جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

Spring 2019-20

Senior Design Project Report

Automation and Control for Solar Car

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering

Team Members

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Project Advisor:

Advisor Name: Dr. Nassim Khaled

Abstract

In these days, the world is shifting toward renewable energy in order to reduce the pollutions for the hydrocarbons. These renewable energies can be by using solar power, wind power, hydro power and nuclear power. In this project, Mechanical Engineering Department in PMU is working on designing and building a fully functional solar car by distributing the work on multiple groups. Our group was assigned to design a control system for this car. The solar power can be used directly from the panels or it can be stored on rechargeable batteries so you can use it whenever you need it. But, the problem of solar energy is that it is available only when the sun is up while in the dark it will be useless. So, our purpose in this paper, is to show an intelligent design that can let the controller shift between two sources of power the solar panels and the battery. By the help of the irradiance sensor we can know if the solar power we are getting is enough or not to power the solar car otherwise the controller will shift to the battery to power the car.

In this project, our aim is to design and develop a fully functional control system that control how much power the parts of the solar car should get using the Controllino and a set of sensors. In addition, we want to develop a cruise control system to maintain a steady speed to reduce the usage of power.

Acknowledgments

First of all, we would like to thank our advisor Dr. Nassim Khaled for his support and help throughout the project which was really helpful for us to finish this project. Second, we want to thank Dr. Mohamed Elmehdi Saleh, course coordinator for his help and guidance throughout the project. Third, we would like to thank Dr. Faramarz Djavanroodi, chair of the Mechanical Engineering Department at PMU, for giving us the chance to work as a group to build up the same Solar Car project and for his encouragement. Forth, we would like to thank Mr. Stephen John who helped us a lot on starting the project and his caring about our progress throughout the project. Finally, we want to thank our parents for their support financially and morally.

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Chapter 1: Introduction

The United States are facing two problems. They are running out of fuel and the exhaust from vehicles is making the ozone layer diminish. The American citizens are going to have to find a way to preserve fuel and at the same time, save the ozone layer. We must find a way to improve society and solve these problems. The one solution that will conserve fuel, save the ozone layer, and also, save money is the solar powered car. First, the solar powered car will greatly increase the United States' fuel stockpile. The solar powered car doesn't use gasoline or oil. It uses sunlight to power it so this saves the fuel. Because of the solar powered car, the United States can conserve millions of barrels of fuel each day. Second, the use of the solar power car will help to save the ozone layer. Because the solar powered car doesn't use any gasoline or oil, it doesn't emit any harmful toxins into the atmosphere. This car only uses the fuel of Mother Nature, which is sunlight. Mother Nature cannot harm itself. Therefore, the solar car will reduce the rate at which the ozone layer decreases. Third, using the solar powered car will save money. These cars save money because they do not use gasoline and oil. This will save the money that one would normally use for the frequent oil changes. In the long run this car could save someone millions of dollars. by owning a solar powered car, one wound be conserving the greatly needed fuel, reducing the loss of the constant decreasing ozone layer, and also, saving millions of dollars. This car is the answer to all problems. The solar powered car is the best car on the road. This is the best invention since electricity. If everyone in America owned a solar powered car, America would be a better place.

1.1 Project Definition

The main project was building a fully functional solar car. The car needed many thing functions such as control system (our area), motor, body, …etc. So, we were distributed into groups to work on every section and finally build the car.

In this project, our team was selected to design and test a Control System for the solar car which also called Automation and Control for Solar Car. This system will allow us to control the speed of the car, how much power we supply to the motor, cruise control and monitor the temperature and the voltage of the solar panels.

1.2 Project Objective

1- Designing and testing of a Solar Car Control System.
2- Studying a different type of controllers and deciding which is the best one.
3- Testing, coding and choosing different types of sensor.
4- To come up with wiring diagram for the control system of the solar car and actually implement the wires in the solar car.

1.3 Applications

- Controlling any type of cars (solar, electric and gas).
- Controlling the Solar car with sensors.
- Coding the sensors needed to ensure the solar car function properly.
- Wiring the sensors and control panel in the solar car.

Chapter 2: Literature Review

2.1 Project Background

Just as the sea level rises so does the price of gas. With such a high demand for these rich resources, we forget what the greatest source of energy is. The sun's energy can be a very effective source of fuel for future vehicles. Solar powered vehicles are more effective and more environmentally friendly compared to electric powered vehicles. While electric is very valuable, we have to burn through resources to find it. As consumers move towards electric powered vehicles, the movement towards solar powered vehicles has slowed. However, this is not a sustainable trend. Solar powered vehicles would be much more sustainable in the long term due to their renewable energy source.

