Stephen Klosterman, Richardson Lab, April '12	

### 2.3 Acronyms

Acronym	Explanation
ATBD	Algorithm Theoretical Basis Document
C <sup>3</sup>	Command, Control, and Configuration Document
SOP	Standard Operating Procedures
QA/QC	Quality Assurance/Quality Control
TIS	Terrestrial Instrument System
L0	Level 0

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L1	Level 1
ENG	NEON Engineering group
CI	NEON Cyberinfrastructure group
DPS	NEON Data Products group
CVAL	NEON Calibration, Validation, and Audit Laboratory
PTR	Problem tracking and resolution
NIST	National Institute of Standards

## 2.4 Verb Convention

“Shall” is used whenever a statement expresses a convention that is binding. The verbs “should” and “may” express non-mandatory provisions. “Will” is used to express a declaration of purpose on the part of the design activity.

## 3 INTRODUCTION

The sensor configuration and sensor command and control described here are related to the digital camera data products. A description of how camera images shall be converted to related L1 data products (e.g. greenness index) is presented in the associated ATBD (AD[05]). Data products are listed in Table 1; “N” refers to the top level of the tower.

**Table 1. L0 Data Products**

L0 Data Product	NEON	DOM	SIT	DPL	PRN	REV	SPN	HOR	VER	REP
Above canopy phenological camera Image RGB	NEON.	DXX.	XXX.	DPO.	00007.	001.	001.	001.	00N.	001
Above canopy phenological camera Image IR	NEON.	DXX.	XXX.	DPO.	00007.	001.	002.	001.	00N.	001
Above canopy phenological camera Image RGB @Solar Noon Exp=2400	NEON.	DXX.	XXX.	DPO.	00007.	001.	003.	001.	00N.	001
Above canopy phenological camera Image IR @Solar Noon Exp=2400	NEON.	DXX.	XXX.	DPO.	00007.	001.	004.	001.	00N.	001
Above canopy phenological camera Image RGB @Solar Noon Exp=1600	NEON.	DXX.	XXX.	DPO.	00007.	001.	005.	001.	00N.	001
Above canopy phenological camera Image IR @Solar Noon Exp=1600	NEON.	DXX.	XXX.	DPO.	00007.	001.	006.	001.	00N.	001
Above canopy phenological camera Image RGB @Solar Noon Exp=800	NEON.	DXX.	XXX.	DPO.	00007.	001.	007.	001.	00N.	001
Above canopy phenological camera Image IR @Solar Noon Exp=800	NEON.	DXX.	XXX.	DPO.	00007.	001.	008.	001.	00N.	001

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Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 009. 001. 00N. 001  
@Solar Noon Exp=480

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 010. 001. 00N. 001  
@Solar Noon Exp=480

Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 011. 001. 00N. 001  
@Solar Noon Exp=192

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 012. 001. 00N. 001  
@Solar Noon Exp=192

Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 013. 001. 00N. 001  
@Solar Noon Exp=96

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 014. 001. 00N. 001  
@Solar Noon Exp=96

Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 015. 001. 00N. 001  
@Solar Noon Exp=48

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 016. 001. 00N. 001  
@Solar Noon Exp=48

Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 017. 001. 00N. 001  
@Solar Noon Exp=24

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 018. 001. 00N. 001  
@Solar Noon Exp=24

Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 019. 001. 00N. 001  
@Solar Noon Exp=12

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 020. 001. 00N. 001  
@Solar Noon Exp=12

Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 021. 001. 00N. 001  
@Solar Noon Exp=6

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 022. 001. 00N. 001  
@Solar Noon Exp=6

Above canopy phenological camera Image RGB NEON. DXX. XXX. DPO. 00007. 001. 023. 001. 00N. 001  
@Solar Noon Exp=3

Above canopy phenological camera Image IR NEON. DXX. XXX. DPO. 00007. 001. 024. 001. 00N. 001  
@Solar Noon Exp=3

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Understory/ground-based phenology and/or snow pack phenological camera Image RGB	NEON.	DXX.	XXX.	DPO.	00008.	001.	001.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR	NEON.	DXX.	XXX.	DPO.	00008.	001.	002.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=2400	NEON.	DXX.	XXX.	DPO.	00008.	001.	003.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=2400	NEON.	DXX.	XXX.	DPO.	00008.	001.	004.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=1600	NEON.	DXX.	XXX.	DPO.	00008.	001.	005.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Camera Image IR @Solar Noon Exp=1600	NEON.	DXX.	XXX.	DPO.	00008.	001.	006.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=800	NEON.	DXX.	XXX.	DPO.	00008.	001.	007.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=800	NEON.	DXX.	XXX.	DPO.	00008.	001.	008.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=480	NEON.	DXX.	XXX.	DPO.	00008.	001.	009.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=480	NEON.	DXX.	XXX.	DPO.	00008.	001.	010.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=192	NEON.	DXX.	XXX.	DPO.	00008.	001.	011.	001.	001.	001



