SPECIFICATION
FOR THE
Climate Change Environmental Monitoring System

Prepared for:

EG207 Instrumentation and Measurement
Fall 2021

REVISION LOG

Version/Release	Description	Date	Issuer
-	Initial Issue	9/12/21	PSD
A	Definition of baseplate geometry	9/20/21	PSD
B	Added Arduino MEGA 2560 Mounting Outline	9/29/21	PSD

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1 SCOPE

This document lists the technical, project and verification requirements for the Climate Change Environmental Monitoring System (hereby referred to as the "System") for which a Prototype System is to be developed by the EG207 Fall 2021 class sections within the Southern New Hampshire Univerity (SNHU) School of Engineering, Technology and Aeronautics (SETA). SNHU-SETA will hereby be referred to as the "Customer". The System will provide the means to continually monitor environmental conditions and record data in a data log. Sections 1 and 2 of this document list the scope and applicable documents/files to this project. Section 3 provides the technical and project requirements while Section 4 provides the verification requirements. The Customer has identified the methods of verification for some of the primary requirements as identified in Section 4. Each team may determine the methods of verification for the remaining requirements not addressed by the customer.

1.1 Introduction

The System will measure and monitor the following environmental variables using the customer-supplied environmental sensors shown in Table 1. The sensor datasheets are provided in Section 5.

Environmental Variable	Customer-Supplied Sensor
Temperature	DHT11
Humidity	
Visible Light Illuminance	CDS-55 Photoresistor
UV Light Intensity	Parallax 28091
Water Collection/Rate	TBS

Table 1. System Environmental Variables and Customer-Supplied Sensors

The Customer will also provide an Arduino Uno or MEGA microcontroller board as part of an ELEGOO project kit and a licensed version of LabVIEW® 2019. Arduino software is open-source and free to use. Arduino software customized to the sensors provided as part of the ELEGOO kit is provided on the CD provided with that kit.

1.2 System Definition

The sensor package system layout is shown in Figure 1. A student-provided laptop running LabVIEW 2019 should provide a virtual instrument front panel which controls and reads from the sensor package.

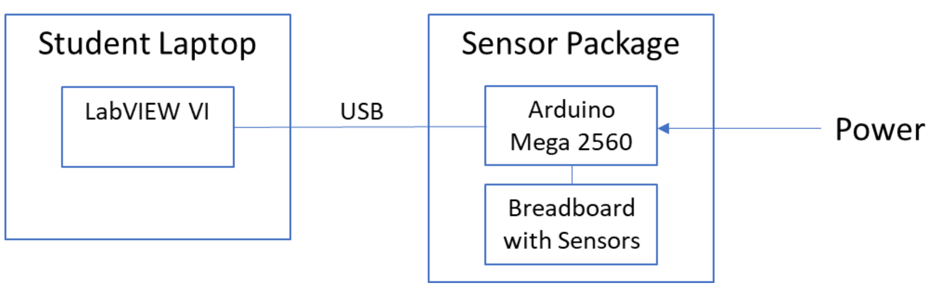


Figure 1. EG207 Fall 2021 Sensor System Layout

1.3 Responsibilities

The Customer will provide the software, data acquisition and sensor hardware as identified in Section 1.1. The Project Team shall be responsible for the following;

1. Analysis and design of an environmental monitoring system using a LabVIEW® Virtual Instrument (VI) interface with the Arduino microcontroller/data acquisition board and a multiple sensor breadboard,
2. Analysis, design and fabrication of;
    a. Prototype sensor housing or casing such that this component can be fabricated via 3-D printing, and
    b. Prototype system baseplate machined in Aluminum 6061-T6
3. Assembly and test of the prototype environmental monitoring system,
4. Verification of the fully-integrated environmental monitoring system in accordance with the verification methods and details provided in Section 4, and
5. Execution of this project in accordance with the project requirements specified in Section 3.5.

2 APPLICABLE DOCUMENTS

The documents listed in this section are applicable to this specification. Document revisions and versions are not specified as the specific applicable document revision or version is the current revision or version in effect.

2.1 Customer Specifications and Files

The following customer specifications and files are applicable to this document.

Document No./Filename	Title
DHT-Technical-Data-Sheet.pdf	Datasheet – DHT11
CDS-55 Photoresistor.pdf	Datasheet – CDS-55
28091-UV-Sensor.pdf	Datasheet – Parallax 28091 UV Sensor
TBS	Datasheet – Water Collection Module
	ELEGOO Arduino Mega 2650 CD (Files, Code, Libraries)

2.2 Project Documents

The following project documents are applicable to this.