Control system are very important for cars in general (solar, electric and gas) and without it we cannot control the cars in safe ways. For example, in these days, car manufacturers are providing their cars with radar cruise controls as a helper for the drivers to keep them safe by keep the distance between the car and the vehicle in front safe for braking if the front vehicle brakes suddenly by controlling the brakes. In addition, this level of safety cannot be reached without the control system built in these cars.

2.2 Previous Work

For the purpose of this essay solar energy will be defined as a source of fuel used by solar powered vehicles. Also, solar panels will be referred to as hardware that is used to obtain energy from the sun. Deteriorate or deterioration will be referred to the wear and tear of materials over a period of time. Consumer will be referred to a common person that operates a vehicle.

To complete this project, we had to look throughout the previous projects and researches. These projects or researches can be paper researches or video researches. In our case, we used (youtube.com) as our main resource because what we mainly do in our project is coding the sensors using Arduino such as temperature sensor lm35 and coding of the lcd screen i2c. We started looking for temperature sensor coding and we found many tutorials on Arduino coding of the sensors. As an example, we found (SDev Electronics channel) in (youtube.com) and he started showing the components and the wiring. Then, he shows how to wire the sensor to the board and how to connect it to the Arduino software. Finally, he wrote the coding on the Arduino and he uploaded it to the sensor. He ended by trying the sensor and it works.

For the LCD screen i2c we also searched in (youtube.com) and we found (Robojax channel). He shows how to connect the screen to the board and the Arduino software and then he codes it. Finally, he shows the information he wants on it and we used the screen to view the temperature using the lm35.

Chapter 3: System Design

As we are working on the control system of the solar car we set some specifications and standards to get to our goal. These specifications are as follow:

1- The power that the control system need should not exceed a certain limit but unfortunately, we could not get this information from the other groups so we can use the power that we get from the solar panel and the batteries efficiently.
2- The space that we need must fit our components and the wirings must be provided by the body and the chase groups which we did not get yet.
3- The power that reach to the motor must satisfy the motor needs the power of the motor was not provided to us.
4- The components must be able to work under Saudi Arabia's tough weather conditions (Hot weather and High humidity) in the Summer season.

The standards we followed were engineering standards which can make sure to get the best result of the components and the system. These standards are mentioned in the engineering design standards section below.

In our project we considered many alternatives with our components and how we assemble it. For the components we had a variety of choices e.g. when we decided to buy the Temperature sensors we had many choices such as thermocouples, resistor temperature detectors, thermistors, infrared sensors, semiconductors, thermometers and we went with the semiconductors according to the researches and advices we had.

To start our design, we had to ask our adviser Dr. Nassim Khaled to help us on how the design must be done, how we can start and who could help us to complete our design. Then, Dr. Nassim Khaled showed us roughly on a scratch paper which parts to buy and how to assemble it. In addition, he told us we have to visit an electrical professor to give an approval to work with our design and what we can do to improve it. Also, Dr. Nassim advise us to work with Mr. Stephen John. So, we started buying the components we need and we did visit Mr. Stephen John who helped us by teaching us how to start coding the components using Arduino. Finally, we used what we learn to code the components we bought and we did it.

3.1 Design Constraints and Design Methodology

3.1.1 Geometrical Constraints

At the beginning of our design we needed some information about how much power we are getting to the car from the solar panel and we could not get it yet from the other groups yet. In addition, we needed to know how much space we have to put our control system and we could not know it. Also, the availability of the parts was one of the constraints we had where we could not find e.g. the irradiance sensor. Programming the sensors, we had was also one of the constraints because we are using a new controller that we could not find enough information about.

3.1.2 Sustainability

We faced some problems with sustainability due to the lack of information that we get from other groups and due to COVID-19 disease which let our meetings online which is not that efficient. But we tried our best to finish our project on time.

3.1.3 Environmental

The nature of our job does not have any harm against the environment so we really did not find any environmental constraints.

3.1.4 Social

Socially, we had some difficulties reaching to the groups we need information from so to accommodate this problem Dr. Elmehdi gather us in a WhatsApp group so we can reach to each other easily.

3.1.5 Economic

Economically, there were some difficulties with the prices of some of the parts such as the Controllino which was like 1600 SAR but we manage our budget to buy it and the other parts.

3.1.6 Safety

In safety manner we are working with electricity which put us in danger with fires and shocks. But, fortunately our system does not need that much of electricity.

