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ARM Based Remote Monitoring and Control System for Environmental Parameters in Green House

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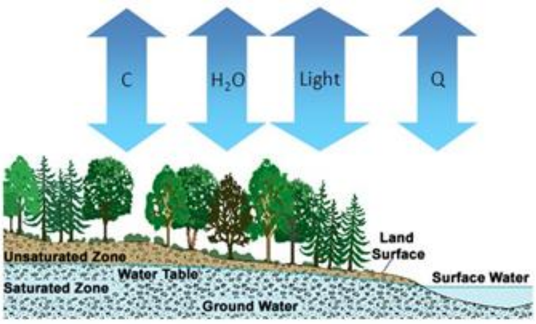
Abstract:

As Home Energy Use Is Increasing And Renewable Energy Systems Are Deployed, Home Energy Management System (Hems) Needs To Consider Both Energy Consumption And Generation Simultaneously To Minimize The Energy Cost. This Paper Proposes A Smart Hems Architecture That Considers Both Energy Consumption And Generation Simultaneously. Zigbee Based Energy Measurement Modules Are Used To Monitor the Energy Consumption Of Home Appliances And Lights. A Plc Based Renewable Energy Gateway Is Used To Monitor The Energy Generation Of Renewable Energies. The Home Server Gathers The Energy Consumption And Generation Data, Analyzes Them For Energy Estimation, And Controls The Home Energy Use Schedule To Minimize The Energy Cost. The Remote Energy Management Server Aggregates The Energy Data From Numerous Home Servers, Compares Them, And Creates Useful Statistical Analysis Information. By Considering Both Energy Consumption And Generation, The Proposed Hems Architecture Is Expected To Optimize Home Energy Use Result In Home Energy Cost.



Introduction to Embedded Systems:

Embedded systems are electronic devices that incorporate microprocessors with in There implementations. The main purposes of the microprocessors are to simplify the system design and provide flexibility. Having a microprocessor in the device means that removing the bugs, making modifications, or adding new features are only matters of rewriting the software that controls the device. Or in other words embedded computer systems are electronic systems that include a microcomputer to perform a specific dedicated application. The computer is hidden inside these products. Embedded systems are ubiquitous. Every week millions of tiny computer chips come pouring out of factories finding their way into our everyday products.

Embedded systems are self-contained programs that are embedded within a piece of hardware. Whereas a regular computer has many different applications and software that can be applied to various tasks, embedded systems are usually set to a specific task that cannot be altered without physically manipulating the circuitry. Another way to think of an embedded system is as a computer system that is created with optimal efficiency, thereby allowing it to complete specific functions as quickly as possible.

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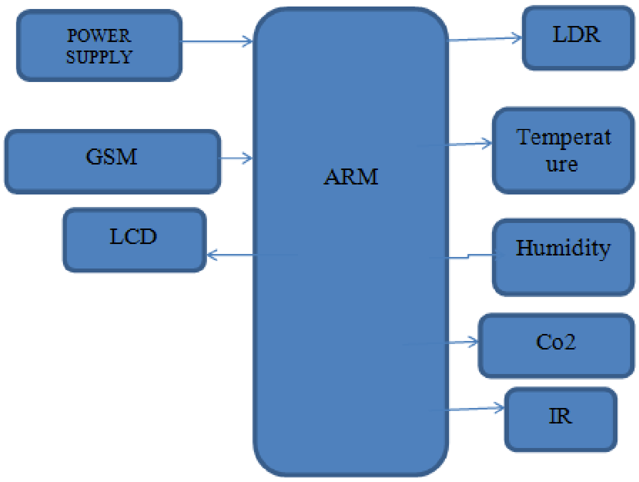
BLOCK DIAGRAM:



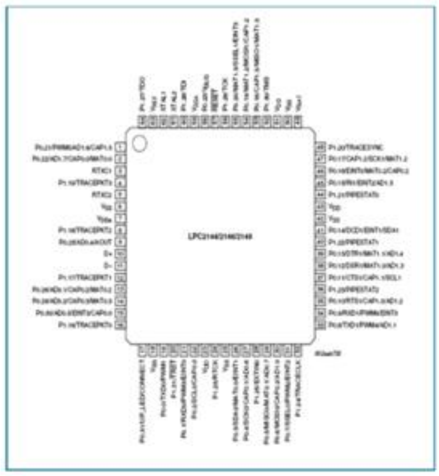
Ease of Use

ARM Microcontroller: LPC2148:

The LPC2141/42/44/46/48 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2141/42/44/46/48 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale.

Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8kB up to 40kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

The application program may also erase and/or program the flash while the application is running, allowing a great degree of flexibility for data storage field firmware upgrades, etc.



ARM7TDMI-S processor has two instruction sets:

The standard 32-bit ARM set.

• A 16-bit Thumb set.

The Thumb set's 16-bit instruction length allows it to approach twice the density of standard ARM code while retaining most of the ARM's performance advantage over a traditional 16-bit processor using 16-bit registers. This is possible because Thumb code operates on the same 32-bit register set as ARM code.Thumb code is able to provide up to 65 % of the code size of ARM, and 160 % of the performance of an equivalent ARM processor connected to a 16-bit memory system. The particular flash implementation in the LPC2141/42/44/46/48 allows for full speed execution also in ARM mode. It is recommended to program performance critical and short code sections (such as interrupt service routines and DSP algorithms) in ARM mode. The impact on the overall code size will be minimal but the speed can be increased by 30% over Thumb mode.have been defined before or immediately following the equation. Use "(1)", not "Eq. (1)" or "equation (1)", except at the beginning of a sentence: "Equation (1) is . . ."

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Power Supply

In this project we have power supplies with +5V & -5V option normally +5V is enough for total circuit. Another (-5V) supply is used in case of OP amp circuit .Transformer primary side has 230/50HZ AC voltage whereas at the secondary winding the voltage is step downed to 12/50hz and this voltage is rectified using two full wave rectifiers .the rectified output is given to a filter circuit to fiter the unwanted ac in the signal After that the output is again applied to a regulator LM7805(to provide +5v) regulator. Whereas LM7905 is for providing –5V regulation (+12V circuit is used for stepper motors, Fan and Relay by using LM7812 regulator same process like above supplies.)Do not use the word “essentially” to mean “approximately” or “effectively”. In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.

GSM

GSM (Global System for Mobile communication) is a digital mobile telephone system that is widely used in Europe and other parts of the world for transmitting mobile voice and data services. GSM uses a variation of Time Division Multiple Access (TDMA) and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band.GSM was first introduced in 1991. As of the end of 1997, GSM service was available in more than 100 countries and has become the de facto standard in Europe and Asia.

3.1 What does GSM offer

GSM supports voice calls and data transfer speeds of up to 9.6 kbit/s, together with the transmission of SMS (Short Message Service). GSM operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US. The 850MHz band is also used for GSM and 3G in Australia, Canada and many South American countries.

By having harmonized spectrum across most of the globe, GSM’s international roaming capability allows users to access the same services when travelling abroad as at home. This gives consumers seamless and same number connectivity in more than 218 countries. Terrestrial GSM networks now cover more than 80% of the world’s population. GSM satellite roaming has also extended service access to areas where terrestrial coverage is not available.

HISTORY:

In 1982, the European Conference of Postal and Telecommunications Administrations (CEPT) created the Group Special Mobile (GSM) to develop a standard for a mobile telephone system that could be used across Europe. In 1987, a memorandum of understanding was signed by 13 countries to develop a common cellular telephone system across Europe. Finally the system created by SINTEF lead by TorleivMaseng was selected.In 1989, GSM responsibility was transferred to the European Telecommunications Standards Institute (ETSI) and phase I of the GSM specifications were published in 1990. The first GSM network was launched in 1991 by Radiolinja in Finland with joint technical infrastructure maintenance from Ericsson. By the end of 1993, over a million subscribers were using GSM phone networks being operated by 70 carriers across 48 countries.

3.3 GSM Frequencies

GSM networks operate in a number of different frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G). Most 2G GSM networks operate in the 900 MHz or 1800 MHz bands. Some countries in the Americas (including Canada and the United States) use the 850 MHz and 1900 MHz bands because the 900 and 1800 MHz frequency bands were already allocated. Most 3G GSM networks in Europe operate in the 2100 MHz frequency band. The rarer 400 and 450 MHz frequency bands are assigned in some countries where these frequencies were previously used for first-generation systems.

