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FEEDBACK CONTROL OF DC MOTORS WITH LONG RANGE HC 12 TRANSCEIVER AND ARDUINO

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ABSTRACT. The work demonstrates the possibility to control DC motors at long distance with feedback. The system uses the radio transceivers HC 12, Arduino board and LCD keypad shield. Complete description of the hardware and software parts of the system is presented.

Keywords: *DC feedback control, HC12 transceiver, Arduino.*

INTRODUCTION

One of the problems occurring on remote control devices at long distance is the confirmation of the achievement of the command, on the other word the feedback the action, [1]. For this purpose the actuator must have the capability to send back to the sender the confirmation of the achievement of the order. That supposes a bilateral communication between the sender and the receiver, [12]. In the radio transmission this task can be done using transceivers. Bluetooth devices are actually very popular modules fulfilling this task, being included frequently in phones, computers, TV, etc. The range of such devices is of the order of few meters and the feedback is not necessarily because the user can perceive with its own senses the achievement of the command. The situation is different when using long range devices, as HC 12 Bluetooth modules, which can send data over hundred of meters, [2]. In this case the feedback is absolutely necessarily.

This work proposes a simple and cheap solution to provide a feedback between the sender and receiver using the Arduino platform, [3]. As examples the project was used to control two low power DC motors.

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EXPERIMENTAL

For this project we need two Arduino Uno boards, two HC12 Bluetooth modules, two 3-6 V DC motors, one MX 1805 H bridge and one LCD 1602 keypad shield Arduino compatible. The system consists of two parts, the sender and the receiver.

