DESIGN OF DIGITAL LUX METER BASED ON ARDUINOUSINGEL7900PHOTODIODE SENSOR

ABSTRACT

Aims: Todesignandmanufacturea digitalluxmetertotheilluminationintensity(E)detectiontoolthatis more efficient, relatively cheaper, and can be carried because it has a smaller shape and sizecomparedto tools on the market
Studydesign: Designofluxmeter digitalbasedonArduinounousing anEL7900sensor.
PlaceandDurationofStudy: PhysicsStudyProgram,FacultyofMathematicsand NaturalSciences,Udayana University, fromJune 2024to September2024**.**
Methodology: The method used is to design electronic components so that it can become a digitalluxmeter.ThemainprocessorusesArduino.Themicrocontrollerfunctionsasadataprocessorwhichis the output of the EL 7900 sensor. The HC-SR04 sensor is a distance sensor whose function is tomeasure the distance measured on the design tool. The detection results from the sensor are thenprocessedin themicrocontrollerand displayedon theOLED.
Result: LuxmeterdigitalbasedonArduinounousingEL7900sensorshasbeenproduced.Theresultsoftheresearchshowthatthefurtherthemeasurementdistancefromthelightsource,theilluminationintensity(E)decreases.Thisresearchalsofindsthattheilluminationintensitywillincreaseifthesourcepowerisincreased.Basedoncalibrationtestingbetweenthedesigntoolandthereferencetool,itshowsverygoodresultswithanerrorrateof0.06%.Fieldtestresultsshowedthatthelevelofaccuracyofthe illuminationintensitybetween the design toolandthe referencetoolat a distance of 150 cm from the light source with different light source power reached 99.48 %**Conclusion:**Inthisresearch,digitalluxmetertotheilluminationintensity(E)detectiontool,relativelycheaperandcanbecarriedbecauseithasasmallershapeandsizecomparedtotoolsonthemarket.Basedoncalibrationtesting,itshowsverygoodresultswithanerrorrateof 0.06 %.

Keywords: Light; Distance ;Lux meter;EL 7900 sensor.

1. INTRODUCTION

Light in a room plays an important role in life.Lighting is one of the most important factors inspace design (Abdollahi, 2021). Each designedroom requires different lighting strengths to suitthe needs and functions of the room (Kong &Jakubiec,2021).Theuseofineffectiveandinefficient room lighting can reduce comfort andcausewaste(Belanyetal,2021;Choetal.,2020). Understandinglightingandmeasuringinstruments for measuring lighting strength hasnotreceivedseriousattentioninsociety,especiallyamongthepublic.Technological advances have brought us to anerawheresophisticatedsensorsplayanimportant role in understanding and utilizing thesurroundingenvironment.Oneofthecrucialsensors in many applications is the light sensor,which allows us to measure the lighting strengtharounduswithveryaccurateprecision.The measuring instrument for lighting strength in aroom is a lux meter. The unit of measurement fora lux meter is lux. Lux meters are equipped withlight sensors that are sensitive to changes in theamount of light received. All lux meters consist ofa frame, a sensor with a photocell, and a panellayer. The sensor is placed on the light source tobemeasured(NurHudha,etal.,2021).Basedonthe description above, this study aims to designand manufacture a digital lux meter based on theEL7900lightsensorasthemainfocusofexplorationand innovationinlighting strength.

1.1 SensorPhotodiodeEL7900

The EL7900 photodiode is a light detector thatconverts light intensity into electric current. TheEL7900photodiodeispackagedinanintegratedcircuit(IC)thatcontainsacombinationofaphotodiodeandacurrentamplifier.Thisdetectoriscapable ofdetectinglightintensitywitharange between 1 lux to 8,000 lux and requires apowersupplybetween2.7Vto5.5V.Pinassignmentandspectralresponseofthe EL7900 photodiode The EL7900 photodiode isa light detector that converts light intensity intoelectriccurrent.TheEL7900photodiodeispackagedinanintegratedcircuit(IC)thatcontains a combination of a photodiode and acurrentamplifier.Thisdetectoriscapable ofdetecting light intensity with a range between 1lux to 8,000 lux and requires a power supplybetween 2.7 V to 5.5 V. Pin assignment andspectralresponseoftheEL7900photodiode

1.2 ArduinoUnoR3

ArduinoUnoR3isamicrocontrollerdevelopment board based on the ATmega328Pchip.ArduinoUnoR3has14digitalinput/output

(I / O) pins, where 14 of them can be used asPWM outputs including (pins 0 to 13), 6 analoginput pins, using 16 MHz crystals including pinsA0toA5,USBconnection,powerjack,ICSPheader and reset button. These are all that areneededto support amicrocontrollercircuit.