GSM-900 uses 890–915 MHz to send information from the mobile station to the base station (uplink) and 935–960 MHz for the other direction (downlink), providing 124 RF channels (channel numbers 1 to 124) spaced at 200 kHz. Duplex spacing of 45 MHz is used. In some countries the GSM-900 band has been extended to cover a larger frequency range. This 'extended GSM', E-GSM, uses 880–915 MHz (uplink) and 925–960 MHz (downlink), adding 50 channels (channel numbers 975 to 1023 and 0) to the original GSM-900 band.

Time division multiplexing is used to allow eight full-rate or sixteen half-rate speech channels per radio frequency channel. There are eight radio timeslots (giving eight burst periods) grouped into what is called a TDMA frame. Half rate channels use alternate frames in the same timeslot. The channel data rate for all 8 channels is 270.833 Kbit/s, and the frame duration is 4.615 ms. The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900.3.4 GSM

ARCHITECTURE:

The GSM network consists mainly of the following functional parts:

3.4.1 MSC

The mobile service switching centre (MSC) is the core switching entity in the network. The MSC is connected to the radio access network (RAN); the RAN is formed by the BSCs and BTSs within the Public Land Mobile Network (PLMN). Users of the GSM network are registered with an MSC; all calls to and from the user are controlled by the MSC. A GSM network has one or more MSCs, geographically distributed.

16 * 2 Alphanumeric LCD

Liquid crystal display is very important device in embedded system. It offers high flexibility to user as he can display the required data on it. A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. LCDs therefore need a light source and are classified as "passive" displays. Here the lcd has different memories to display data, those are discussed below.

Display data RAM (DDRAM) stores display data represented in 8-bit character codes. Its extended capacity is 80 X 8 bits, or 80 characters. The area in display data RAM (DDRAM) that is not used for display can be used as general data RAM. So whatever you send on the DDRAM is actually displayed on the LCD. For LCDs like 1x16, only 16 characters are visible, so whatever you write after 16 chars is written in DDRAM but is not visible to the user.

Figure below will show you the DDRAM addresses of 2 Line LCD.

IR COMMUNICATIONS

DEFINITION

IR wireless is the use of wireless technology in devices or systems that convey data through infrared (IR) radiation. Infrared is electromagnetic energy at a wavelength or wavelengths somewhat longer than those of red light. The shortest-wavelength IR borders visible red in the spectrum. The longest-wavelength IR borders radio waves.

ORIGIN OF NAME

The name means below red, the Latin infra meaning "below". Red is the color of the longest wavelengths of visible light. Infrared light has a longer wavelength (and so a lower frequency) than that of red light visible to humans, hence the literal meaning of below red.

WHAT IS INFRARED

Infrared energy is light that we cannot see, but our bodies can detect as heat. It is part of the electromagnetic spectrum that includes radio waves, X-rays and visible light. All of these forms of energy have a specific frequency, as represented in the chart below. Infrared energy is comprised of those frequencies that exist just below the red end of the visible spectrum, and for cooking properties they have a very unique benefit - when they strike organic molecules (such as any type of food), they cause the molecules to vibrate, thereby creating heat.

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Although almost any type of electromagnetic energy can cause heating, for the purpose of cooking, infrared energy is the perfect choice. IR wireless is used for short- and medium-range communications and control. Some systems operate in line-of-sight mode; this means that there must be a visually unobstructed straight line through space between the transmitter (source) and receiver (destination). Other systems operate in diffuse mode, also called scatter mode. This type of system can function when the source and destination are not directly visible to each other. An example is a television remote-control box. The box does not have to be pointed directly at the set, although the box must be in the same room as the set, or just outside the room with the door open.IR wireless technology is used in intrusion detectors; home-entertainment control units; robot control systems; medium-range, line-of-sight laser communications; cordless microphones, headsets, modems, and printers and other peripherals. Infrared is an energy radiation with a frequency below our eyes sensitivity, so we cannot see it. Even that we cannot "see" sound frequencies, we know that it exist, we can listen them. Even that we cannot see or hear infrared, we can feel it at our skin temperature sensors. When you approach your hand to fire or warm element, you will "feel" the heat, but you can't see it. You can see the fire because it emits other types of radiation, visible to your eyes, but it also emits lots of infrared that you can only feel in your skin.

