Design Documentation

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High level requirements

*Hardware*

|  |  |  |
| --- | --- | --- |
| Requirement Id | Description | Type |
| HLR\_HW\_001 | The system shall have a dedicated display that supports Latin characters | Hardware |
| HLR\_HW\_002 | The system shall have a dedicated display that supports numerical characters | Hardware |
| HLR\_HW\_003 | The system should have a display module that supports special characters | Hardware |
| HLR\_HW\_004 | The system shall have dedicated light sources to show warnings related to pitch, roll, hot temperature, and cold temperature | Hardware |
| HLR\_HW\_005 | The system should have a dedicated display that supports different levels of brightness | Hardware |
| HLR\_HW\_006 | The system shall have a dedicated display to show pitch, roll, yaw, module temperature, ambient temperature | Hardware |
| HLR\_HW\_007 | The system should have a dedicated display to show yaw and humidity | Hardware |
| HLR\_HW\_008 | The system shall have a dedicated external module to measure ambient temperature | Hardware |
| HLR\_HW\_009 | The system should have a dedicated external module to measure humidity data | Hardware |
| HLR\_HW\_010 | The system shall have an internal module to measure pitch, roll, and module temperature data | Hardware |
| HLR\_HW\_011 | The system should have an internal module to measure yaw | Hardware |
| HLR\_HW\_012 | The system shall have a button to reset the whole system | Hardware |
| HLR\_HW\_013 | The system shall have a dedicated microcontroller to control the outputs of the system | Hardware |
| HLR\_HW\_014 | The system shall have a button to switch display page | Hardware |

*Software*

|  |  |  |
| --- | --- | --- |
| Requirement ID | Description | Type |
| HLR\_SW\_001 | The system shall control the dedicated display for pitch, roll, yaw, ambient temperature, module temperature, and humidity | Software |
| HLR\_SW\_003 | The system shall have a dedicated virtual display that supports circular gauges | Software |
| HLR\_SW\_004 | The system shall have a dedicated virtual display that supports linear gauges | Software |
| HLR\_SW\_005 | The system shall have a dedicated virtual display that supports an artificial horizon gauge | Software |
| HLR\_SW\_006 | The system shall control the virtual display for pitch, roll, internal module temperature, ambient temperature, and humidity | Software |
| HLR\_SW\_008 | The system shall smooth data received from the internal module | Software |
| HLR\_SW\_009 | The internal module for pitch, roll, yaw, and internal module temperature shall send pitch, roll, module temperature, and in the correct order to the system | Software |
| HLR\_SW\_010 | The internal module for pitch, roll, yaw and internal module temperature should send yaw in the correct order to the system | Software |
| HLR\_SW\_011 | The external module for ambient temperature and humidity shall send ambient temperature in the correct order to the system | Software |
| HLR\_SW\_012 | The external module for ambient temperature and humidity should send humidity in the correct order to the system | Software |
| HLR\_SW\_013 | The system shall control all the dedicated light sources for warnings related to roll, pitch, hot temperature, and cold temperature | Software |
| HLR\_SW\_014 | The system shall control the page number of the dedicated display | Software |
| HLR\_SW\_015 | The system shall send a DeSyncCheck value to the virtual display | Software |
| HLR\_SW\_016 | The system shall run the virtual display in an infinite loop using a function break to stop the infinite loop | Software |
| HLR\_SW\_017 | The system shall send the GPSwaypoints to the virtual display in the correct order | Software |

Intermediate level requirements

*Hardware*

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| --- | --- | --- | --- |
| Requirement Id | Description | Type | Traceability  High-level  requirement/s |
| ILR\_HW\_001 | The system dedicated display shall be an LCD display with 2 rows and 16 columns of characters | Hardware | HLR\_HW\_001  HLR\_HW\_002  HLR\_HW\_003  HLR\_HW\_005  HLR\_HW\_006  HLR\_HW\_007 |
| ILR\_HW\_002 | The dedicated display shall support the font “New times Roman” | Hardware | HLR\_HW\_001  HLR\_HW\_006  HLR\_HW\_007 |
| ILR\_HW\_003 | The dedicated display should support the special character “colons” | Hardware | HLR\_HW\_003 |
| ILR\_HW\_004 | The dedicated display should support integers | Hardware | HLR\_HW\_002  HLR\_HW\_006  HLR\_HW\_007 |
| ILR\_HW\_005 | The dedicated display should support decimals |  | HLR\_HW\_002 |
| ILR\_HW\_006 | The dedicated display shall have a potentiometer with a resistance of 10K to adjust the brightness of the display | Hardware | HLR\_HW\_005 |
| ILR\_HW\_007 | The light source for cold temperature warning should be a blue LED, with 200cd/m^2 brightness | Hardware | HLR\_HW\_004 |
| ILR\_HW\_008 | The light source for hot temperature warning should be a red LED with 200cd/m^2 brightness | Hardware | HLR\_HW\_004 |
| ILR\_HW\_009 | The light source for pitch warning should be a yellow LED with 200cd/m^2 brightness | Hardware | HLR\_HW\_004 |
| ILR\_HW\_010 | The light source for roll warning should be a green LED with 200cd/m^2 brightness | Hardware | HLR\_HW\_004 |
| ILR\_HW\_011 | The system shall have a dedicated microcontroller with a clock speed of 16Mhz to control outputs of the system | Hardware | HLR\_HW\_013 |
| ILR\_HW\_012 | The internal module shall be a Module with a gyroscope, accelerometer, and temperature sensor | Hardware | HLR\_HW\_010  HLR\_HW\_011 |
| ILR\_HW\_013 | The external module shall be a Module with a temperature sensor and humidity sensor | Hardware | HLR\_HW\_008  HLR\_HW\_009 |
| ILR\_HW\_017 | The button for resetting the system shall have a rating of 50mA | Hardware | HLR\_HW\_012 |
| ILR\_HW\_018 | The button for switching LCD page shall have a rating of 50mA | Hardware | HLR\_HW\_014 |