1.3 OrganicLightEmittingDiode(OLED)

Arduino Uno R3 is a microcontroller developmentboard based on the ATmega328P chip. ArduinoUno R3 has 14 digital input/output (I / O) pins,where 14 of which can be used as PWM outputsincluding(pins0to13),and 6analoginputpins,using16 MHz crystals including pins A0 to A5, USBconnection, power jack, ICSP header and resetbutton. These are all that areneeded to support amicrocontroller circuit.

2. METHODOLOGY

2.1 DesignofSystem

The design diagram for the Arduino-based digitallux meter research using the EL7900 PhotodiodesensorisshowninFigure1.Theblockdia graminFigure1.beginswiththeL7900Photodiodese nsorwhichconvertstheinputsignalintheformof light intensity into an analog signal in the formof voltage. Furthermore, this signal is sent to theATmega328PmicrocontrollerlocatedontheArd uinoUnoR3 board. This data orsignalisprocessedbytheembeddedprogramcode onthemicrocontroller.Theprocesseddataisthendis played on OLED in the form of light intensityexpressedin lux units

2.2 CalibrationMethods

Thecalibrationandtestingprocessofthedesigntoo liscarriedoutbycomparingtheresultsofthelightingi ntensitymeasurementsbetweenthedesigntoolan dthestandardtool.Quantitatively,the level of accuracy or linearity of the designtooliscarriedoutbythelinearregressionpro cess. Light intensity calibration is carried outwithvariationsindistancerangingfrom25cmto 100 cm, with an interval of 25 cm. Distanceinterval measurements are carried out for 10secondseach.Calibrationinthisstudywascarrie d out to determine the level of accuracy ofthedesigntoolwiththeSmartSensorAS803luxm eterasareferenceinunderstandingtheconceptofli ghtmeasurement,knowingthelightingstrengthofa lightsource,andknowing therelationshipbetweendistanceandlightingstreng th. In this study, a flashlight was used as alight source.

3. RESULTSANDDISCUSSION

3.1 Results

Research on the design and manufacture of a luxmeterdigitalbasedonArduinousingan EL7900 photodiodesensorwascarriedoutattheElectronics and Instrumentation Laboratory of thePhysics Study Program, Udayana University areshowninFigure2.Thefunctionofeachcomponen t is as follows: Arduino Uno R3 withATmega328Pmicrocontrolleristhemainproces sor of all components inthe circuit thatfunctions as the center for processing input andoutput signals. The EL7900 sensor is a sensorthat functions to detect light intensity. The batteryfunctions as a power source for the digital luxmeter. OLED 128 x 64 is a display media thatfunctionstodisplaydatareadingresults.Theapp earance of the designed digital lux meter isshowninFigure3.Figure3.istheinitialdisplayofadi gitalluxmeterbasedonLightusingtheEL7900photo diodesensor. Onthe OLED thewordsluxmeterdigitalaredisplayed.Asformakin g the writing on the initial display, it is madein the Arduino IDE with the following programcode. Figure 4 shows the results of reading thelightintensitymeasurementdatadisplayedonthe OLEDwithalightintensityvalueof15.83Lux.Theprog ramcodetodisplaytheresultsofreadingthemeasure mentdatais asfollows