INFRARED IN ELECTRONICS

Infra-Red is interesting, because it is easily generated and doesn't suffer electromagnetic interference, so it is nicely used to communication and control, but it is not perfect, some other light emissions could contains infrared as well, and that can interfere in this communication. The sun is an example, since it emits a wide spectrum or radiation. The adventure of using lots of infra-red in TV/VCR remote controls and other applications, brought infra-red diodes (emitter and receivers) at very low cost at the market. From now on you should think as infrared as just a "red" light.

This light can means something to the receiver, the "on or off" radiation can transmit different meanings. Lots of things can generate infrared, anything that radiate heat do it, including out body, lamps, stove, oven, friction your hands together, even the hot water at the faucet. To allow a good communication using infra-red, and avoid those "fake" signals, it is imperative to use a "key" that can tell the receiver what is the real data transmitted and what is fake. As an analogy, looking eye naked to the night sky you can see hundreds of stars, but you can spot easily a faraway airplane just by its flashing strobe light. That strobe light is the "key", the "coding" element that alerts us.

Similar to the airplane at the night sky, our TV room may have hundreds of tinny IR sources, our body and the lamps around, even the hot cup of tea. A way to avoid all those other sources, is generating a key, like the flashing airplane. So, remote controls use to pulsate its infrared in a certain frequency. The IR receiver module at the TV, VCR or stereo "tunes" to this certain frequency and ignores all other IR received. The best frequency for the job is between 30 and 60 kHz, the most used is around 36 kHz

IR GENERATION

To generate a 36 kHz pulsating infrared is quite easy, more difficult is to receive and identify this frequency. This is why some companies produce infrared receives, that contains the filters, decoding circuits and the output shaper, that delivers a square wave, meaning the existence or not of the 36kHz incoming pulsating infrared. It means that those 3 dollars small units, have an output pin that goes high (+5V) when there is a pulsating 36kHz infrared in front of it, and zero volts when there is not this radiation.

A square wave of approximately 27uS (microseconds) injected at the base of a transistor, can drive an infrared LED to transmit this pulsating light wave. Upon its presence, the commercial receiver will switch its output to high level (+5V).If you can turn on and off this frequency at the transmitter; your receiver's output will indicate when the transmitter is on or off.

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Those IR demodulators have inverted logic at its output, when a burst of IR is sensed it drives its output to low level, meaning logic level = 1. The TV, VCR, and Audio equipment manufacturers for long use infra-red at their remote controls. To avoid a Philips remote control to change channels in a Panasonic TV, they use different codification at the infrared, even that all of them use basically the same transmitted frequency, from 36 to 50 kHz. So, all of them use a different combination of bits or how to code the transmitted data to avoid interference.

IR LED AND IR SENSOR

IR LED is used as a source of infrared rays. It comes in two packages 3mm or 5mm. 3mm is better as it is requires less space. IR sensor is nothing but a diode, which is sensitive for infrared radiation. This infrared transmitter and receiver are called as IR TX-RX pair. It can be obtained from any decent electronics component shop and costs less than 10Rs. Following snap shows 3mm and 5mm IR pairs. Color of IR transmitter and receiver is different. However you may come across pairs which appear exactly same or even has opposite colors than shown in above picture and it is not possible to distinguish between TX and RX visually. In case you will have to take help of multi-meter to distinguish between them.

Here is how you can distinguish between IR TX-RX using DMM:

•Connect cathode of one LED to +ve terminal of DMM

•Connect anode of the same LED to common terminal of DMM(means connect LED such that It gets reverse biased by DMM)

•Set DMM to measure resistance up to 2M Ohm.

•Check the reading.

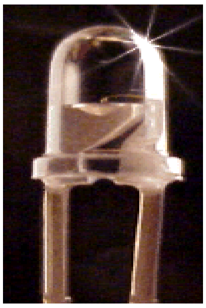
•Repeat above procedure with second LED.

In above process, when you get the reading of the few hundred Kilo Ohms on DMM, then it indicated that LED that you are testing is IR sensor. In case of IR transmitter DMM will not show any reading.