*Software*

|  |  |  |  |
| --- | --- | --- | --- |
| Requirement ID | Description | Type | Traceability  High-level  requirement/s |
| ILR\_SW\_001 | The system shall control the main LCD display, and positions (2 rows, and 16 columns of characters) | Software | HLR\_SW\_001  HLR\_SW\_014 |
| ILR\_SW\_002 | The system shall control the virtual display gauge position for internal module temperature (300 pixels from left, and 150 pixels from bottom) | Software | HLR\_SW\_006  HLR\_SW\_009 |
| ILR\_SW\_003 | The system shall control the virtual display gauge position for ambient temperature (300 pixels from left and 300 pixels from bottom) | Software | HLR\_SW\_006  HLR\_SW\_011 |
| ILR\_SW\_004 | The system shall control the virtual display gauge position for humidity (300 pixels from left, and 10 pixels from bottom) | Software | HLR\_SW\_006  HLR\_SW\_012 |
| ILR\_SW\_005 | The system shall control the virtual display gauge limits for internal module temperature and ambient temperature (-127 to 127) | Software | HLR\_SW\_006  HLR\_SW\_009  HLR\_SW\_011 |
| ILR\_SW\_006 | The system shall control the virtual display gauge limits for humidity (0 to 127) | Software | HLR\_SW\_006  HLR\_SW\_012 |
| ILR\_SW\_007 | The virtual display shall show internal module temperature, and ambient temperature on circular gauges in degrees Celsius | Software | HLR\_SW\_003  HLR\_SW\_006  HLR\_SW\_009  HLR\_SW\_011 |
| ILR\_SW\_008 | The system shall control the virtual display Major Ticks for internal module temperature, and ambient temperature (-120, -60, 0, 60, 120) | Software | HLR\_SW\_006  HLR\_SW\_009  HLR\_SW\_011 |
| ILR\_SW\_009 | The system shall control the virtual display Major Ticks for humidity (0, 20, 40, 60, 80, 100, 120) | Software | HLR\_SW\_006  HLR\_SW\_012 |
| ILR\_SW\_010 | The system shall smooth data received from the internal module using a complimentary filter | Software | HLR\_SW\_008 |
| ILR\_SW\_011 | The virtual display shall show roll and pitch on an artificial horizon gauge in degrees | Software | HLR\_SW\_005  HLR\_SW\_006  HLR\_SW\_009 |
| ILR\_SW\_012 | The virtual display shall show humidity on a linear gauge in grams per cubic meter | Software | HLR\_SW\_004  HLR\_SW\_006  HLR\_SW\_012 |
| ILR\_SW\_014 | The system shall activate the dedicated light source for cold temperature warning when the ambient temperature is less than 8 degrees or else it shall deactivate the light source for cold temperature warning | Software | HLR\_SW\_013  HLR\_SW\_011 |
| ILR\_SW\_016 | The system shall activate the dedicated light source for hot temperature warning when the ambient temperature is more than 31 degrees or else it shall deactivate the dedicated light source for hot temperature warning | Software | HLR\_SW\_013  HLR\_SW\_011 |
| ILR\_SW\_018 | The system shall activate the dedicated light source for pitch warning when the pitch is more than 45 degrees or less than -45 degrees or else is shall deactivate the dedicated light source for pitching warning | Software | HLR\_SW\_013  HLR\_SW\_009 |
| ILR\_SW\_020 | The system shall activate the dedicated light source for roll warning when the roll is more than 45 degrees or less than -45 degrees or else it shall deactivate the dedicated light source for roll warning | Software | HLR\_SW\_013  HLR\_SW\_009 |
| ILR\_SW\_022 | The system shall convert pitch, roll, yaw, internal module temperature, ambient temperature, humidity, and the GPSWaypoints from “uint8” to “int8” | Software | HLR\_SW\_017 |
| ILR\_SW\_023 | The value of the system DeSyncCheck shall be equal to 128 | Software | HLR\_SW\_009  HLR\_SW\_010  HLR\_SW\_011  HLR\_SW\_012  HLR\_SW\_015 |
| ILR\_SW\_024 | The system shall run the virtual display in an infinite loop using a while loop | Software | HLR\_SW\_003  HLR\_SW\_004  HLR\_SW\_005  HLR\_SW\_006  HLR\_SW\_016 |
| ILR\_SW\_025 | The system shall have a function break to stop the infinite loop using an if statement | Software | HLR\_SW\_003  HLR\_SW\_004  HLR\_SW\_005  HLR\_SW\_006  HLR\_SW\_016 |
| ILR\_SW\_026 | The system shall communicate with the internal module for pitch, roll, yaw, and internal module temperature at address “0x68” | Software | HLR\_SW\_009  HLR\_SW\_010 |
| ILR\_SW\_027 | The system shall configure the sensitivity of the accelerometer inside the internal module for pitch, roll, yaw, internal module temperature to +2/-2g | Software | HLR\_SW\_009  HLR\_SW\_010 |
| ILR\_SW\_028 | The system shall configure the sensitivity of the gyroscope inside the internal module for pitch, roll, yaw, internal mobule temperature to +2/-2g to +250(deg/s)/-250(deg/s) | Software | HLR\_SW\_009  HLR\_SW\_010 |