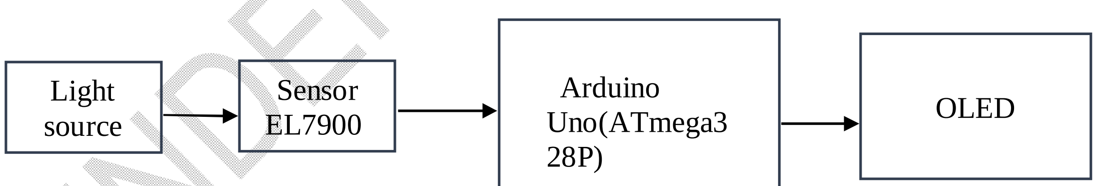

Figure1.Blockdiagram ofmeasuring instrumentdesign

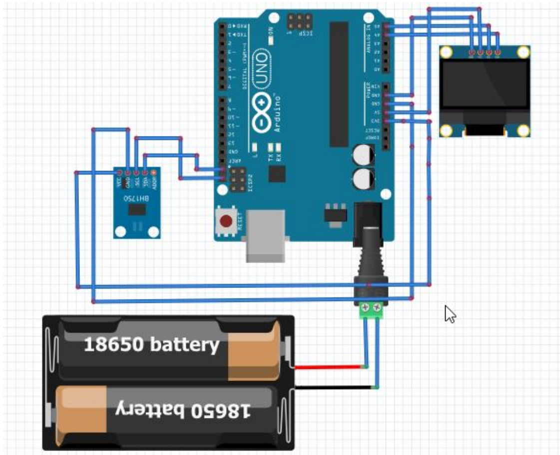

Fig.2.Resultofdesigntool

Fig3.ResultsofReadingMeasurementDataforDesignTools

3.2 Discussion

3.2.1 DesignToolCalibration

The calibration and testing process of the designtool was carried out by comparing the results ofthe lighting strength measurements between thedesigntoolandthestandardtool.Calibrationwas carriedoutwithvariationsindistancerangingfrom25 cm to 100 cm, with an interval of 25 cm. Thedistanceintervalmeasurementwascarriedoutf or10 seconds each. Calibration in this study wascarried out to determine the level of accuracy ofthe design tool with the Smart Sensor AS803 luxmeter as a reference. In this study, a flashlightwas used as a light source. The measurementresults are shown inTable1.

Table 1showsthevalueoftheilluminationintensity (E)at25cmofthereference tool is 348 lux and the design tool is336lux.Thevalueoftheilluminationintensity (E) at a distance of 50 cm of the reference toolis 247 lux and the design tool is 232 lux. whilethe illumination intensity at a distance of 75 cmof the reference tool is 173 lux and the designtool is 165 lux and the illumination intensity at adistance of 100 cm of the reference tool is 107luxandthedesigntoolis97lux.Fromthisstudy,the furtherthedistanceofthelight source from the measuring instrument, thesmallertheilluminationintensityvalueobtained .Thisisbytheformulaofillumination intensity is inversely proportional todistance,meaningthatifthedistanceisgreater,the value of the illumination intensity of the lightwillbesmaller.Likewise,viceversa,ifthedistance is smaller, the value of the illuminationintensityofthelightwillbegreater.Intheory,theillumination intensity (E) in a plane because thelight source with an intensity I, decreases with thesquare of the distance between the light sourceand the plane, mathematically it can be writtenwith the equation :

$$E=I/r^2 \quad (3\text{-}1)$$

Where E is the illuminance (lux), I is the luminousintensity(candela=cd)/(lumens=lm)andri sthedistance of the plane from the light source (m). Intheory, candela is a measure of light intensity in acertaindirectionorangle,forexample,lightfromaflashlight,oralaserwhosemeasurementisfocused in a certain direction, while lumens arethe total light produced by a light source withouttaking into account the direction and angle of thelight source, for example measuring TL lamps,LEDs.

To determine the level of accuracy of the designtoolwiththereferencetoolisshowninaregressiongraphasinFigure4,showingthelevelofaccuracybetweenthedesigntoolandthereference tool is very good with a coefficient ofdeterminationR^2=0.9994,meaningthatthelevelof conformityatthetimeofmeasurementreaches99.94%.Figure5.isacorrelationgraphofmeasurements between the reference tool andthe design tool. Figure 5. shows a decrease inlightingintensity(E)hasthesamepatternbetween the design tool and the reference toolalongwiththeincreaseinthemeasurementdistancefromthelightsource.Therearedifferences in measurement results between thedesigntoolandthereferencetool.Severalfactors causedifferencesinmeasurementreadingsincludingtooldistance,time, and observation eye. This was also obtainedbyDolera-Morenoetal.,(2020)statingthatobservationtimeaffectsthemagnitudeofthelightintensity, the longer the measurement, themore fluctuating value, meaning that the detectedlightbecomesunstable(Ibañezetal.,2017).