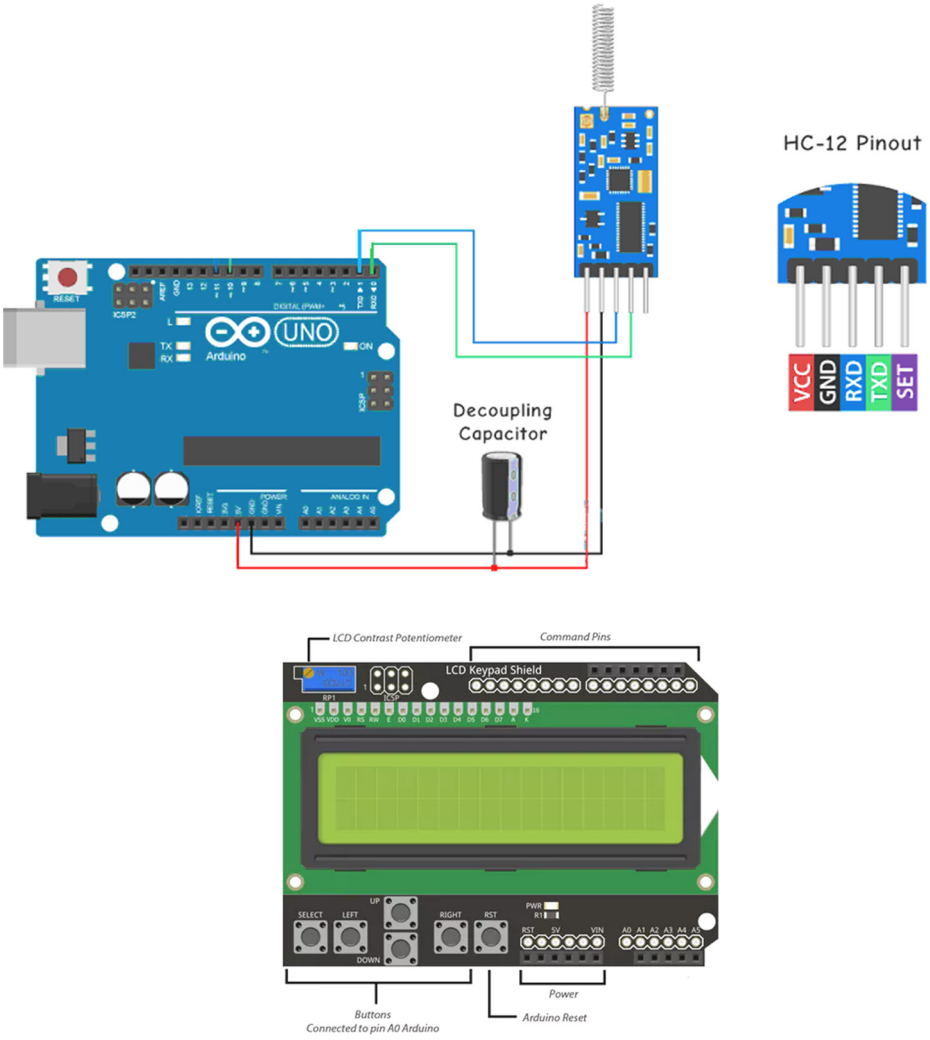

Fig. 1. The sender with HC12 module and Arduino Uno.
The image of the LCD keypad shield.

The sender is very simple. The LCD keypad is plugged onto the Arduino board and then the HC 12 is soldered on the back side of the Arduino board, as shown in figure 1. The correspondence of the pins is shown in table 1.

Table 1

HC12	Arduino
Vcc	+5V
GND	GND
Tx	Rx
Rx	Tx
Set	NC

It is suitable to connect a decoupling capacitor of 100□F on the power rails of HC12 to prevent fluctuations of the alimentation voltage.

The receiver contains one Arduino Uno board to which the HC 12 is attached in the same manner as for the sender, (Fig. 2). On the pins D12-D14 are connected the entries IN1-IN4 of the H bridge. The GND of the H bridge is connected

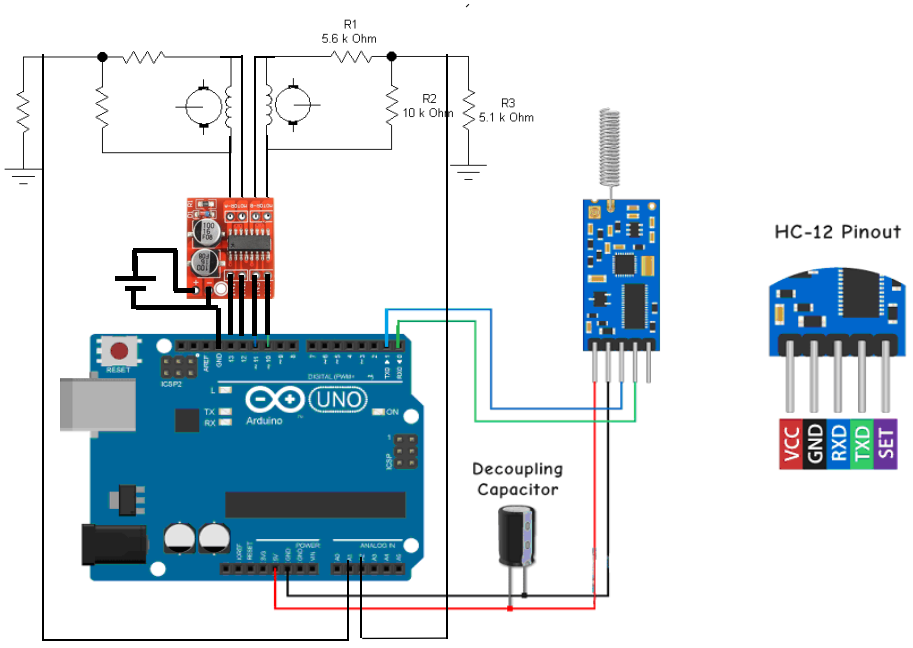

Fig. 2. The receiver

to the GND of Arduino board, and the +V is connected to a separately battery power, as shown in figure 2. The DC motors are connected to the outputs of the H bridge. The voltage applied to the motor is collected by a resistive divider and applied to the entries A1 and A2 of the Arduino board for the feedback, [4, 5, 11].