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Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=192	NEON.	DXX.	XXX.	DPO.	00008.	001.	012.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=96	NEON.	DXX.	XXX.	DPO.	00008.	001.	013.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=96	NEON.	DXX.	XXX.	DPO.	00008.	001.	014.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=48	NEON.	DXX.	XXX.	DPO.	00008.	001.	015.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=48	NEON.	DXX.	XXX.	DPO.	00008.	001.	016.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=24	NEON.	DXX.	XXX.	DPO.	00008.	001.	017.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=24	NEON.	DXX.	XXX.	DPO.	00008.	001.	018.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=12	NEON.	DXX.	XXX.	DPO.	00008.	001.	019.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=12	NEON.	DXX.	XXX.	DPO.	00008.	001.	020.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=6	NEON.	DXX.	XXX.	DPO.	00008.	001.	021.	001.	001.	001

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Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=6	NEON.	DXX.	XXX.	DPO.	00008.	001.	022.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB @Solar Noon Exp=3	NEON.	DXX.	XXX.	DPO.	00008.	001.	023.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image IR @Solar Noon Exp=3	NEON.	DXX.	XXX.	DPO.	00008.	001.	024.	001.	001.	001
Understory/ground-based phenology and/or snow pack phenological camera Image RGB resolution 2560x1944	NEON.	DXX.	XXX.	DPO.	00008.	001.	025.	001.	001.	001


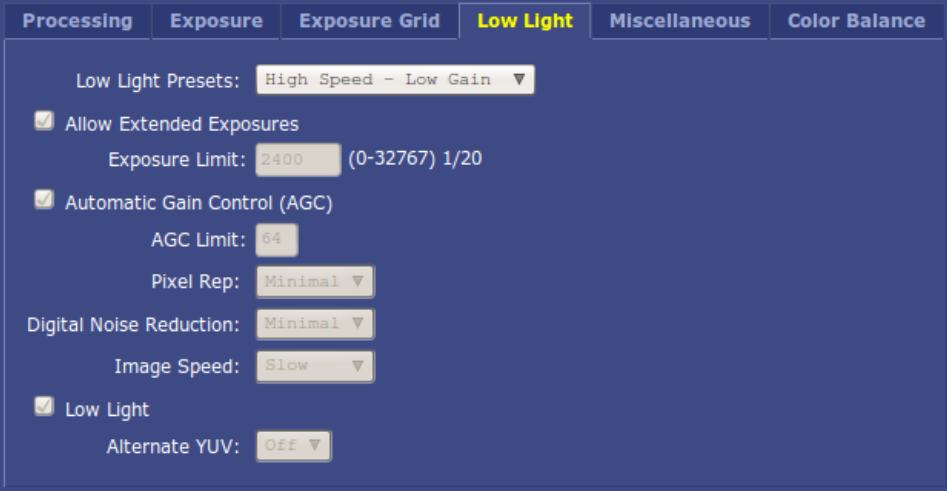

**4 OVERVIEW OF SENSOR CONFIGURATION**

The primary incoming images shall be unfiltered and uncorrected beyond the internal camera processing to create the minimally compressed jpegs described in this document.

**Table 2.** Sensor configuration settings.

Parameter	Default Setting
Digital camera image acquisition rate	15 minutes—captures both RGB and then IR images spaced by 30 seconds RD [07]. The Understory/ground-based phenology and/or snow pack phenological camera will also capture a set of images at the resolution settings of 2560x1944. All other images are captured at 1296x960. At solar noon each day the camera shall capture a cycle of images with the following exposure settings: 2400, 1600, 800, 480, 192, 96, 48, 24, 12, 6, and 3.
Data acquired from sensor	Digital Image
Image>Processing>Resolution	1296x960 QFULL* for all images other than a set of RGB and IR Understory/ground-based phenology and/or snow pack phenological camera images which will follow those captured at 1296x960 at the higher resolution of 2560x1944
Image>Processing>Saturation	140
Image>Processing>Auto Contrast	Check box

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Image>Processing>JPEG Quality	90
Image>Processing>Sharpen	Check box
Image>Processing>JPEG Size	0
Image>Exposure	Select "Auto"; Exposure 1600; Brightness 100; Sync: Select "Off"
Image>Exposure Grid	
Image>Low Light	
Image>Miscellaneous	