3.2.2 ImplementationofDesignTools

The application of the design tool is carried outusing TL lamps with varying lamp power. Theresultsofthestudyshowthatthelightingintensity (E) with varying lamp power at a distance of 150cmfromthelightsourceas inTable2.

Table 1. Thelightingintensityvalueofthestandardreferencetoolwith thedesigntool

No	Distance(cm)	Illuminationstrength(E) reference device (lux)	Illuminationstrength(E) designtool(lux)
1	25	348	336
2	50	247	232
3	75	173	165
4	100	107	97

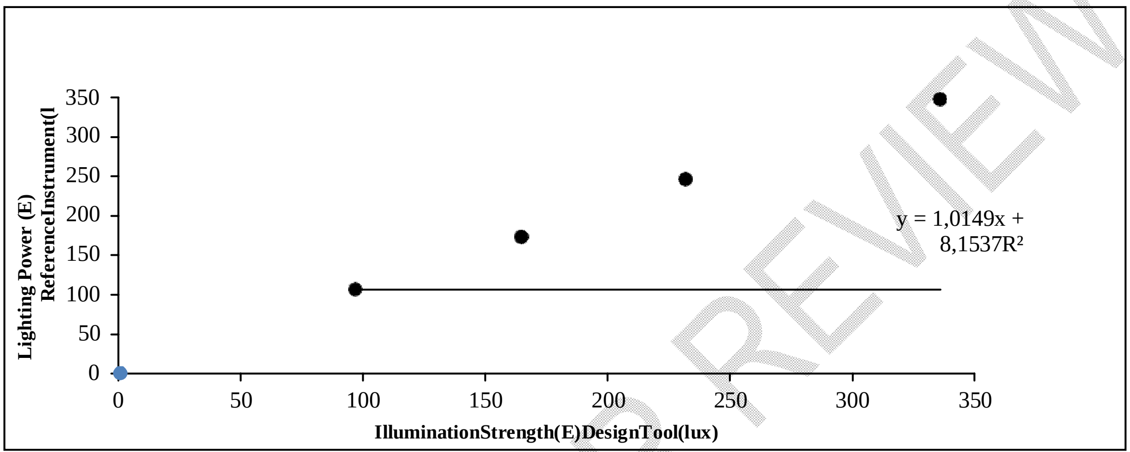

Fig 4. Regression graph between the illumination strength (E) of the design tool and the reference toolata distanceof25,50, 75,and100 cm fromthe light source

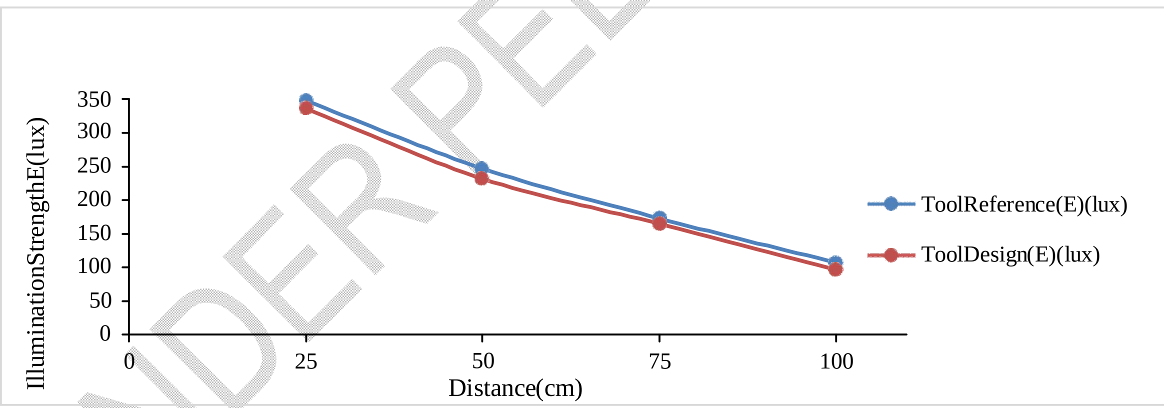

Fig 5. Calibration graph of lighting strength (E) between the design tool and the reference tool at adistanceof 25, 50,75, and 100 cm

Table2. Resultsofmeasurementsoflightingstrength(E)atadistanceof150cmfromthelightsource,variationsin light source power