Low level requirements

*Hardware*

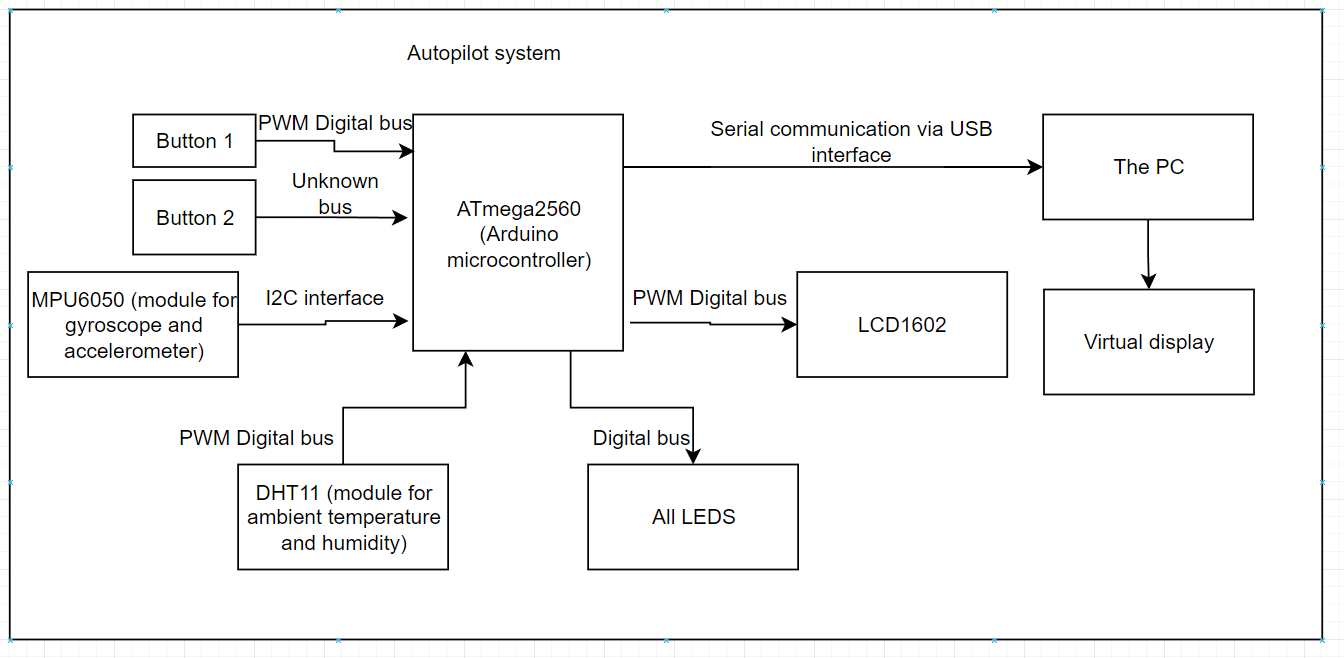
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| --- | --- | --- | --- | --- |
| Requirement ID | Description | Type | Traceability  High-level  requirement/s | Traceability  Intermediate-level  requirement/s |
| LLR\_HW\_001 | The dedicated display shall have the following part number “LCD1602” by KAMAMI | Hardware | HLR\_HW\_001  HLR\_HW\_002  HLR\_HW\_003  HLR\_HW\_005  HLR\_HW\_006  HLR\_HW\_007 | ILR\_HW\_001  ILR\_HW\_002  ILR\_HW\_003  ILR\_HW\_004  ILR\_HW\_005  ILR\_HW\_006 |
| LLR\_HW\_002 | The dedicated display LCD1602 shall have an PWM interface with the following related PINs connections:  LCD1602 pin 4(RS) to ATMEGA2560-16AU pin 16  LCD1602 pin 6(E) to ATMEGA2560-16AU pin 17  LCD1602 pin 11(DB4) to ATMEGA2560-16AU pin 18  LCD1602 pin 12(DB5) to ATMEGA2560-16AU pin 23  LCD1602 pin13(DB6) to ATMEGA2560-16AU pin 24  LCD1602 pin 14(DB7) to ATMEGA2560-16AU pin 25  (related datasheets in evidence) | Hardware | HLR\_HW\_001  HLR\_HW\_002  HLR\_HW\_003  HLR\_HW\_005  HLR\_HW\_006  HLR\_HW\_007 | ILR\_HW\_001  ILR\_HW\_002  ILR\_HW\_003  ILR\_HW\_004  ILR\_HW\_005  ILR\_HW\_006 |
| LLR\_HW\_003 | The dedicated display shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the PWM bus | Hardware | HLR\_HW\_001  HLR\_HW\_002  HLR\_HW\_003  HLR\_HW\_005  HLR\_HW\_006  HLR\_HW\_007 | ILR\_HW\_001  ILR\_HW\_002  ILR\_HW\_003  ILR\_HW\_004  ILR\_HW\_005  ILR\_HW\_006 |
| LLR\_HW\_004 | The internal module shall have the following part number “MPU6050” by InvenSense | Hardware | HLR\_HW\_010  HLR\_HW\_011 | ILR\_HW\_012 |
| LLR\_HW\_005 | The internal module MPU6050 shall have an I2C interface with the following related PINs connections: MPU6050 pin 24(SDA) to ATMEGA2560-16AU pin 44  MPU6050 pin 23(SCL) to ATMEGA2560 pin 43 | Hardware | HLR\_HW\_010  HLR\_HW\_011 | ILR\_HW\_012 |
| LLR\_HW\_006 | The internal module shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the I2C bus | Hardware | HLR\_HW\_010  HLR\_HW\_011 | ILR\_HW\_012 |
| LLR\_HW\_007 | The external module shall have the following part number “386” by Adafruit Accessories | Hardware | HLR\_HW\_008  HLR\_HW\_009 | ILR\_HW\_013 |
| LLR\_HW\_008 | The external module (known as DHT11) shall have an PWM interface with the following PINs connections:  DHT11 pin 2 to ATMEGA2560-16AU pin 1 | Hardware | HLR\_HW\_008  HLR\_HW\_009 | ILR\_HW\_013 |
| LLR\_HW\_009 | The external module shall be connected with female to male cables to the ATMEGA2560-16AU using the PWM bus | Hardware | HLR\_HW\_008  HLR\_HW\_009 | ILR\_HW\_013 |
| LLR\_HW\_010 | The dedicated microcontroller shall have the following part number “ATMEGA2560-16AU” by Microchip Technology/Atmel | Hardware | HLR\_HW\_013 | ILR\_HW\_011 |
| LLR\_HW\_011 | The dedicated light source for hot temperature warning shall have the following number “WP7113SRD/D” by Kingbright | Hardware | HLR\_HW\_004 | ILR\_HW\_008 |
| LLR\_HW\_012 | The dedicated light source for hot temperature warning (Red LED) shall have a Digital interface with the following related PINs connections:  Red LED anode pin to ATMEGA2560-16AU pin 78 | Hardware | HLR\_HW\_004 | ILR\_HW\_008 |