RESULTS AND DISCUSSION

The important piece of this system is the HC 12 Bluetooth transceiver. It is a wireless serial port communication module working in the frequency band from 433.4 MHz to 473.0 MHz. The domain is divided into 100 channels separated by 400 KHz each to other. The transmission power can be set in the range -1dBm (0.79mW) to 20dBm (100mW), and the receiving sensitivity can be set in the range -117dBm (0.019pW) to -100dBm (10pW). These values, as well as the working frequency, can be set accessing the AT command of the module, [2]. However we can use the modules as they come from the manufacturer, without any supplementary setting, because they are set to work at the maximum power and high reception sensitivity on the cannel 001. The system contains two HC 12 modules set as sender and receiver.

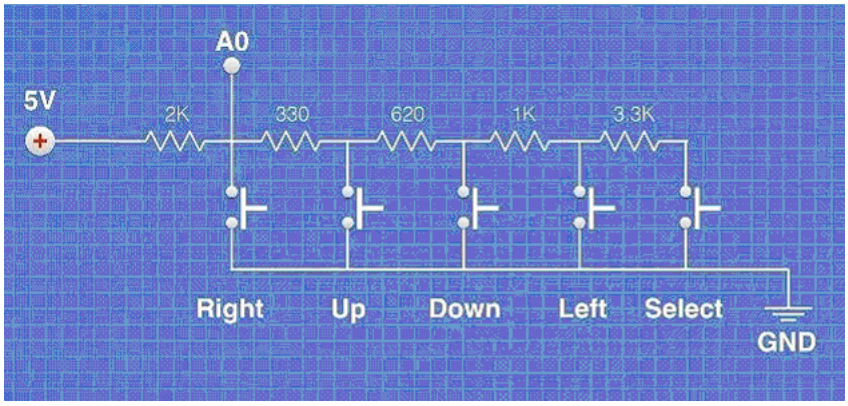

Fig. 3. The inner voltage resistive divider of the LCD keypad shield

The sender sends analog data read from a resistive voltage divider, included into the LCD keypad shield. The analog values are applied to the pin A0 which is connected to the inner resistive divider as shown in figure 3. When pressing one of the buttons Right, Left, Up, Down, Select, a given value of the voltage, between 0

and 5V, is applied to the pin A0. The ADC of Arduino converts these analog values in binary data from 0 to 1023. In the Arduino code of the sender we divide by 4 these data. This conversion is necessarily because the data from 0 to 255 can be sent over the Bluetooth device as 1 byte, which is easier to be accepted on the receiver side, [6, 7]. The module HC12 is set on sender mode by the code.

The code for the sender.

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(8, 9, 4, 5, 6, 7);
int x;
int M1=0;
int M2=0;

void setup() {
Serial.begin(9600); // Default communication rate of the Bluetooth module
lcd.begin(16, 2);
}

void loop() {
  x = analogRead(A0);
  //read analog data for LCD Keypad
  Serial.write(x/4); // Dividing by 4 for converting from 0 - 1023 to 0 - 256, (1 byte)
range
  // Send the values via the serial port to the slave HC-05 Bluetooth device
  delay(20);

  lcd.setCursor(0, 0);
     lcd.print("sent x=");
     lcd.print(x/4);
  lcd.print("       ");
  delay(20);
//displays locally the sending x data

while (Serial.available() == 0) {}
  M1 = Serial.read();
  //delay(10);
  //Serial.write(val);
```