No	Lightsourcepower (watts)	Illuminationstrength(E) reference device (lux)	Illuminationstrength(E) designtool(lux)
1	9	97	87
2	12	133	121
3	15	172	160
4	18	214	190

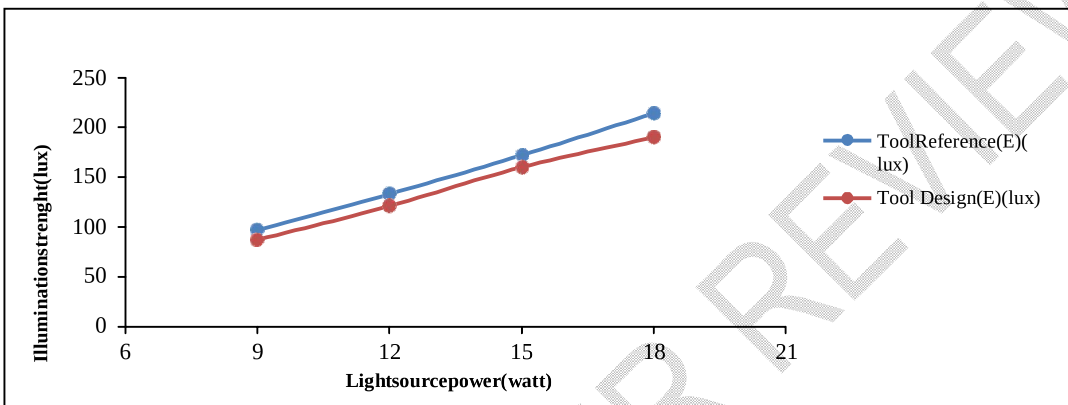

Fig 6. Regression graph of the lighting strength of the design tool and the reference tool at a distance of150cmfrom the lightsource usingthe variation functionof thelight sourcepower.

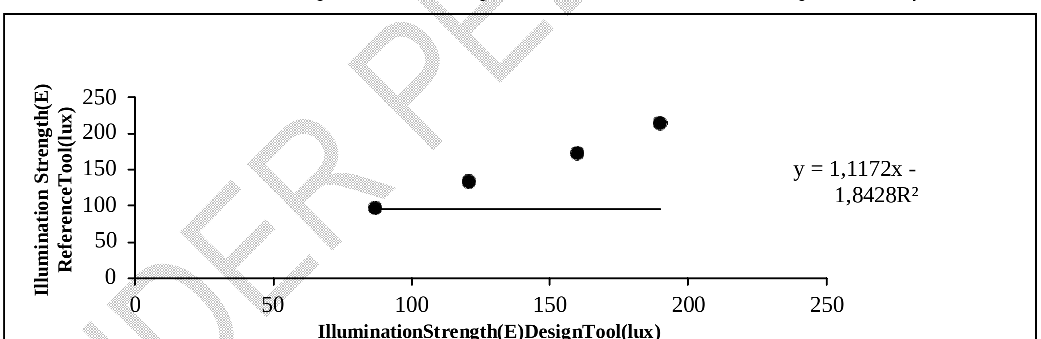

Fig 7. Regression graph of the lighting strength of the design tool with the reference tool at a distance of150cm fromthelight source,thefunction ofthe variationof thepowerofthelight source

showsthatthesmallerthelamppowerused,thesmallerthelightingintensityvalueobtained.Thisis in accordance with the formula for lightingintensityisdirectlyproportionaltodistance, meaningthatifthelightsourcepowerisgreater,thelightintensityvaluewillbegreater.Likewise,vice versa, if the light source power is smaller,thelightintensityvaluewillbesmaller.Todetermine the level of accuracy of the designtool using regression as in Figure 6, shows thatwhen measuring the same distance from thelightsource(150cm),thelightingintensity increases (increases) along with the increase inlamp power (light source), conversely the lightingintensity will decrease along with the decrease inthe light source power, this is in accordance withtheresultsofresearchbyIngrametal.(2019)thatlighting intensity depends on the source powerand distance from the light source. To determinethelevel of accuracyof the designtoolusingregressionasinFigure7,itshowsthatthelevelofaccuracyofthedesigntoolwiththereferencetoolis 99.48%. which is indicated by the coefficient ofdetermination R^2=0.9948