3.1.7 Ethical

This project had similar previous project which let us with a problem that we cannot copy others work because it is unethical to do that. So, we tried to get with a new design by developing others work.

3.1.8 Design Methodology

To start our design, we thought about our main objective which was getting the car to run which require us to connect the power sources (the solar panel and the batteries) to the electric motor. To reach our goal, we had to ask the team responsible for the motor to give us the exact power they need to run their motor. In addition, we asked the teams responsible for the batteries and the solar panel how much power they are going to supply us to know the right components we need in order to complete our project. In addition, we have a problem getting the information from the other teams because they have not decided yet how many solar panels and batteries they want and what power they need for the motor. So, we decided to build a demo that will work as the actual control system but in a smaller scale.

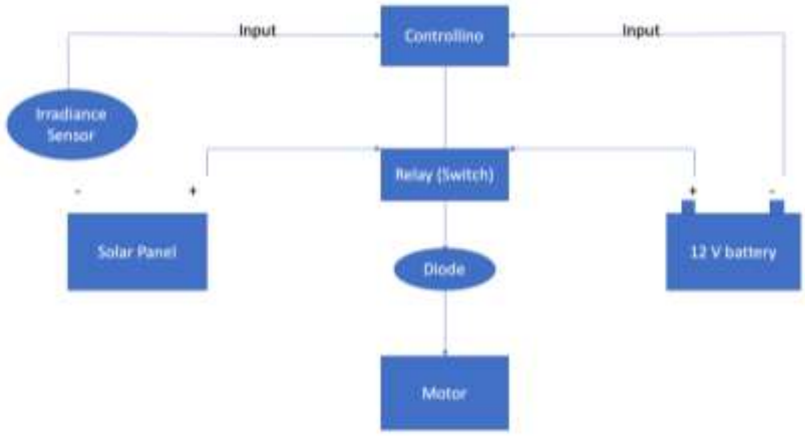


Figure #1: The primary design of the control system

We started by coding the components by using Arduino mega and Arduino software. We did code all the components we had using Arduino and we tested it many times and it works perfectly. Then we started with a new control system called Controllino and applied all the codes with slight difference in the analog and tested it and it worked perfectly.

The following figures shows our work on the Arduino Mega and Controllino Mega.