Document No./Filename	Title
EG207_PDR_Template.pptx	Preliminary Design Review Slide Template

2.3 I&M References and Standards

The following industry standards are applicable to this specification.

Document No.	Title
ISBN 9781439848838	JOHN G. WEBSTER; HALIT EREN. Measurement, Instrumentation, and Sensors Handbook : Two-Volume Set. Boca Raton: CRC Press, 2014.

3 REQUIREMENTS

This section defines the functional, performance, interface, design, resource and project requirements of the System. Please note that the verification requirements are listed in Section 4.

3.1 FUNCTIONAL

The System shall satisfy the following functional requirements.

3.1.1 Virtual Instrument Front Panel

The System virtual instrument panel shall provide the ability to display each sensor reading and warning/alarm indications, include the necessary controls to operate the sensor package, indicate the current system configuration and operating mode and provide a STOP button to end operation of the system.

3.1.2 Sensor Update/Read Rate

The System shall read each sensor (identified in Section 1.1) at a rate which is consistent with the response of each sensor such that measurement noise is minimized and the System monitoring performance is stable. The System shall display a reasonable set of sensor measurements in real-time and with appropriate units.

3.1.3 Warning and Alarm Indication

The System shall provide an indication of warning or alarm for each type of measurement within the sensor prototype. This indication shall appear on the instrument display as independent “Warning” and “Alarm” LEDs for each measurement. These LEDs must be positioned to the right of the sensor numerical indicator. The criteria (allowable sensor yellow or red limits, etc.) adopted for the basis of this indication shall be formally documented. The Instructor will provide additional criteria for “out of range” sensor conditions during the calibration activity.

3.1.4 Waveform Display

The prototype shall display real-time measurement data for at least two sensors on a LabVIEW front panel waveform chart. The sensor readout rate and LabVIEW data collection rates shall be optimized so there is no “dropout” of measurement data on the waveform charts.

3.1.5 Data Logging

The System shall provide the capability of logging each environmental measurement and LED indication. This data shall be time-stamped and be written to an external file for every 8-hour shift. Each file shall possess a filename structure which indicates the date and shift the data was logged. The frequency of data logging (number of updates between data writes) shall be an input on the System instrument panel.

3.1.6 Operational Modes

The System shall operate on a continuous, uninterrupted basis. An additional operating mode such as diagnostics or calibration mode may be implemented and controlled from the System virtual instrument panel. The System shall provide a clear indication of its present operating mode on the panel.

3.2 PERFORMANCE

The System shall satisfy the performance requirements specified in this section.

3.2.1 Sensor Accuracy

The System shall measure the environmental variables specified in Section 1.1 to the accuracies (or better than those) listed in Table 2.

Environmental Variable	Accuracy
Temperature	± 2.5 °C
Humidity	± 7%
Visible Illuminance	5%
UV Light Intensity	10%
Water Collection/Flow	TBS

Table 2. Sensor Accuracy Requirements

3.2.2 Sensor Precision

The System sensors shall provide the measurement precision better than or equal to those precisions listed in Table 3.

Environmental Variable	Precision
Temperature	2 °C
Humidity	2 %
Visible Illuminance	10 lux
UV Light Intensity	20 lux
Water Collection/Flow	TBS

Table 3. Sensor Precision Requirements

3.2.3 Calibration or Diagnostics

The System shall provide the means to perform a calibration of the sensors or a limited diagnostic check on the system health. This function shall be controlled by an input on the System panel with a clear indication of its operational mode.

3.3 INTERFACE

The System shall satisfy the interface requirements specified in this section.

3.3.1 Mounting

The System shall satisfy the mounting requirements specified herein.

3.3.1.1 Baseplate Bottom Surface

The System shall include a metallic baseplate which provides a flat underside surface that will rest on a flat surface. The baseplate shall also include tapped holes at each corner to allow securing the housing cover to the baseplate.

3.3.1.2 Housing Cover to Baseplate

The System housing cover shall mount to its baseplate through 4 holes at the corner of the baseplate and cover profile. The housing cover shall provide clearance holes at these locations such that fasteners can secure the cover to the baseplate.

3.3.1.3 Arduino MEGA 2560 Mounting

The Arduino MEGA 2560 mounting (stand-off) outline in shown in Figure 2.