| LLR\_HW\_013 | The dedicated light source for hot temperature warning shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the Digital bus | Hardware | HLR\_HW\_004 | ILR\_HW\_008 |
| LLR\_HW\_014 | The dedicated light source for cold temperature warning shall have the following number “L-7113QBC-D” by Kingbright | Hardware | HLR\_HW\_004 | ILR\_HW\_007 |
| LLR\_HW\_015 | The dedicated light source for cold temperature warning (Blue LED) shall have a Digital interface with the following related PINs connections:  Blue LED anode pin to ATMEGA2560-16AU pin 72 | Hardware | HLR\_HW\_004 | ILR\_HW\_007 |
| LLR\_HW\_016 | The dedicated light source for cold temperature warning shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the Digital bus | Hardware | HLR\_HW\_004 | ILR\_HW\_007 |
| LLR\_HW\_017 | The dedicated light source for pitch warning shall have the following part number “L-53YD” by Kingbright | Hardware | HLR\_HW\_004 | ILR\_HW\_009 |
| LLR\_HW\_018 | The dedicated light source for pitch warning (Yellow LED) shall have a Digital interface with the following related PINs connections:  Yellow LED anode pin to ATMEGA2560-16AU pin 76 | Hardware | HLR\_HW\_004 | ILR\_HW\_009 |
| LLR\_HW\_019 | The dedicated light source for pitch warning shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the Digital bus | Hardware | HLR\_HW\_004 | ILR\_HW\_009 |
| LLR\_HW\_020 | The dedicated light source for roll warning shall have the following part number “WP7113GD” by Kingbright | Hardware | HLR\_HW\_004 | ILR\_HW\_010 |
| LLR\_HW\_021 | The dedicated light source for roll warning (Green LED) shall have a Digital interface with the following related PINs connections:  Green LED anode pin to ATMEGA2560-16AU pin 74 | Hardware | HLR\_HW\_004 | ILR\_HW\_010 |
| LLR\_HW\_022 | The dedicated light source for roll warning shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the Digital bus | Hardware | HLR\_HW\_004 | ILR\_HW\_010 |
| LLR\_HW\_023 | The button for switching dedicated display page shall have the following reference number “MS-100630” by Mountain Switch | Hardware | HLR\_HW\_014 | ILR\_HW\_018 |
| LLR\_HW\_024 | The button for switching dedicated display page shall have a PWM interface with the following related PINs connections:  Button pin T3 to ATMEGA-16AU pin 7 | Hardware | HLR\_HW\_014 | ILR\_HW\_018 |
| LLR\_HW\_025 | The button for switching dedicated display page shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the Digital bus | Hardware | HLR\_HW\_014 | ILR\_HW\_018 |
| LLR\_HW\_026 | The button for resetting the system shall have the following reference number “MS-100630” by Mountain Switch | Hardware | HLR\_HW\_012 | ILR\_HW\_017 |
| LLR\_HW\_027 | The button for resetting the system shall have a unknown interface with the following related PINs connections:  Button pin T1 to ATMEGA2560-16AU pin 30 | Hardware | HLR\_HW\_012 | ILR\_HW\_017 |
| LLR\_HW\_028 | The button for resetting the system shall be connected with male to male cables on a solderless breadboard to the ATMEGA2560-16AU using the Digital bus | Hardware | HLR\_HW\_012 | ILR\_HW\_017 |