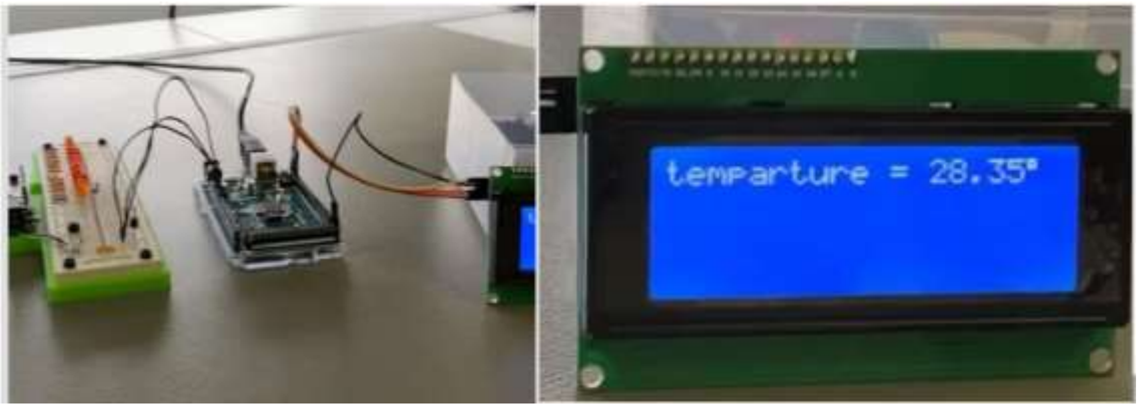


Figure #2: LM35 sensor using Arduino

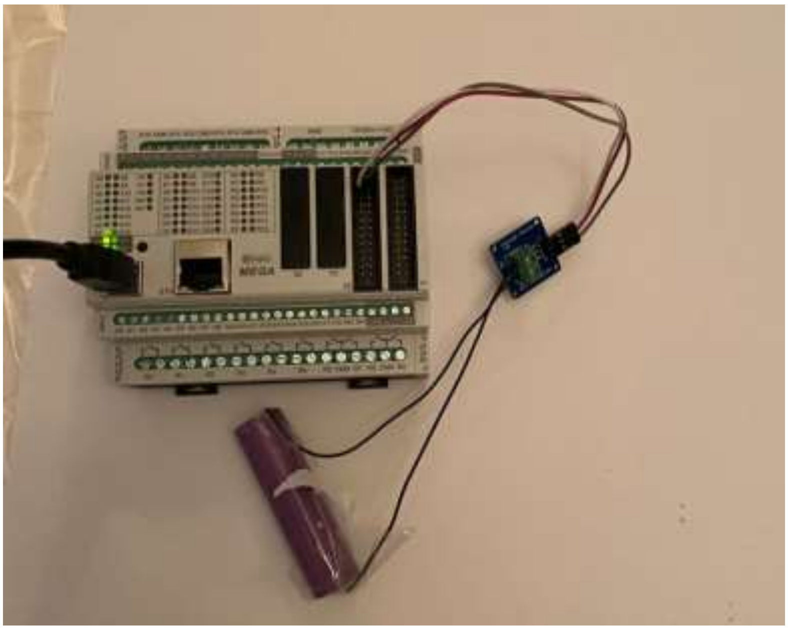


Figure #3: Voltage sensor using Contrallino

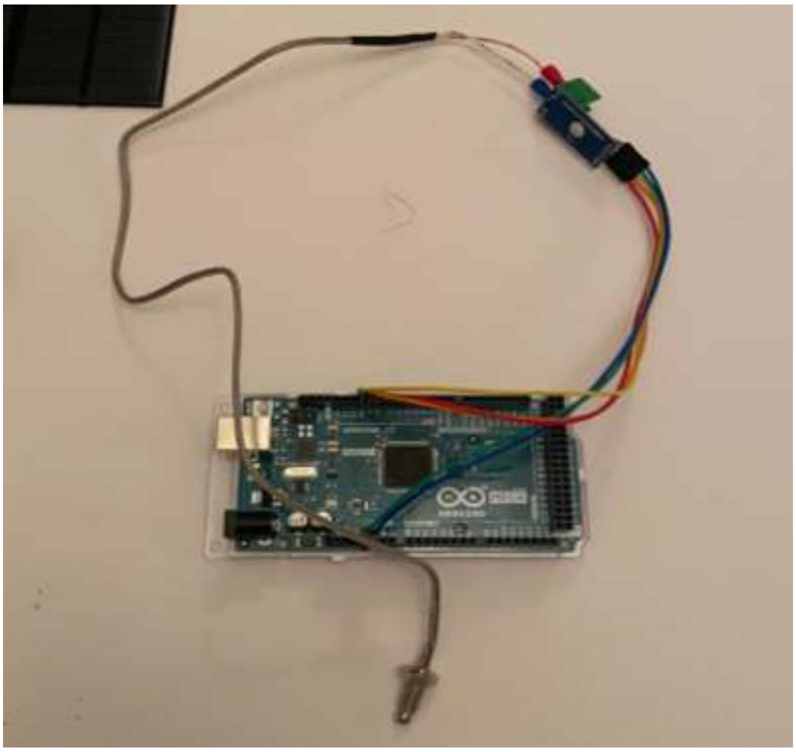


Figure #4: Thermocouple using Arduino

3.2 Engineering Design standards

Table #1: Engineering Standards	
Item	**Specifications or standards**
Controllino Mega	EN61010-1 EN61010-2-201 EN61131-2
Current Sensor	CAN/CSA-C22.2 No. 60950-1-03 UL 60950-1:2003 EN 60950-1:2001
The Others	Available in the datasheets in the Appendix

These standards are about the safety requirements and the requirement for the programmable controllers and they are all available in the datasheets.

3.4 Product Subsystems and selection of Components

In our project we considered many alternatives with our components and how we assemble it. For the components we had a variety of choices e.g. when we decided to buy the Temperature sensors we had many choices such as thermocouples, resistor temperature detectors, thermistors, infrared sensors, semiconductors, thermometers and we went with the semiconductors according to the researches and advices we had. And the other alternatives as follows in the table:

Table #2: The Alternatives of the Components

Item	**Alternatives**	**Choice**	**Reason**
Controller (Controllino)	- Controllino Mini. - Controllino Maxi. - Controllino Mega.	Controllino Mega.	Is that it can work with the demo and the actual project.
Temperature Sensor	- Thermocouples - Resistor temperature detectors - Thermistors - Infrared sensors - Semiconductors - Thermometers	Semiconductor (lm35 temperature sensor)	The researches from previous projects and the advices we get from our advisor.
Voltage Sensor	- Capacitive voltage sensor. - Resistive voltage sensor	Resistive voltage sensor.	Previous researches and advices.
Current Sensor	- Direct - Indirect	Indirect	We need to be able to control it and switch its place whenever we need.
Irradiance Sensor	-	BH1750	Previous projects and advices.
LCD Screen	-	6- 4x20 LCD screen	Advise from a friend.

