

M & M sorting machine description.

This project is intended for educational purpose or the curious experimenter, it gives a good insight in what is needed for automation of a given process.

The basic function of the machine is to sort out M & Ms in different colours, this can be achieved in different ways, and there are several problems that have to be solved along the way of getting it up and running.

Hardware description:

The hardware consists of a couple of DC motors, a servo motor, and a colour sensor module, along with this is a couple of homemade sensors at different places in the machine in order to keep track of how things are running, all this functions are of course handled by a R8C/13 micro controller with proper software programmed into it.

The control of the DC motors is done by a L298N dual H bridge driver that is driven by PWM signals from the micro controller, the voltage on the sense resistors is raised via an op-amp for measuring the motors current by the micro controllers AD inputs, in this way it is possible to take action if one of the motors is blocked.

Controlling of the servo motor is done by a special circuit that consists of a 555 timer, and a 4052 multiplexer that selects one of seven preset servo positions via 3 input lines, in this way the micro controller do not have to take care of providing a stable servo pulse while doing all the other stuff it has to do.

The colour sensor module is a standard unit bought at www.parallax.com it is called TCS230 colour sensor module, you should also download the datasheet for this sensor to learn more about it.

An old Nokia 3310 LC display is used to show the colour sample values and the colour detected, it is also used to show how many M&M of each colour there where, and the total number of M&Ms. As this display runs @ 3.3V, I have made a small interface circuit to take care of this, it consists of a 3.3V low drop regulator with capacitors, a 74HCT573 octal latch, and a couple of resistors, there is also 2 switches to control the machine, and 2 SMD Leds for backlighting of the display.

The R8C/13 micro controller module is connected as simple as possible, only the programming interface is used for programming the device, all other port pins are used for other functions, and are routed to sockets as needed.

The 5 above mentioned circuits are each build on there own circuit board, this is done so they can be used for other experiments as well.

All the circuits can of course be combined on a single piece of veroboard if you would prefer this instead, you can then leave out most of the voltage regulators shown for these circuits

The machine is working as follows:

Pressing the [C] key on the Nokia phone will start the machine, and a second press will stop it again, pressing the [A] key will show counter values for each M&M colour that has been sorted, and the total number of M&M's, each time the machine is started, all counters are cleared.

When you start the machine the M&M's are falling through 2 holes in the top plate and is taken to another hole in bottom top plate via the dispensing wheel that has 4 holes in it, it falls into a buffer

tube where a homemade sensor is located at the bottom of this tube, when the sensor is activated the second wheel (sorter wheel) is starting to turn and in this way one M&M is taken from the bottom of this tube at a time and is moved underneath the colour sensor module, a second sensor is looking at a small piece of aluminium tape that is attached to the sorter wheel in such a way that it will trigger this sensor when the M&M is located right beneath the colour sensor module (this will be approximately 90 degrees), the sorter wheel only has one hole in it.

The colour sensor module is now triggered 3 times with red, green, and blue colour filters selected, and the value for each colour sample is used to determine which colour it is looking at.

When a colour is detected and evaluated, the resulting colour number is selected (0 – 6) and the servo is moving the sorter tube to the respective container and the M&M falls into it, this will continue until all the M&M is sorted, or the machine is stopped again.

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Software description:

The software is using the timers and counter that are available in the micro controller to generate PWM signals for the 2 DC motors and counting the frequency from the colour sensor module.

Timer X is used for generating PWM signal to the dispensing motor, and Timer Z is used for the sorter motor PWM signal, both timers are interrupt driven with reload on underflow off the timer/counter register, the clock signal for these timers are the main clock frequency divided by 8, and this clock is divided further by the timers prescaler registers to give a PWM signal off a usable frequency.

The frequency from the colour sensor module is measured by counter Y's input pin, the counter is preset to 255 on start of counting routine, and the preset value is counted down, when finished counting the value in the counter register is subtracted from 255 to get the wanted result, the counting routines are started when a M&M is located right beneath the colour sensor module, this is detected by an reflective sensor that is looking at the sorter wheel where a piece off aluminium tape is located.

But before all this can happen the machine has to be started by pressing [(] key on the Nokia phone, this will start motor1, the dispensing wheel, and start turning the mixer arm attached to the top off this, thereby the M&Ms will start to fall down into the buffer tube, and when the sensor located at the bottom is activated, the sorter motor starts to turn and moves the M&Ms to the colour sensor module one by one, the module is activated, and the colour of the M&M is evaluated, the result of this evaluation is transferred to the servo sorter witch moves to the right position.

The counters in the software is cleared when the machine is started, and there values are read when the machine is stopped after sorting, this is done by first pressing [(] to stop the machine, and then [/] key, this will display all counter values.

How the program is running is controlled by a couple off variables that tells the different subroutines how to act when the are called. The control off the dispensing motor is done with the variables "M1_dir, M1_cnt, and counter", M1_cnt is used to control the speed off the dispensing motor, and M1_dir is used to control the direction off witch the motor is turning, this is used to prevent the M&M from getting stuck in the machines dispensing part, this is done by measuring the motor current with an analogue input pin and change direction off the motor if a certain limit is reached and thereby 'shake' the M&Ms free again. This trick can only be used by the dispensing motor because the sorter motor must not run CCW for to long as the M&Ms would fall into the sorter arm without being evaluated by the colour sensor module so a little different approach must be used here. The sorter motor uses variables M2_dir, M2_cnt, M2_dir_cnt, and counter for status and control purpose, again M2_cnt is controlling the speed and M2_dir the direction of the motor, and now the third variable, M2_dir_cnt, witch is used to count how many PWM cycles the motor has been running CCW, in this way the motor will only give some small 'chattering' movements CCW, and free the stuck M&M.

When the program detects that the M&M is underneath the colour sensor module a subroutine is called that measures the red, green, and blue colour values, these are also shown on the Nokia LCD together with the detected colour, this is done by counting down timer Y during a given time period, and in this way measure the input frequency at timer Y's input pin.

These 3 colour values are evaluated in another subroutine, and the result is a number from 0 – 6 that indicates the colour detected. This information is used to set-up the outputs that control the servo sorter circuit, and thereby move the servo sorter arm to the right position for this colour.

The different M&M colour counters are updated at each colour evaluation, and the total M&M counter is updated when the [/] is pressed.