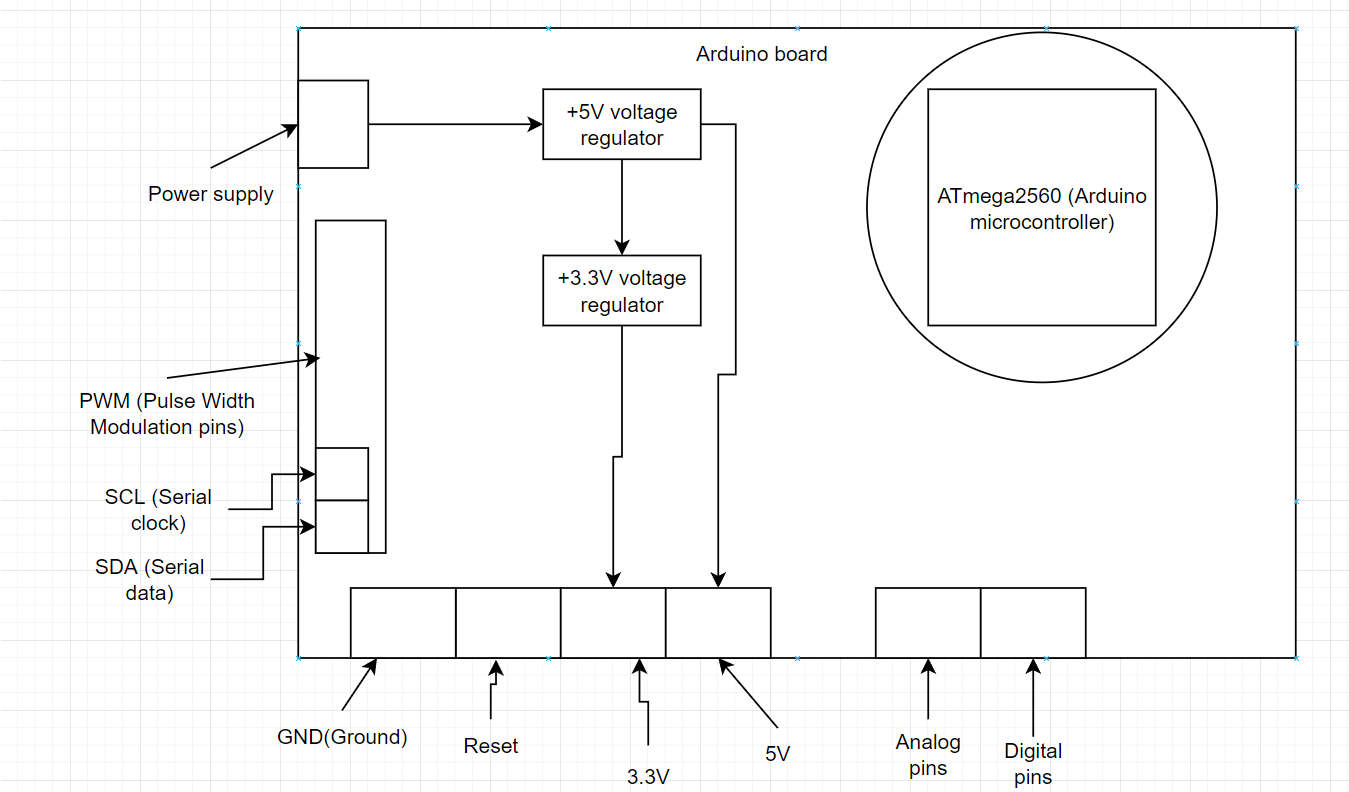
*Software*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Requirement ID | Description | Type | Traceability  High-level  requirement/s | Traceability  Inter-level  requirement/s |
| LLR\_SW\_001 | The function that sends roll, pitch, yaw, ambient temperature, module temperature, humidity, and GPS data to the Virtual display shall have the following characteristics:  Function prototype: void SerialCommunication(float roll, float pitch, float yaw, float Tmp, float temperature, float humidity)  The function shall have no return  The function shall call the GPSWaypoints, Serial.write, and Serial.read functions  Function SerialCommunication input arguments:  roll – Value of roll to be sent to the virtual display  pitch – Value of roll to be sent to the virtual display  yaw – Value of yaw to be sent to the virtual display  tmp - Value of internal module temperature to be sent to the virtual display  humidity – Value of humidity to be sent to the virtual display  temperature – Value of ambient temperature to be sent to the virtual display | Software | HLR\_SW\_006  HLR\_SW\_015  HLR\_SW\_016 | ILR\_SW\_002  ILR\_SW\_003  ILR\_SW\_004  ILR\_SW\_005  ILR\_SW\_006  ILR\_SW\_007  ILR\_SW\_008  ILR\_SW\_009 |
| LLR\_SW\_002 | The function that writes GPSWaypoints data shall have the following characteristics :  Function prototype: void GPSWaypoints()  The GPSWaypoints function shall send the latitude and longitude for each waypoint  The function shall have no return, and shall have no inputs | Software | HLR\_SW\_009 | ILR\_SW\_022 |
| LLR\_SW\_003 | The function that calculates IMU error shall have the following characteristics:  Function prototype: void calculate\_IMU\_error()  The function shall have no return, and shall have no inputs | Software | HLR\_SW\_009  HLR\_SW\_010 | ILR\_SW\_026  ILR\_SW\_027  ILR\_SW\_028 |
| LLR\_SW\_004 | The function that controls the LCD display shall have the following characteristics:  Function prototype: void LCDDisplay(float humidity,float temperature, float roll, float pitch, float yaw, float Tmp, int buttonState)  The function shall have no return  The function shall call the lcd.setCursor, lcd.print, and lcd.clear functions  Function LCDDisplay input arguments:  humidity – Value of humidity to be sent to the dedicated display  temperature – Value of ambient temperature to be sent to the dedicated display  roll – Value of roll to be sent to the dedicated display  pitch – Value of pitch to be sent to the dedicated display  yaw – Value of yaw to be sent to the dedicated display  Tmp – Value of internal module temperature to be sent to the dedicated display  buttonState – Value of buttonState to control what page of LCD is used | Software | HLR\_SW\_001  HLR\_SW\_014 | ILR\_SW\_001 |
| LLR\_SW\_005 | The function that controls the dedicated light source for hot temperature warning shall have the following characteristics:  Function prototype: void HotTempWarning(float temperature)  The function shall have no return  The function shall call the digitalWrite function  Function HotTempWarning input arguments:  temperature – Value of ambient temperature to decide the state of the dedicated light source for hot temperature warning | Software | HLR\_SW\_013  HLR\_SW\_009 | ILR\_SW\_016 |
| LLR\_SW\_006 | The function that controls the dedicated light source for cold temperature warning shall have the following characteristics:  Function prototype: void ColdTempWarning(float temperature)  The function shall have no return  The function shall call the digitalWrite function  Function ColdTempWarning input arguments:  temperature – Value of ambient temperature to decide the state of the dedicated light source for cold temperature warning | Software | HLR\_SW\_013  HLR\_SW\_009 | ILR\_SW\_014 |