Chapter 4: Conclusions and Future Recommendations

7.1 Conclusions

In conclusion, renewable energy is considered nowadays to decrease the pollutions that occur due to hydrocarbons. The renewable energies can be using hydro power, solar power, nuclear power and wind power. In addition, we worked on designing and building a fully functional solar car by dividing the work to several groups of students. Our group was focused on design a control system for this specific car. We got help from Dr. Nassim Khaled our advisor and many channels in YouTube to lead us to work on Controllino and Arduino. Furthermore, as a group we faced a significant challenge due to COVID-19 disease which let our meetings online which is not that efficient. Even though, we tried our best to finish our project on time. Also, due to this issue we faced a challenge to get our materials that we need for this project. Finally, we have learned several things by working in this project to improve some skills such as teamwork, communication and coding.

7.2 Future Recommendations

At the end of this project we had some recommendations to improve the design and the system. First, we would recommend to gather more information about the project from the other groups which will help to improve the design and the system. Second, we recommend that in order to program the system perfectly without any problems you need to learn more about coding using the Arduino software. This will help to improve both the system and design. Third, we recommend to start working on the second goal which was to design and build a cruise control system to help us control the solar car better. For future work we need to connect all the sensors together to get the fully functional control system. To do that we need to follow the design that we created to our control system.

References

1- SDev Electronics YouTube Chanel, Published 2018, https://youtu.be/9czGfmporjs (Chapter 3, Design Methodology).

2- Robojax YouTube Chanel, Published 2018, https://youtu.be/q9YC_GVHy5A (Chapter 3, Design Methodology).

3- https://www.iecee.org/dyn/www/f?p=106:49:0::::FSP_STD_ID:4279 (Chapter 3, Design Methodology).

4- https://webstore.ansi.org/Standards/CSA/CSAC22609502007R2016?gclid=EAIaIQobChMIsKWCw7fe6AIVUUHTCh20MQGtEAAYASAAEgLxSPD_BwE (Chapter 3, Design Methodology).

5- Arduino Company, downloading and Learning the Arduino Software to code the sensors https://www.arduino.cc/.

Appendix A: Progress Reports

	SDP – WEEKLY MEETING REPORT
	Department of Mechanical Engineering **Prince Mohammad bin Fahd University**

SEMESTER:	**SPRING**	**ACADEMIC YEAR:**	**2019-2020**
PROJECT TITLE	**Automation and Control for Solar Car**		
SUPERVISORS	**Dr. Nassim Khaled**		

Month 2: March

#	ID Number	Member Name
1	201500745	Abdulrahman Al-Maidani
2	201701925	Rashed Al-Balawi
3	201500970	Noor Al-Mutairi
4	201602288	Faisal Al-Shathri
5	201501203	Haythm Al-Thubaiti

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Planning and System Designing	All	100	
2	Buying Required Parts	All	100	
3	Programming the Sensors Using Arduino	All	100	
4	Wiring and Hardware Testing on Arduino	All	100	
5	Reports	All	100	

List the tasks planned for the month of April and the team member/s assigned to conduct these tasks

#	Task description	Team member/s Assigned
1	Applying the Codes from Arduino to Controllino	All
2	Wiring and Hardware Testing on Controllino	All
3	Final Prototype	All
4	Final Report	All
5	Presenting the Project	All

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

<table>
<tr><td colspan="5"><u>Outcome MEEN4:</u>
an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts</td></tr>
<tr><td>Criteria</td><td>None (1)</td><td>Low (2)</td><td>Moderate (3)</td><td>High (4)</td></tr>
<tr><td>MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context</td><td>Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts</td><td>Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts</td><td>Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts</td><td>Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts</td></tr>
<tr><td colspan="5"><u>Outcome MEEN5:</u>
an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives</td></tr>
<tr><td>Criteria</td><td>None (1)</td><td>Low (2)</td><td>Moderate (3)</td><td>High (4)</td></tr>
<tr><td>MEEN5A: Ability to develop team work plans and allocate resources and tasks</td><td>Fails to develop team work plans and allocate resources and tasks</td><td>Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks</td><td>Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks</td><td>Properly and efficently makes team work plans and allocate resources and tasks</td></tr>
<tr><td>MEEN5B: Ability to participate and function effectively in team work projects to meet objectives</td><td>Fails to participate and function effectively in team work projects to meet objectives</td><td>Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives</td><td>Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives</td><td>Function effectively in team work projects to meet objectives</td></tr>
<tr><td>MEEN5C: Ability to communicate effectively with team members</td><td>Fails to communicate effectively with team members</td><td>Shows limited and less than adequate ability to communicate effectively with team members</td><td>Demonstrates satisfactory ability to communicate effectively with team members</td><td>Communicates properly and effectively with team members</td></tr>
</table>