Following snap shows typical DMM reading obtained when IR receiver is connected to it as mentioned above. Second snap shows how sensor's resistance increases when it is covered by a finger. Note that, these are just illustrative figures and they will depend upon sensor as well as DMM that you are using. While buying an IR sensor, make sure that its reverse resistance in ambient light is below 1000K. If it is more than this value, then it will not be able to generate sufficient voltage across external resistor and hence will be less sensitive to small variation in incident light. The circuit diagram::Circuit diagram for IR sensor module is very simple and straight forward. Circuit is divided into two sections. IR TX and IR RX are to be soldered on small general purpose Grid PCB. From this module, take out 3 wires of sufficiently long length (say 1 ft). Then, as shown above, connect them to VCC, preset and to ground on main board. By adjusting preset, you can adjust sensitivity of the sensor. VCC should be connected to 5V supply.

IR TRANSMITTER

IR LED



IR LED emits infrared radiation. This radiation illuminates the surface in front of LED. Surface reflects the infrared light. Depending on the reflectivity of the surface, amount of light reflected varies. This reflected light is made incident on reverse biased IR sensor. When photons are incident on reverse biased junction of this diode, electron-hole pairs are generated, which results in reverse leakage current. Amount of electron-hole pairs generated depends on intensity of incident IR radiation. More intense radiation results in more reverse leakage current.

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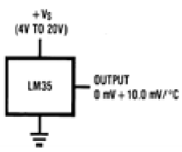
This current can be passed through a resistor so as to get proportional voltage. Thus as intensity of incident rays varies, voltage across resistor will vary accordingly.This voltage can then be given to OPAMP based comparator. Output of the comparator can be read by uc. Alternatively, you can use on-chip ADC in AVR microcontroller to measure this voltage and perform comparison in software.

IR RECEIVER

TEMPERATURE SENSOR

Temperature Sensor which converts temperature value into electrical signals. We used IC called LM 35 as a temperature sensor. LM35 series sensors are precision integrated-circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 requires no external calibration since it is internally calibrated. . The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range.



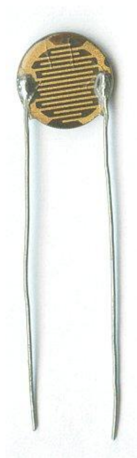
LM35

□ LM35 is precision integrated circuit temperature sensor. Its output voltage is linearly proportional to temperature (in celsius).

The LM35 thus has an advantage over linear temperature sensors calibrated in° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over full −55 to +150°C temperature range

LIGHT DEPENDENT RESISTOR (LDR)

A photo resistor is an electronic component whose resistance decreases with increasing incident light intensity. It can also be called a light-dependent resistor (LDR), or photo conductor.Other light dependent resistors, or photo resistors have been made using materials including Cadmium Sulphide, Lead Sulphide and the more commonly used semiconductor materials including Ge ,Si and GaAs.



A light dependent resistor

The photo resistor, or Light Dependent Resistor, finds many uses as a low cost photo sensitive element and was used for many years in photographic light meters as well as other applications.such as flame, smoke, and burgler detectors, card readers and lighting controls for street lamps.Units for the light intensity are Lux or Lumence.

Carbon Dioxide (CO2Sensor)

Excellent performance CO2 Sensor, for use in a wide range of applications, including air quality monitoring,

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smoke alarms, mine and tunnel warning systems, greenhouses, etc. The sensor is easy to use and can be easily incorporated in a small portable unit.

Features:

•HighSensitivity

•DetectionRange:0-10,000ppmCO2

•ResponseTime:<60s

•HeaterVoltage:6.0V

• Dimensions: 16mm Diameter, 15mm High excluding pins, Pins - 6mm High.

HUMIDITY SENSOR

Humidity is the quantity of water content in atmosphere.

The sensor output will be a variable voltage with respect to the

humidity level. Humidity will be measured in percentage. The

SY-HS-220 humidity sensor is used which converts relative

humidity to the output voltage with operating humidity range

30% - 90% RH and accuracy is ± 5% RH (at +25°C). In

nonnal condition the humidity will be around 50% to 70%. In

our module we will be setting minimum level to 50% and

maximum level to 65%. If the current reading falls below the

minimum level the relay3 will be triggered to switch ON the

water sprinkler, which will spray water to raise humidity level.

Similarly if the humidity rises above maximum limit relay4

will be triggered which in tum OFF the water sprinkler or connect drier fan to it.Basic structure Although there are many ways in which LDR's or photo resistors can be manufactured, ther are naturally a few more common methods that are seen. Essentially the LDR or photo resistor consists of a resistive material sensitive to light that is exposed to light. The photo resistive element comprises section of material with contacts at either end. Although many of the material used for light dependent resistors are semiconductors, when used as photo resistors, they are used only as a resistive element and there are no p-n junctions. Accordingly the devices purely passive.