| LLR\_SW\_007 | The function that controls the dedicated light source for pitch warning shall have the following characteristics:  Function prototype: void PitchWarning(float pitch)  The function shall have no return  The function shall call the digitalWrite function  Function PitchWarning input arguments:  pitch – Value of pitch to decide the state of the dedicated light source for pitch warning | Software | HLR\_SW\_013  HLR\_SW\_009 | ILR\_SW\_018 |
| LLR\_SW\_008 | The function that controls the dedicated light source for roll warning shall have the following characteristics:  Function prototype: void RollWarning(float roll)  The function shall have no return  The function shall call the digitalWrite function  Function RollWarning input arguments:  roll – Value of roll to decide the state of the dedicated light source for roll warning | Software | HLR\_SW\_013  HLR\_SW\_009 | ILR\_SW\_020 |
| LLR\_SW\_009 | The function that displays the waypoints shall have the following characteristics:  Function prototype: MATLABFunction2(GPSWaypoint1lat, GPSWaypoint1long, GPSWaypoint2lat, GPSWaypoint2long, GPSWaypoint3lat, GPSWaypoint3long , GPSWaypoint4lat, GPSWaypoint4long, GPSWaypoint5lat, GPSWaypoint5long);  The function shall have no return values  GPSWaypoint1long – Value of the longitude for waypoint 1  GPSWaypoint1lat – Value of the latitude for waypoint 1  GPSWaypoint2long – Value of the longitude for waypoint 2  GPSWaypoint2lat – Value of the latitude for waypoint 2  GPSWaypoint3long – Value of the longitude for waypoint 3  GPSWaypoint3lat – Value of the latitude for waypoint 3  GPSWaypoint4long – Value of the longitude for waypoint 4  GPSWaypoint4lat – Value of the latitude for waypoint 4  GPSWaypoint5long – Value of the longitude for waypoint 5  GPSWaypoint5lat – Value of the latitude for waypoint 5 | Software | HLR\_SW\_017 | ILR\_SW\_022 |
| LLR\_SW\_010 | The function that reads the state of the warnings for the dedicated light sources shall have the following characteristics:  Function prototype: [ROLL\_WARNING, PITCH\_WARNING, TEMPERATURE\_TOO\_HOT, TEMPERATURE\_TOO\_COLD] = MATLABFunction3(roll,pitch,amb\_temp)  The return values of the MATLABFunction3 function gives the state of the Hot temperature warning, Cold temperature warning, pitch warning, and roll warning  Function MATLABFunction3 input arguments:  Roll – Value of roll to decide the state of the dedicated roll warning for virtual display  Pitch - Value of pitch to decide the state of the dedicated pitch warning for virtual display  Ambient temperature - Value of ambient temperature to decide the state of the dedicated warnings for cold temperature and hot temperature | Software | HLR\_SW\_013  HLR\_SW\_009 | ILR\_SW\_014  ILR\_SW\_016  ILR\_SW\_018  ILR\_SW\_020 |
| LLR\_SW\_011 | The code that controls the position, limits, major ticks, and major ticks labels of the circular gauge for ambient temperature shall have the following characteristics:  The code shall return a circular gauge on the virtual display showing the ambient temperature  cg1 input arguments:  [300 300 120 120] – Array describing the position of the gauge inside the virtual display  [-127 127] – Array describing the limits of the gauge  [-120 60 0, 60, 120] – Array describing the numbers at which major ticks shall be shown  [-120 60 0, 60, 120] – Array describing the numbers at which labels of the major ticks shall be shown | Software | HLR\_SW\_006  HLR\_SW\_015  HLR\_SW\_016 | ILR\_SW\_003  ILR\_SW\_005  ILR\_SW\_007  ILR\_SW\_008 |
| LLR\_SW\_012 | The code that controls the position, limits, major ticks, and major ticks labels of the circular gauge for internal module temperature shall have the following characteristics:  The code shall return a circular gauge on the virtual display showing the internal module temperature  cg2 input arguments:  [300 150 120 120] – Array describing the position of the gauge inside the virtual display  [-127 127] – Array describing the limits of the gauge  [-120 60 0, 60, 120] – Array describing the numbers at which major ticks shall be shown  [-120 60 0, 60, 120] – Array describing the numbers at which labels of the major ticks shall be shown | Software | HLR\_SW\_006  HLR\_SW\_015  HLR\_SW\_016 | ILR\_SW\_002  ILR\_SW\_005  ILR\_SW\_007  ILR\_SW\_008 |