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	Abdulrahman Al-Maidani	3	4	3	4
2	Rashed Al-Balawi	4	4	4	4
3	Noor Al-Mutairi	3	4	3	4
4	Faisal Al-Shathri	3	4	3	4
5	Haythm Al-Thubaiti	3	4	3	4

Comments on individual members

Name	Comments
Abdulrahman	Good involvement
Rashed	Great programming skills
Noor	Good involvement
Faisal	Good involvement
Haythm	Good involvement

Appendix B: Engineering standards (Local and International)

The engineering standards that the parts follow is:

Internationally:

1) International Standards.
2) American National Standards Institute (ANSI).
3) International Standards Organizations (ISO).

Locally:

1) Saudi Standards Metrology and Quality Organization (SASO).

Appendix C: Bill of Materials

Table #3: Bill of Materials		
Item	**Quantity**	**Price**
Controllino Mega	1	1400 SAR
Arduino Mega 2560	1	200 SAR
Thermocouple max6675	1	35 SAR
LCD 4X20 with module	1	110 SAR
Current Sensor 712	1	35 SAR
Voltage Sensor	1	25 SAR
Temperature Sensor LM 35	2	30 SAR
Others	-	300 SAR
Total		2135 SAR

Appendix D: Datasheets

DATASHEET

CONTROLLINO MEGA

Controllino is an Arduino standard and Arduino software compatible PLC.

Ordering information: Controllino Maxi, Art.Nr: 100-200-00

General:

Standard	EN61010-1 EN61010-2-201 EN61131-2
Dimensions (W × H × D)	107x90x62mm
Weight	350g
Mounting	Top hat rail EN50022, 35mm

Environmental conditions, Indoor use only:

Operating ambient temperature	0°C – 55°C
Relative humidity – non-condensing	80 % for temp. up to 31 °C, decreasing linearly to 50 % relative humidity at 55 °C
Pollution Degree	PD2
Altitude	up to 2000m AMSL
Vibration ($5 \le f \le 9$ Hz) Vibration ($9 \le f \le 150$ Hz)	1,75 mm amplitude sinus 3,5 mm amplitude random 0,5 g acceleration sinus 1,0 g acceleration random
Transport and Storage	-20°C – +70°C 10 to 90% no condensation Altitude 3000m AMSL
Shock response	15g, 11ms half sinus all 3 axes

V1.0 – 19.04.2016

LM35 Precision Centigrade Temperature Sensors

1 Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates From 4 V to 30 V
- Less Than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

2 Applications

- Power Supplies
- Battery Management
- HVAC
- Appliances

3 Description

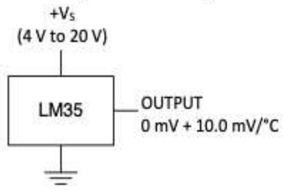
The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

Device Information(1)

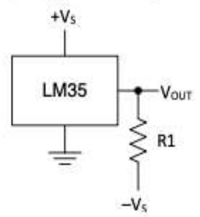
PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM35	TO-CAN (3)	4.699 mm × 4.699 mm
	TO-92 (3)	4.30 mm × 4.30 mm
	SOIC (8)	4.90 mm × 3.91 mm
	TO-220 (3)	14.986 mm × 10.16 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Basic Centigrade Temperature Sensor (2°C to 150°C)



Full-Range Centigrade Temperature Sensor



Choose $R_1 = -V_S / 50\ \mu A$
V_{OUT} = 1500 mV at 150°C
V_{OUT} = 250 mV at 25°C
V_{OUT} = –550 mV at –55°C

ACS712

Fully Integrated, Hall Effect-Based Linear Current Sensor IC with 2.1 kVRMS Isolation and a Low-Resistance Current Conductor