A typical structure for a Light Dependent Resistor uses an active semiconductor layer that is deposited on an insulating substrate. The semiconductor is normally lightly doped to enable it to have the required level of conductivity. Contacts then placed either side of the exposed area. In many instances the area between the contacts is in the form of zig zag, or inter digital pattern. This maximizes the exposed area and by keeping the distance between the contacts small it enhances the gain. It also possible to use a poly crystalline semiconductor that is deposited onto a substrate such as ceramic. This makes for a very low cost light dependent resistor.

Operation

Light Dependent Resistor made of a high resistance semiconductor, if light falling on the is of high enough efficiently, photon absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.In intrinsic devices, the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electrons across the entire band gap. Extrinsic devices have impurities added , which have a ground state energy closer to the conduction band, since the electrons don't have so far to jump, lower energy photons (i.e. longer wavelengths and lower frequencies) will suffice to trigger the device.

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Characteristics of LDR

The characteristics of LDR are shown below. Here the resistance variations are shown as a function of illumination. The resistance of LDR decreases with increasing incident light intensity

LDR Applications:

LDR's are very useful especially in light/dark sensor circuits. Normally the resistance of LDR is very high, sometimes as high as 1000k ohms,but when they are illuminated with light, resistance drops immediately.

1. Camera light meters.
2. Clock radios.
3. Security alarms.
4. Optical switches.
5. Far infrared detector.
6. Streetlights.

SERIALCOMMUNICATION

INTRODUCTION

Computers transfer data in two ways: parallel and serial. In parallel data transfers, often 8 or more lines (wire conductors) are used to transfer data to a device that is only a few feet away. Examples of parallel transfers are printers and hard disks; each uses cables with many wire strips. Although in such cases a lot of data can be transferred in a short amount of time by using many wires in parallel, the distance cannot be great. To transfer to a device located many meters away, the serial method is used. In serial communication, the data is sent one bit at a time, in contrast to parallel communication, in which the data is sent a byte or more at a time. The 8051 has serial communication capability built into it, thereby making possible fast data transfer using only a few wires.When a microprocessor communicates with the outside world, it provides the data in byte-sized chunks. In some cases, such as printers, the information is simply grabbed from the 8-bit data bus of the printer. This can work only if the cable is not too long, since long cables diminish and even distort signals. Furthermore, an 8-bit data path is expensive. For these reasons, serial communication is used for transferring data between two systems located at distances of hundreds of feet to millions of miles apart. The Figures shows serial versus parallel data transfers.

What's New in µVision4?

µVision3 adds many new features to the Editor like Text Templates, Quick Function Navigation, and Syntax Coloring with brace high lighting Configuration Wizard for dialog based startup and debugger setup. µVision3 is fully compatible to µVision4 and can be used in parallel with µVision4.

What is µVision4?

µVision3 is an IDE (Integrated Development Environment) that helps you write, compile, and debug embedded programs. It encapsulates the following components:

•A project manager.

•A make facility.

•Tool configuration.

•Editor.

•A powerful debugger.

To help you get started, several example programs (located in the \C51\Examples, \C251\Examples, \C166\Examples, and \ARM\...\Examples) are provided.

•HELLO is a simple program that prints the string "Hello World" using the Serial Interface.

•MEASURE is a data acquisition system for analog and digital systems.

•TRAFFIC is a traffic light controller with the RTX Tiny operating system.

•SIEVE is the SIEVE Benchmark.

•DHRY is the Dhrystone Benchmark.

•WHETS is the Single-Precision Whetstone Benchmark.

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Additional example programs not listed here are provided for each device architecture.

Building an Application in µVision4

To build (compile, assemble, and link) an application in µVision4, you must:

1.Select Project - (forexample,166\EXAMPLES\HELLO\HELLO.UV4).

2.Select Project - Rebuild all target files or Build target.

µVision4 compiles, assembles, and links the files in your project.

Conclusion:

The project "Real Time Vehicle Monitoring and Tracking System based on Embedded Linux Board and Android Application "has been successfully designed and tested Integrating features of all the hardware components used have developed it. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly, using highly advanced IC's and with the help of growing technology the project has been successfully implemented.

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