| LLR\_SW\_013 | The code that controls the position, limits, major ticks, and major ticks labels of the linear for internal module humidity shall have the following characteristics:  The code shall return a linear gauge on the virtual display showing the humidity  Code input arguments:  [300 10 200 80] – Array describing the position of the gauge inside the virtual display  [0 127] – Array describing the limits of the gauge  [0 20 40 60 80 100 120] – Array describing the numbers at which major ticks shall be shown  [0 20 40 60 80 100 120] – Array describing the numbers at which labels of the major ticks shall be shown | Software | HLR\_SW\_006  HLR\_SW\_015  HLR\_SW\_016 | ILR\_SW\_004  ILR\_SW\_006  ILR\_SW\_009 |
| LLR\_SW\_014 | The code that converts pitch, roll, yaw, internal module temperature, ambient temperature, humidity, and the GPSWaypoints from “uint8” to “int8” shall have the following characteristics:  The code shall not have a return value  Code input arguments:  a(1) – First value of the “uint8” array  b(1) – First value converted from “uint8” to “int8”  a(2) – Second value of the “uint8” array  b(2) – Second value converted from “uint8” to “int8”  …  a(16) – Sixteenth value of the “uint8” array  b(16) – Sixteenth value converted from “uint8” to “int8” | Software | HLR\_SW\_017 | ILR\_SW\_022 |
| LLR\_SW\_015 | The code that ensures the data has been sent in the correct order shall have the following characteristics:  The code shall not have a return value  Code input arguments:  a(17) – Seventeenth value of the “uint8” array | Software | HLR\_SW\_009  HLR\_SW\_010  HLR\_SW\_011  HLR\_SW\_012  HLR\_SW\_015 | ILR\_SW\_023 |
| LLR\_SW\_016 | The code that runs the virtual display in an infinite loop shall have the following characteristics:  The code shall have no return value, and shall have no inputs | Software | HLR\_SW\_003  HLR\_SW\_004  HLR\_SW\_005  HLR\_SW\_006  HLR\_SW\_016 | ILR\_SW\_024 |
| LLR\_SW\_017 | The code that implements a function break to stop the infinite loop shall have the following characteristics  The code shall have no return value, and shall have no inputs | Software | HLR\_SW\_003  HLR\_SW\_004  HLR\_SW\_005  HLR\_SW\_006  HLR\_SW\_016 | ILR\_SW\_025 |
| LLR\_SW\_018 | The code that communicates with the internal module for pitch, roll, yaw, and internal module temperature at the address “0x68” shall have the following characteristics:  The code shall call the wire.write, wire.begin, wire.beginTransmission functions  The code shall have no return value  Input arguments  MPU – Communication to be started with the MPU6050  0x6B - register 6B to be talked  0x00 – a 0 to be placed into the 6B register | Software | HLR\_SW\_009  HLR\_SW\_010 | ILR\_SW\_026 |
| LLR\_SW\_019 | The code that configures the sensitivity of the accelerometer inside the internal module for pitch, roll, yaw, internal module temperature to +2/-2g shall have the following characteristics:  The code shall call the wire.write, wire.begin, wire.beginTransmission functions  The code shall have no return value  Input arguments  MPU – Communication to be started with the MPU6050  0x1C – 1C hex register to be communicated with  0x10 – Register bits to be set as 00010000 | Software | HLR\_SW\_009  HLR\_SW\_010 | ILR\_SW\_027 |
| LLR\_SW\_020 | The code that configures the sensitivity of the gyroscope inside the internal module for pitch, roll, yaw, internal module temperature to +2/-2g shall have the following characteristics:  The code shall call the wire.write, wire.begin, wire.beginTransmission functions  The code shall have no return value  Input arguments:  MPU – Communication to be started with the MPU6050  0x1B – 1B hex register to be communicated with  0x10 – Register bits to be set as 00010000 | Software | HLR\_SW\_009  HLR\_SW\_010 | ILR\_SW\_028 |