Features and Benefits

- Low-noise analog signal path
- Device bandwidth is set via the new FILTER pin
- 5 µs output rise time in response to step input current
- 80 kHz bandwidth
- Total output error 1.5% at T_A= 25°C
- Small footprint, low-profile SOIC8 package
- 1.2 mΩ internal conductor resistance
- 2.1 kVRMS minimum isolation voltage from pins 1-4 to pins 5-8
- 5.0 V, single supply operation
- 66 to 185 mV/A output sensitivity
- Output voltage proportional to AC or DC currents
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Nearly zero magnetic hysteresis
- Ratiometric output from supply voltage

TÜV America
Certificate Number:
U8V 06 05 54214 010

Package: 8 Lead SOIC (suffix LC)

Approximate Scale 1:1

Description

The Allegro® ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switch-mode power supplies, and overcurrent fault protection. The device is not intended for automotive applications.

The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging.

The output of the device has a positive slope (>$V_{IOUT(Q)}$) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sampling. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of

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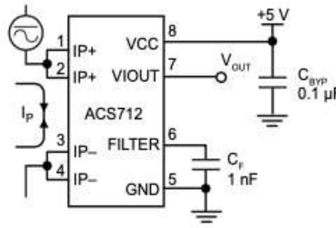
Typical Application



Application 1. The ACS712 outputs an analog signal, V_{OUT}. that varies linearly with the uni- or bi-directional AC or DC primary sampled current, I_P, within the range specified. C_F is recommended for noise management, with values that depend on the application.

Description (continued)

the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the signal leads (pins 5 through 8). This allows the ACS712 to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

The ACS712 is provided in a small, surface mount SOIC8 package. The leadframe is plated with 100% matte tin, which is compatible with standard lead (Pb) free printed circuit board assembly processes. Internally, the device is Pb-free, except for flip-chip high-temperature Pb-based solder balls, currently exempt from RoHS. The device is fully calibrated prior to shipment from the factory.

Selection Guide

Part Number	Packing*	T_A (°C)	Optimized Range, I_P (A)	Sensitivity, Sens (Typ) (mV/A)
ACS712ELCTR-05B-T	Tape and reel, 3000 pieces/reel	–40 to 85	±5	185
ACS712ELCTR-20A-T	Tape and reel, 3000 pieces/reel	–40 to 85	±20	100
ACS712ELCTR-30A-T	Tape and reel, 3000 pieces/reel	–40 to 85	±30	66

*Contact Allegro for additional packing options.

Absolute Maximum Ratings

Characteristic	Symbol	Notes	Rating	Units
Supply Voltage	V_{CC}		8	V
Reverse Supply Voltage	V_{RCC}		–0.1	V
Output Voltage	V_{IOUT}		8	V
Reverse Output Voltage	V_{RIOUT}		–0.1	V
Output Current Source	$I_{IOUT(Source)}$		3	mA
Output Current Sink	$I_{IOUT(Sink)}$		10	mA
Overcurrent Transient Tolerance	I_P	1 pulse, 100 ms	100	A
Nominal Operating Ambient Temperature	T_A	Range E	–40 to 85	°C
Maximum Junction Temperature	T_J(max)		165	°C
Storage Temperature	T_{stg}		–65 to 170	°C

Isolation Characteristics

Characteristic	Symbol	Notes	Rating	Unit
Dielectric Strength Test Voltage*	V_{ISO}	Agency type-tested for 60 seconds per UL standard 60950-1, 1st Edition	2100	VAC
Working Voltage for Basic Isolation	V_{WFSI}	For basic (single) isolation per UL standard 60950-1, 1st Edition	354	VDC or V_{pk}
Working Voltage for Reinforced Isolation	V_{WFRI}	For reinforced (double) isolation per UL standard 60950-1, 1st Edition	184	VDC or V_{pk}

* Allegro does not conduct 60-second testing. It is done only during the UL certification process.

Parameter	Specification
Fire and Electric Shock	CAN/CSA-C22.2 No. 60950-1-03 UL 60950-1:2003 EN 60950-1:2001

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Appendix E: Program Codes

Current_sensor

```
#include <Controllino.h>
#define current CONTROLLINO_A3

double mVperAmp = 66; // use 100 for 20A Module and 66 for 30A Module
double RawValue= 0;
double ACSoffset = 2500;
double Voltage = 0;
double Amps = 0;

void setup(){
 Serial.begin(9600);
}

void loop(){
 RawValue = analogRead(CONTROLLINO_A3);
 Voltage = (RawValue / 1024.0) * 5000; // Gets you mV
 Amps = ((Voltage + ACSoffset) / mVperAmp)-7.88;

 Serial.print("Amps = "); // shows the voltage measured
 Serial.println(Amps,2); // the '2' after voltage allows you to display 2 digits after decimal point
 delay(1000);
}
```