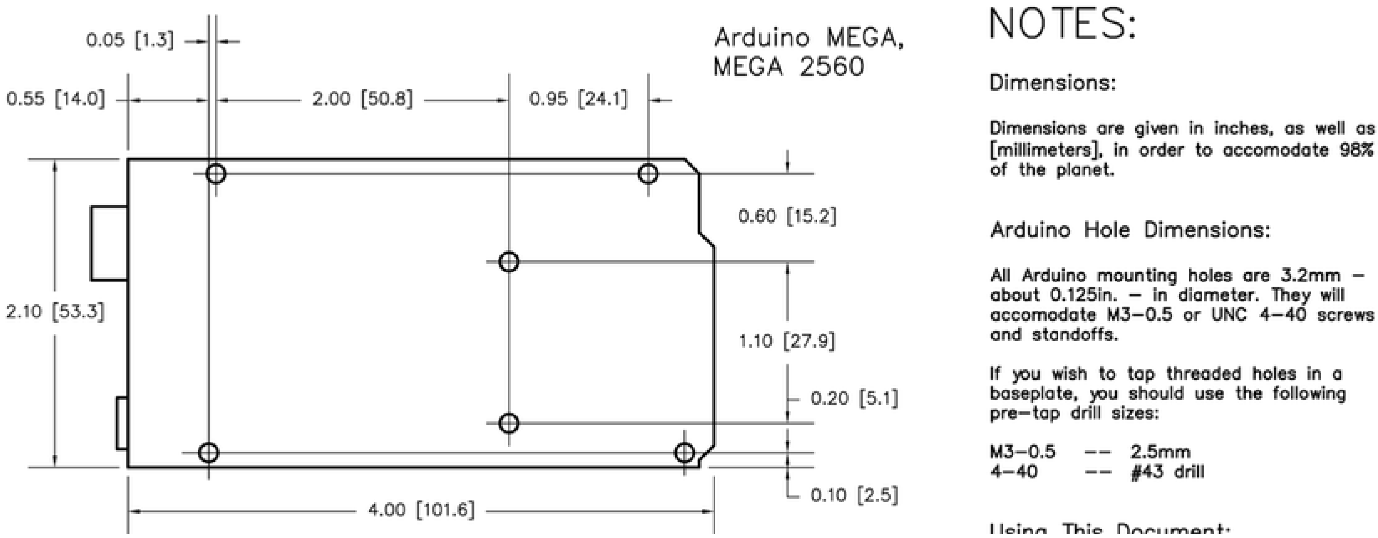


Figure 2. Arduino MEGA 2560 Mounting Outline

3.3.2 Electrical

The System sensors shall be fully powered by the power busses available on the Arduino microcontroller. Use of external power supplies is not allowed. The sensors shall be seated in one of the ELEGOO kit breadboards as part of its breadboard configuration. The complete System Sensor setup (including wiring to the Arduino) shall be documented.

3.3.3 Data and Power Access

The System shall allow access to the Arduino MEGA 2560 USB and power connectors with the MEGA board mounted on its baseplate and its housing cover in place mounted to the baseplate.

3.4 DESIGN

The System shall satisfy the design requirements specified herein.

3.4.1 Housing Design

The System housing design shall be compatible with the mounting interface specified in Section 3.3.1.2. It shall be free of sharp edges and shall allow fabrication by 3-D printing processes. The housing design profile should match that of the baseplate described in Section 3.4.2..

3.4.2 Baseplate Design

The System baseplate shall be designed as a 8” x 8” x ½" Aluminum 6061-T6 plate and shall include clearance holes with underside counterbores to secure the Arduino Mega 2560 via five standoffs to the baseplate.

3.4.3 Electrical Design

The System electrical design shall minimize electronic noise, provide stable sensor readouts and be properly grounded.

3.4.4 Hardware

All mechanical hardware used in the System design shall be standard and be no smaller than a #6-32 size.

3.5 PROJECT

The Project Team shall satisfy the following requirements in the execution of this project.

3.5.1 Team Structure

Each team member shall serve as the Team Leader for at least a two-week period. This person shall work with the team to schedule and execute the necessary activities to accomplish the objectives of this project. This person shall also be responsible for forwarding on all required team communications to the customer as described in the next section. All team decisions made shall be made by a fully democratic process.