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Image>Color Balance	 <p>Processing Exposure Exposure Grid Low Light Miscellaneous <b>Color Balance</b></p> <p>Balance: <input type="radio"/> Auto <input checked="" type="radio"/> Manual</p> <p>Type: <input type="text" value="Average"/></p> <p>Skew (auto): R <input type="text" value="256"/> G <input type="text" value="256"/> B <input type="text" value="256"/></p> <p>Initial (manual): R <input type="text" value="385"/> G <input type="text" value="256"/> B <input type="text" value="330"/></p> <p>(256 means "no change")</p>
Overlay	Check "TIME/DATE/TEXT STAMP"
Overlay>Text	[sitename] – NetCam SC IR - %a %b %d %Y %H:%M:%S CST Temperature: \$ {IC} \260C internal
FTP	TBD
Date/Time	<p><i>Date/Time note: The time zone will vary depending on your location, but should not be on Daylight Savings Time.</i></p>  <p>Image Overlay FTP <b>Date/Time</b> Network Dial-Out Security Advanced</p> <p><input checked="" type="radio"/> <b>AUTOMATIC</b></p> <p>Time Server: <input type="text" value="time.nist.gov"/></p> <p><input type="radio"/> <b>MANUAL</b></p> <p>Date: <input type="text" value="2011-05-04"/></p> <p>Time: <input type="text" value="16:04:10"/></p> <p><input type="button" value="Sync"/></p> <p><b>TIME ZONE</b></p> <p>Time Zone: <input type="text" value="EST5"/></p> <p>PST8PDT Pacific Standard/Daylight Time MST7MDT Mountain Standard/Daylight Time MST7 Mountain Standard Time (Arizona) CST6CDT Central Standard/Daylight Time EST5EDT Eastern Standard/Daylight Time</p> <p><input type="button" value="Help"/> <input type="button" value="Apply"/> <input type="button" value="Cancel"/></p>
Network	<p>Additional settings on this tab are automatically filled if Ethernet is checked and DHCP is selected.</p>  <p>Image Overlay FTP Date/Time <b>Network</b> Dial-Out Security Adv</p> <p><input checked="" type="checkbox"/> <b>ETHERNET</b></p> <p>IP Assignment: <input checked="" type="radio"/> DHCP <input type="radio"/> Manual</p>
Dial Out	"Dial-Out" should be unchecked.
Weather	"POLL WEATHER DATA" Uncheck this box.

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LED	Off
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**5 COMMAND AND CONTROL**

**5.1 Error handling**

This sensor provides no direct error notification (i.e. data stream for error status), nor does the associated Compact Outdoor Enclosure. However, imagery will be subject to plausibility testing as described in the associated ATBD (AD[05]). Errors shall be reported to PTR.

**5.2 Sensor phenocam controls specification**

**5.2.1 Enclosure**

The Stardot NetCam SC CAM-SEC5IR-B is housed in a Compact Outdoor Enclosure. The Compact Outdoor Enclosure requires no heating as the camera generates sufficient heat to keep the system ice-free (Andrew Richardson; personal communication (2013)).

**5.2.2 Reference Panels**

The Stardot NetCam SC CAM-SEC5IR-B requires regular calibration and validation to monitor the health of the camera sensor and the color balance of images.

A National Institute of Standards (NIST) traceable gray spectralon panel with a known reflectance between 20-40% is required to evaluate long-term stability of the imaging sensor. Figure 1 depicts an example configuration showing the placement of the reference panel, (denoted as Ref Panel) in relation to the camera. Quarterly calibrations will be conducted by affixing the spectralon panel as shown in Figure 1 for a minimum of 2 hours around solar noon each quarter. Additional details regarding the spectralon panel and color cards may be found in AD[06].

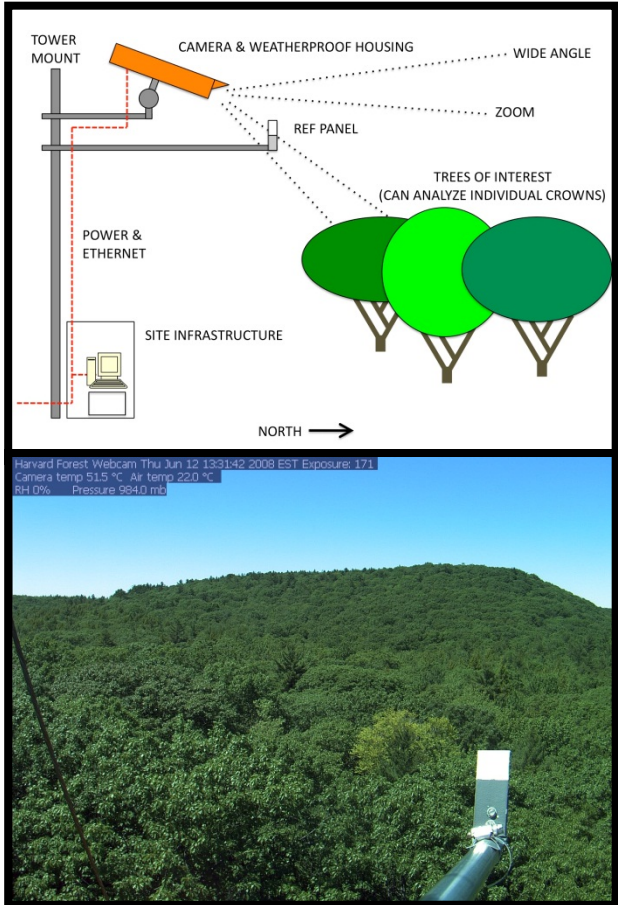


Figure 1. Example reference panel configuration for evaluating long-term sensor stability and facilitating data comparison. Note that this will be updated to match the finalized method. Images from RD[05].

Images will be flagged starting once a field technician attached the reference panel to the infrastructure for calibration. Flaggering of images for calibration will stop once the field technician removes the reference panel.