LCD_i2c

```
#include <Wire.h>
#include <LiquidCrystal_PCF8574.h>
#define LM35 A0
#define LM35 A1
#define YELLOW 13
#define RED 12

LiquidCrystal_PCF8574 lcd(0x27);  // set the LCD address to 0x27 for a 16 chars and 2 line display

int show;

void setup()
{
  int error;

  Serial.begin(115200);
  Serial.begin(9600);
  Serial.println("LCD...");

  // See http://playground.arduino.cc/Main/I2cScanner
  Wire.begin();
  Wire.beginTransmission(0x27); //Your LCD Address
  error = Wire.endTransmission();
  Serial.print("Error: ");
  Serial.print(error);

  if (error == 0) {
    Serial.println(": LCD found.");

  } else {
    Serial.println(": LCD not found.");
```

LCD_i2c

```
  if (error == 0) {
    Serial.println(": LCD found.");

  } else {
    Serial.println(": LCD not found.");
  } // if

  lcd.begin(16, 2); // initialize the lcd
  show = 0;
}


void loop()
{
   float lmvalue = analogRead(LM35);
  float tempr = (lmvalue * 500)/1023;

  Serial.print("temparture = ");
  Serial.print(tempr); //Temperature in Celcius
  Serial.print((char)223);
  if (show == 0) {
    lcd.setBacklight(255);
    lcd.home();
    delay(1000);
  }
}
```

TEMP_SENSOR_CODE

```
#include <Controllino.h>
#define LM35 CONTROLLINO_A6


void setup() {
  Serial.begin(9600);
  pinMode(CONTROLLINO_A6, INPUT);



}

void loop() {
  float lmvalue = analogRead(CONTROLLINO_A6);
  float tempr = ((lmvalue * 500)/1023);
  Serial.println ();
  Serial.print("temparture = ");
  Serial.print( tempr); //Temperature in Celcius
  Serial.print (" "C");
  delay (1000);


}
```

TEMP_SENSOR_CODE_Combinedsensors

```
#define LM35A A0
#define LM35B A1


int analogInput = A2;
float vout = 0.0;
float vin = 0.0;
float R1 = 824.0; //
float R2 = 184.0; //
int value = 0;

void setup() {
  Serial.begin(9600);
   pinMode(Analog, INPUT);

   Serial.print("DC VOLTMETER");



}

void loop() {
  float lmvalueA = analogRead(LM35A);
  float temprA = (lmvalueA * 500)/1023;
  Serial.println ();
  Serial.print("temparatureA = ");
  Serial.print( temprA); //Temperature in Celcius
  Serial.print (" "C");

  float lmvalueB = analogRead(LM35B);
  float temprB = (lmvalueB * 500)/1023;
```

TEMP_SENSOR_CODE_Combinedsensors

```
  Serial.print("DC VOLTMETER");


}

void loop() {
  float lmvalueA = analogRead(LM35A);
  float temprA = (lmvalueA * 500)/1023;
  Serial.println ();
  Serial.print("tempartureA = ");
  Serial.print( temprA); //Temperature in Celcius
  Serial.print (" "C");

  float lmvalueB = analogRead(LM35B);
  float temprB = (lmvalueB * 500)/1023;
  Serial.println ();
  Serial.print("tempartureB = ");
  Serial.print( temprB); //Temperature in Celcius
  Serial.print (" "C");

// read the value at analog input
   value = analogRead(analogInput);
   vout = (value * 5.0) / 1024.0; // see text
   vin = vout / (R2/(R1+R2))+0.53;

Serial.print("INPUT V= ");
Serial.println(vin,2);
delay(2000);
}
```

Volt_sensor_

```
#include <Controllino.h>
#define Volt CONTROLLINO_A2
float vout = 0.0;
float vin = 0.0;
float R1 = 824.0; //
float R2 = 184.0; //
int value = 0;
void setup(){
   pinMode(CONTROLLINO_A2, INPUT);
   Serial.begin(9600);
   Serial.print("DC VOLTMETER");
}
void loop(){
   // read the value at analog input
   value = analogRead(CONTROLLINO_A2);
   vout = (value * 5.0) / 1024.0; // see text
   vin = vout / (R2/(R1+R2))+(12.2*0.045);

Serial.print("INPUT V= ");
Serial.println(vin,2);
Serial.println("Verror =5.4%");
delay(2000);
}
```