3.5.2 Team Communications

Each member of each team will be responsible for providing a series of three written pieces of communication as part of this project. The team will be prompted by the customer when these communications are due. These communications shall consist of the following;

1) A short technical memorandum from each team member (including the team leader) to the team leader providing a technical summary of a technical analysis performed by the team member. This correspondence is due at the time of the Preliminary and Critical Design Review presentations defined in Section 3.5.3,
2) An email assessment of an impact made by a change in this project specification. The customer shall determine when this assessment is required.
3) While serving as Team Leader, a weekly email status report each Friday detailing the tasks that were completed during the week, the tasks planned for the coming week and indication of any pending/current problems or issues.

3.5.3 Preliminary and Critical Design Review Presentations

Each team shall provide short presentations summarizing the state of their system designs at two design reviews; a Preliminary Design Review (three weeks after specification release) and a Critical Design Review (approximately 4 weeks before project completion). MS-Powerpoint presentation templates shall be provided to each team which explicitly lists the information which the customer will expect to see presented at this review.

3.5.4 System Fabrication

Each team shall designate at least one member responsible for manufacture of the baseplate in the SETA IDEA Lab and another member responsible for 3-D printing of the Sensor housing cover. The baseplate design should be completed early to allow the baseplate manufacturing process ample time for the baseplate manufacture. It is strongly recommended that baseplate manufacture begins immediately after returning from the Fall break in October 2021. The 3-D printing file and drawing should be available in mid-November 2021.

3.5.5 System Demonstration

Each team will be required to demonstrate that their final System meets the requirements of this specification. This should be verified before the final Verification process is instructed by the Instructor. With the team's system running, the Instructor will stimulate each sensor and observe the VI readings and warning/alarm indication. Each team shall submit a verification report detailing this compliance. A Verification Report template (MS-Word) shall be provided to each team for additional guidance.

3.5.6 System Acceptance Data Package (ADP)

Each team will provide the following documentation in support of their system development;

1) Inventor model files (*.ipt,*.iam) for the sensor package assembly,
2) Inventor STL file of the sensor housing cover and an outline drawing of the cover,
3) Sensor package baseplate part files and fabrication drawing,
4) Sensor limits and decision-making flowchart,
5) System Electrical Circuit Diagram (including Arduino) with photographs of breadboard setup,
6) Final LabVIEW VI file (*.vi) and Arduino Code Listing (*.ino),
7) Example System Data Log file, and
8) Verification Report

4 VERIFICATION AND TEST REQUIREMENTS

The Project Team shall verify the System satisfies the requirements specified herein in accordance with the requirements set forth in this section.

4.1 VERIFICATION MODELS

A breadboard of the System shall be designed, fabricated assembled and developmentally-tested as part of this project.

4.2 VERIFICATION COMPLIANCE

The Project Team shall verify the System performance and function in accordance with the details listed in this section and Table 1.

Table 4. System Verification Compliance Matrix

METHODS:	**MODELS:**	**PHASES:**
(A)nalysis	1. Prototype (PR)/Breadboard (BB)	Developmental (D)
(D)emonstration	2. Engineering Model (EM)	Qualification (Q)
(I)nspection	3. Structural Model (SM)	Protoflight (P)
(M)easurement	4. Qualification Model (QM)	Flight Acceptance (FA)
(S)imilarity	5. Protoflight (PFM)	
(T)est	6. Flight Model (FM)	
(V)alidation of Records		

Req. Ref.	Title	D1	Notes/Basis
3.1	**FUNCTIONAL REQUIREMENTS**		
3.1.1	Virtual Instrument Front Panel	D,I	
3.1.2	Sensor Update/Read Rate	A,D	
3.1.3	Warning and Alarm Indication	D,T	Sensor yellow and red limits and decision-making flow chart req'd
3.1.4	Waveform Display	D	
3.1.5	Data Logging	D,I	Data file to be provided in ADP
3.1.6	Operational Modes	D	
3.2	**PERFORMANCE REQUIREMENTS**		
3.2.1	Sensor Accuracy	V	Standard to be used for accuracy determination
3.2.2	Sensor Precision	A,V	Standard deviation analysis req'd
3.2.3	Calibration or Diagnostics	D	
3.3	**INTERFACE REQUIREMENTS**		
3.3.1	Mounting	A,D	
3.3.1.1	Baseplate Bottom Surface	D	
3.3.1.2	Housing to Baseplate	D	
3.3.2	Electrical	V,D	System Electrical Circuit Diagram req'd (including Arduino functions)
3.3.3	Data Power and Access	D	
3.4	**DESIGN REQUIREMENTS**		