4. CONCLUSION

Theconclusionsobtainedare:

1. The design and manufacture digitallux meterbased on Arduino Uno using an EL 7900 sensorhas beenproduced.
2. Design digitallux meter has been producedrelatively cheaply and can be carried becauseit has a smaller shape and size compared totools on themarket.
3. Thelevelofaccuracyoftheilluminationintensitybetweenthedesigntoolandthereference tool at a distance of 150 cm from thelightsourcereached 99.48%

REFERENCES

1. Abdollahi,R.(2021).Designoflightingsystemforsacredplaceswiththeapproachofimprovingtechnicalandeconomicconditions.AinShamsEngeneeringJournal, 12(3), 2899-2905. https://doi.org/10.1016/j.asej.2021.02.021.
2. Bahrin. 2017.LightingControlSystemUsingArduino UnoAtIchsanUniversityGorontalo.ILKOMScientificJournal.9:283-284.
3. Belany,P.,Hrabovsky,P.,&Kolkova,Z.(2021).Combinationoflightingretrofitandlifecyclecostanalysisfor energyefficiencyimprovementinbuildings.EnergyReports,7,2470-2483https://doi.org/10.1016/j.egyr.2021.04.044.
4. Cho,Y.,Seo,J.,Lee,H.,Choi,S.,Choi,A.,Sung,M.,&Hur,Y.(2020).Platformdesignforlifelog-basedsmartlightingcontrol.BuildingandEnvironment,185. https://doi.org/10.1016/j.buildenv.2020.107267.
5. Dólera-Moreno,C.,Palazón-Bru,A.,Colomina-Climent, F., & Gil-Guillén, V. F.(2020). Construction and internal validationof a new mortality risk score for patientsadmittedtotheintensivecareunit.InternationalJournalofClinicalPractice,70(1.
6. Efrianto, Ridwan., I. Fahruzi. 2016. MotorSecurity System Using Smartcard BatamStatePolytechnic.IntegrationJournal. 8(1):2.
7. Fuada, S. 2017. Design of Control SystemonDigitalIC-BasedCrackerDryerPrototypeUsingProteus 7.0Software.ControlSystem-ElectricPower-Telecommunication-Computer.6(1):89.
8. Ibañez,C.A.,Zafra,J.C.G.,&Sacht,H.M.(2017).NaturalandArtificialLightingAnalysisinaClassroomofTechnicalDrawing: Measurements and HDR ImagesUse. Procedia Engineering, 196, 964–971.https://doi.org/10.1016/j.proeng.2017.08.037.
9. Ingram, G. L., Zhao, Y. B., & Lu, Z. H.(2019).Excitontriggeredluminancedegradationoforganiclightemittingdiodes.Organic Electronics,69,160–163.https://doi.org/10.1016/j.orgel.2019.03.023
10. Kong, Z., & Jakubiec, J. A. (2021).Instantaneouslightingqualitywithinhighereducational classrooms in Singapore.FrontiersofArchitecturalResearch, 10(4),787–802.https://doi.org/10.1016/j.foar.2021.05.001.
11. Mutmainnah, I. Rofii., Misto & D.U. Azmi.2020. Electrical and Optical Characteristicsof LEDs and Lasers. Journal of Theory andApplicationsof Physics.08(02):203-204.
12. Sari,K., C. Suhery& Y. Arman. 2015.Implementation of Fish Feed System UsingBuzzer and Microcontroller Based InterfaceApplication.UntanComputerSystemCoding Journal 03:112.
13. Suryani, E., Rully, A.H. &Ulfa, E.R. 2021.ImplementationofDynamicSystemSimulation Models in the Corn Industry. CVBudiUtama. Yogyakarta.
14. Suryantoro,H.&A.Budiyanto.2019.Labview &ArduinoBasedWaterLevelMonitoringSystemPrototypeasaSupportingMeansforControl SystemInstrumentation.JournalOfLaboratory.1(3):22-23.
15. Winata,A.S.2019.ArduinoUnoandAndroidBasedDigitalLockEncryptedCombination of Vigenere Cipher and XorCipherAlgorithms.UndergraduateStudy Program in Computer Science, Faculty ofComputerScienceandInformationTechnology, University of North Sumatra.Medan.