Verification

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test case no. | Type  Top level  Inter level  Low level | Description | Test step/Evidence used | Reference/Evidence  (video id)  (wiring diagram) | Requirements fulfilled |
| 001 | Hardware | The system shall have a dedicated display to show pitch, roll, yaw, module temperature, ambient temperature  The system should have a dedicated display to show yaw and humidity | Datasheets, video ID, and website | LCD website:  <https://www.tme.eu/gb/details/lcd1602/development-kits-accessories/kamami/>  LCD Datasheet:  <https://www.waveshare.com/datasheet/LCD_en_PDF/LCD1602.pdf>  Microcontroller datasheet:  <https://www.arduino.cc/en/uploads/Main/arduino-mega2560-schematic.pdf>  video ID 01: <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_HW\_001  LLR\_HW\_002  LLR\_HW\_003  LLR\_SW\_011  LLR\_SW\_012  LLR\_SW\_013 |
| 002 | Hardware | The system shall have an internal module to measure pitch, roll, and module temperature data  The system should have an internal module to measure yaw | Datasheets, video ID,  and website | MPU website:  <https://www.mouser.co.uk/ProductDetail/TDK-InvenSense/MPU-6050?qs=u4fy%2FsgLU9O14B5JgyQFvg%3D%3D>  MPU datasheet:  <https://invensense.tdk.com/wp-content/uploads/2015/02/MPU-6000-Datasheet1.pdf>  Microcontroller datasheet:  <https://www.arduino.cc/en/uploads/Main/arduino-mega2560-schematic.pdf>  video ID 01:  <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_HW\_004  LLR\_HW\_005  LLR\_HW\_006 |
| 003 | Hardware | The system shall have a dedicated external module to measure ambient temperature  The system should have a dedicated external module to measure humidity data | Datasheets, video ID,  and website | DHT11 website:  <https://www.mouser.co.uk/ProductDetail/Adafruit/386?qs=sGAEpiMZZMsKEdP9slC0YTF3OTXxDoOr%2Ffb4DgKu8Lg%3D>  DHT11 datasheet:  <https://akizukidenshi.com/download/ds/aosong/DHT11.pdf>  Microcontroller datasheet:  <https://www.arduino.cc/en/uploads/Main/arduino-mega2560-schematic.pdf>  video ID 01:  <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_HW\_007  LLR\_HW\_008  LLR\_HW\_009 |
| 004 | Hardware | The system shall have dedicated light sources to show warnings related to pitch, roll, hot temperature, and cold temperature | Datasheets, video ID,  and website | LED datasheets:  <https://cdn-shop.adafruit.com/datasheets/WP7113SRD-D.pdf> <https://www.kingbright.com/attachments/file/psearch/000/00/watermark00/L-7113QBC-D(Ver.20B).pdf>  <https://docs.rs-online.com/6372/0900766b8151e407.pdf>  <https://www.kingbrightusa.com/images/catalog/SPEC/WP7113GD.pdf>  Microcontroller datasheet:  <https://www.arduino.cc/en/uploads/Main/arduino-mega2560-schematic.pdf>  video ID 02:  <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_HW\_011  LLR\_HW\_012  LLR\_HW\_013  LLR\_HW\_014  LLR\_HW\_015  LLR\_HW\_016  LLR\_HW\_017  LLR\_HW\_018  LLR\_HW\_019  LLR\_HW\_020  LLR\_HW\_021  LLR\_HW\_022 |
| 005 | Hardware | The system shall have a button to reset the whole system  The system shall have a button to switch display page | Datasheets, video ID,  and website | Button datasheet:  <https://www.arduino.cc/documents/datasheets/Button.pdf>  Microcontroller datasheet:  <https://www.arduino.cc/en/uploads/Main/arduino-mega2560-schematic.pdf>  video ID 03:  <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_HW\_023  LLR\_HW\_024  LLR\_HW\_025  LLR\_HW\_026  LLR\_HW\_027  LLR\_HW\_028 |
| 006 | Software | The system shall have a dedicated virtual display that supports circular gauges  The system shall have a dedicated virtual display that supports linear gauges  The system shall have a dedicated virtual display that supports an artificial horizon gauge | video ID | video ID 04: <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_SW\_001 |
| 007 | Software | The system shall control the virtual display for pitch, roll, yaw, ambient temperature, module temperature, and humidity | video ID | video ID 04: <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_SW\_004 |
| 008 | Software | The system shall control all the dedicated light sources for warnings related to roll, pitch, hot temperature, and cold temperature | video ID | video ID 04: <https://livecoventryac-my.sharepoint.com/:v:/g/personal/ayubh4_uni_coventry_ac_uk/EbksBX1-XgFCsV6D9qp8Bo0Bom_RINDnuDoyDLgwetPbWA?e=gVrfNX> | LLR\_SW\_005  LLR\_SW\_006  LLR\_SW\_007  LLR\_SW\_008 |

Block Diagram



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