3.4.1	Housing	V,D	*STL file and outline drawing required for fabrication
3.4.2	Baseplate	V	
3.4.3	Electrical	V	
3.4.4	Hardware	V,I	
3.5	**PROJECT REQUIREMENTS**		
3.5.1	Team Structure	D	
3.5.2	Team Communications	D,I	Weekly email status reports req'd
3.5.3	PDR and CDR Presentations	D	Presentation Templates provided, reviewed class before presentations
3.5.4	System Fabrication	D,I	Baseplate part file/fab drawing and Cover STL file/outline drawing req'd
3.5.4	System Demonstration	D	Instructor executes final verification activity
3.5.5	System ADP	I	ZIP file of all native files

5 SENSOR Datasheets

5.1 DHT11 Temperature/Humidity Sensor Specifications

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution
DHT11	20-90%RH 0-50 ℃	±5%RH	±2℃	1

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

5.2 CDS-55 Photoresistor

ELECTRO-OPTICAL CHARACTERICTICS :

Parameter		Characterictics	Unit
Light Resistance(at 10lux)		18-50	KΩ
Dark Resistance(at 0 lux/Min)		2.0	MΩ
Gamma Value(at 100-10lux)		0.7	γ^{100}_{10}
Power Dissipation(at 25℃)		50	MW
Max Voltage(at 25℃)		100	VDC
Spectral Response peak(at 25℃)		540	nm
Ambient Temperature Range		-30～+70	℃
Response time	Increase	30	ms
	Decrease	30	ms

Light resistance : Measured at 10lux(standard Light source)at a color temperature of 2856K. color temperature)and 2h pre-illumination at 400-600 lux priorto testing .

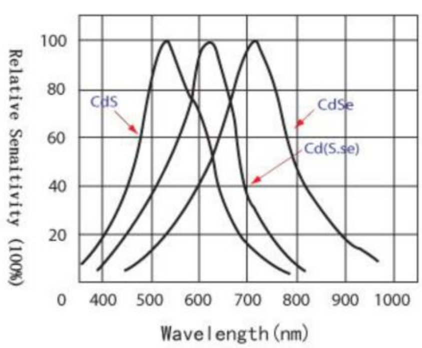
Dark resistance: measured 10 senconds after pulsed 10 lux.

Gamma Characteristic:between 10lux and 100lux and given by $T = \frac{\mathrm{Lon}(R10/R100)}{\mathrm{Log}(100/10)} = \mathrm{Log}(R10/R100)$

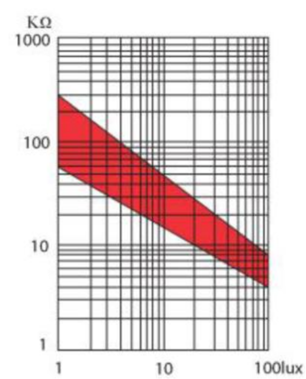
Pmax: Max.power dissipation at ambient temperature of 25℃.

Vmax:Max.voltage in darkness that may be applied to the cell continuously .

■ SPECTRAL RESPONSE :



■ ILLUNINANCE Vs. PHOTO RESISTANCE



5.3 Parallax 28091 UV Light Sensor

UV Sensor User Manual

1. Features

Boost convertor chip	SGM8521
Operating voltage	3.0V-5.5V
Output type	TTL level output
Responsive wavelength	200nm-370nm
Dimensions	21.0mm*13.0mm
Fixing hole size	2.0mm

Operating principle:
This module has an UV sensor, GUVA, which is a ideal device for detecting the amount of UV ray without wavelength filter, since it is UV ray sensitive only. In other word, the wavelengths of 365nm(UV-A) and 320nm(UV-B) are the cut-off thresholds of GUVA.

2. Applications

This module can be applied to UV ray detecting system, outdoors UV monitoring device, sterilizing lamp and etc.

3. Interfaces

Pin No.	Symbol	Descriptions
1	AOUT	Analog output
2	GND	Power ground
3	VCC	Positive power supply (3.0V-5.5V)

5.4 Water Collection Module

This datasheet will be provided.

6 ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are utilized within this specification.

ASTM	American Society for Testing and Materials
CDR	Critical Design Review
CETA	College of Engineering, Technology and Aeronautics
DC	Direct Current
PDR	Preliminary Design Review
SNHU	Southern New Hampshire University (SNHU)
TBS	To Be Specified