Arduino Board

Diagrammatic version, to simplify
But of a slightly older version of the board

Arduino Sketch Structure

- Declare variables at top
- Initialize
  - `setup()` – run once at beginning, set pins
- Running
  - `loop()` – run repeatedly, after `setup()`

Pins can be changed in loop() too, but conceptually easier in setup()

Arduino "Language"

- Language is standard C (but made easy)
- Lots of useful functions
  - `pinMode()` – set a pin as input or output
  - `digitalWrite()` – set a digital pin high/low
  - `digitalRead()` – read a digital pin's state
  - `analogRead()` – read an analog pin
  - `analogWrite()` – write an "analog" PWM value
  - `delay()` – wait an amount of time
  - `millis()` – get the current time
- And many others. And libraries. And examples!

Also: serial library, LCD library, servo examples

Arduino Software

That's the full code for blinking an LED, btw.
Arduino defines several useful functions like digitalWrite() and delay(). more on that later
Processing and Wiring not needed

Sensing the Dark

- Pots are example of a *voltage divider*
- Voltage divider splits a voltage in two
- Same as two resistors, but you can vary them

Arduino Digital Input

- Add switch circuit to any digital input (except pin 13)
- For output, use either existing pin 13 LED or wire up your own

Blinky LED circuit

“hello world” of microcontrollers

wiring diagram

schematic

In schematics signals often flow from top-left to bottom-right
Common nodes like “gnd” are given their own symbol
Pick any digital pin to hook up to, doesn’t matter which

PWM

Output voltage is averaged from on *vs.* off time

output_voltage = (on_time / off_time) * max_voltage

PWM

- Used everywhere
  - Lamp dimmers, motor speed control, power supplies, noise making
- Three characteristics of PWM signals
  - Pulse width range (min/max)
  - Pulse period (= 1/pulses per second)
  - Voltage levels (0-5V, for instance)

External Power

Arduino can run off USB power or external power

External power connector

USB connector

jumper switch to choose power source

External Power

You can use an AC adpater

Connector is standard barrel connector

Make sure it's "center positive"

Voltage can be 9-15V DC

Amps is > 200mA

Actually input voltage can be from like 7.5V to 35V, but don't go over 15V so the voltage regulator doesn't have to work so hard.

/ analogue inputs

As we have seen in the previous section Arduino is able to detect if there is a voltage applied to one of its pins and report it trough the digitalRead function. This is fine in a lot of applications but the light sensor that we have used before it's also able to tell us not just if there is light or not, it's also able to tell us how much light there is. This is the difference between an on/off sensor (simply telling us if something is there or not) and an analogue sensor whose value continuously changes. In order to read this type of sensors we need a different type of pin. In the lower-right part of Arduino you'll see 6 pins marked "Analog In", these are special pins that not only can tell us if there is a voltage applied to them or not but also it value. By using the analogRead function we can read the voltage applied to one of the pins. This function returns a number between 0 and 1023 representing voltages between 0 and 5 volts. For example if there is a voltage of 2.5 volts applied to pin 0 writing analogRead(0) will return 512 etc etc.

If you now build the circuit that you see in the illustration by using a 10k or 4.7k resistor and you run the piece of code you find here you'll see the led blinking at a rate that's dependent on the amount of light that hits the sensor.

A B C D E
F G H I J
GND
13
7
5V Gnd

/ the breadboard

The process of getting a circuit to work is largely based on making lots of changes to it until it behaves properly; it's a very fast iterative process that could be seen as the electronic equivalent to sketching. The design evolves in your hands as you try different combinations. In order to achieve the best results you want to use a system that will allow you to change the connections between components in the fastest, most practical and non-destructive way.

This requirement clearly rules out soldering, it's a time consuming procedure that puts every component under stress every time you heat them up and cool them down.

The answer to our problems comes from a very practical device called "Solder-less Breadboard".

As you can see from the picture it's a small plastic board full of holes, each one of them contains a spring-loaded contact. You can push a component's leg into one of the hole and it will establish an electrical connection with all the other holes in the same vertical column of holes. Each hole is at a distance of 2.54 mm distance from the others, since most of the components have their legs, known to techies as pins, are spaced at that standard distance therefore chips with multiple legs will fit nicely. Not all the contacts on a breadboard are created equal, there are some differences: the topmost and bottom row (coloured in red and blue and aptly marked with + and -) are

/ what is electricity

If you have ever done any plumbing at home, electronics won't be a problem for you to understand. Jokes aside, in order to understand how electricity and electric circuits work the best way is to build a mental model called the "water analogy". Let's take a simple device like a portable fan,

if you take it apart you will see that it contains a small battery a couple of wires going to an electric motor and one of the wires is interrupted by a switch. Now makes sure you have a new battery fitted in the device and activate the switch; the motor will start to spin providing the necessary refreshment. How does this work? Well imagine that the battery is a water pump and the switch is a tap while the motor is one of those wheels you see in watermills, when you open the tap water will flow from the pump and push the wheel into motion.

Now in this simple hydraulic system two parameters are important: the pressure of the water (this is given from how powerful is the pump) and the amount of water that will flow in the pipes (this depends from the size of the pipes and the resistance that the wheel will oppose to the stream of water hitting it).

You quickly understand that if you want the wheel to spin faster you need to increase the size of the pipes (but this works only up to a point) and increase the pressure that the pump can achieve. Increasing the size of the pipes allows more flow of water to go through them, effectively by making them bigger we have reduced the resistance they oppose to the flow of water. This works until a certain point where the wheel won't spin any faster because the pressure of the water is not strong enough and this is when we need the pump to be stronger.

This can go on until the point when the wheel falls apart because the water flow is too strong and destroys it. Another thing you will notice is that as the wheel spins the axle will heat up a little bit, this is because no matter how good is the way we have mounted the wheel the attrition between the axle and the holes it is mounted in will generate heat. This is important to understand that in a system like this not all the energy you pump into the system will be converted into movement, some will be lost in a number of inefficiencies and will generally show up as heat emanating from some parts of the system.

So what are the important parts of the system as we described it before? The pressure produced by the pump is one, the resistance that the pipes and wheel oppose to the flow of water and the actual flow of water (let's say that this is represented by the number of litres of water that flow in one second) are the others.

Without going into much details electricity works a bit like water, you have a kind of pump (any source of electricity like a battery or a wall plug) pushes electric charges (imagine them like "drops" of electricity) down pipes represented by the wires where some devices are able to use them to produce heat (your grandma's thermal blanket)

light (your bedroom's lamp) sound (your stereo) movement (your fan) and much more.

So when you read on a battery 9V you can imagine the Voltage of the battery like the water pressure that can be potentially produced by this little "pump". This is measured in Volts from Alessandro Volta, the inventor of the first battery.

The flow of water has got and electric equivalent called "current" that is measured in Amperes from Andre Marie Ampere. Finally the resistance opposed to the flow of current by any means it travels through is called, yes you guessed right, resistance and it's measured in Ohms from the German physicist Ohm.

Mr ohm is also responsible for coming up with the most important law in electricity and the only formula you will really need to remember.

He was able to demonstrate that in a circuit the Voltage, the Current and the Resistance are all related to each other and in particular that the resistance opposed by the circuits determines the amount of current that will flow through it give a certain supply voltage.

It's very intuitive if you think about it: Take a 9V battery and plug it into a simple circuit while measuring current, you will find that the more resistors you add to the circuit the less current will travel through it. Going back to the water flowing in pipes, given a certain pump if I place a tap (which we can assimilate to a variable resistor in electricity) the more I close the tap, increasing resistance to water flow, less water will flow through the pipes. Mr Ohm summarised his law into this formulas:

R (resistance) = V (voltage) / I (current)

$V = R * I$

$I = V / R$

This is the only rule that you really have to memorise and learn to use, because in most of your work this will be the only one you will really need.

connected horizontally and are used to carry the power across the board so that when we need power or ground we can provide it very quickly with a short jumper (this is not a sweater or a funny insect but a short piece of wire used to connect two points in the circuits) The last this you need to know about breadboards is the in the middle there is a large gap that is as wide as the size of a small chip. This shows that the each vertical line of holes is interrupted in the middle so that when you plug a chip you won't short circuit pins that are on the two sides of the chip, clever eh?

Thanks

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