```
 lcd.setCursor(0, 1);
    lcd.print("M1=");
    lcd.print(M1);
    lcd.print("      ");
 //displays the value M1 sent back by the receiver for feedback
  M2= Serial.read();
    lcd.setCursor(10, 1);
    lcd.print("M2=");
   lcd.print(M2);
    lcd.print("   ");
//displays the value M2 sent back by the receiver for feedback
}
```

The receiver select the data sent by the sender and command a corresponding DC motor, forward, backward or stop, in function of the values of analog data. The interesting part of the project is the feedback action. The principle of working can be easily understood following the figure 4, which presents a generic H bridge powered by a single voltage battery, with a DC motor connected on its output, [8]. A resistive voltage divider R1/R2 is connected at the ends of the DC motor.

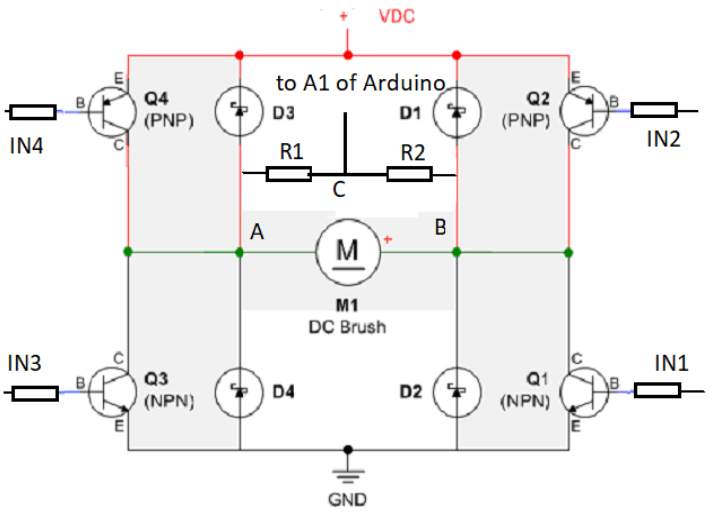

Fig. 4. The generic schema of H bridge.

When the transistors Q1 and Q4 are in ON state, the point A is connected to +Vdc and the B point to the ground. The DC motor will rotate in one direction. The voltage of the point C of the R1/R2 divider is $V_{C1} = V_{dc} \frac{R_1}{R_1 + R_2}$, [9, 10]. When the transistors Q3 and Q2 are in the ON state, the point A is connected to GND and the B point to +Vdc. The DC motor will rotate in opposite direction. The voltage of the point C of the R1/R2 divider is $V_{C2} = V_{dc} \frac{R_2}{R_1 + R_2}$. In both cases the potential of the point C is positive by rapport to GND and proportional to R1 or R2 in function of which transistors are in ON state. It results the possibility to correlate the rotation direction of the motor to the Vc voltage. This voltage is applied to the entries A1 and A2 of the Arduino. These entries are connected to the ground trough the resistor R3, (Fig. 3). Due to this resistor the real voltage of the entries A1 and A2 is: $V_{C1} = V_{dc} \frac{R_1 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$ and $V_{C2} = V_d c \frac{R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$. If the H bridge is not activated the potential on the entries A1 and A2 is zero, due to the resistor R3. The values of Vc are sending back and displayed on the LCD of the sender. So the feedback is achieved. To do this, the HC 12 module is put on the sender mode for few milliseconds, after that it comes back on the receiver mode. This operation is commanded by the code.

If the values of R1 and R2 are different, the Vc1 and Vc2 voltages are different for the forward and backward rotation of the DC motor. In this manner it is possible to know if the DC motor is rotating and what is the direction of rotation.

The receiver code

```
#define in1 10
#define in2 11
#define in3 12
#define in4 13

int xAxis;
int  x = 0;
int M1=0;//feedback for Motor 1
int M2=0;//feedback for Motor 2
```

```
void setup() {

  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);

  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4,LOW);

  Serial.begin(9600);
  // Default communication rate of the Bluetooth module
}

void loop() {

  // Read the incoming data from the
  while (Serial.available() == 0) {}
  x = Serial.read();
  delay(10);

  // Convert back the 0 - 255 range to 0 - 1023, suitable for motor control
  xAxis = x * 4;

  if (xAxis > 50 & xAxis < 170) {
    //forward
    digitalWrite(in1,HIGH);
    digitalWrite(in2,LOW);
    digitalWrite(in3, LOW);
    digitalWrite(in4, HIGH);
    }
 else if (xAxis > 210 & xAxis < 370) {
    //backward
    digitalWrite(in1,LOW);
    digitalWrite(in2, HIGH);
    digitalWrite(in3, HIGH);
    digitalWrite(in4, LOW);
 }
```

```
 else if (xAxis > 400 & xAxis < 650 ) {
   //left
  digitalWrite(in1,LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4,HIGH);
 }

 else if (xAxis < 20 ) {
   //right
  digitalWrite(in1,HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4,LOW);
 }
else if (xAxis > 700) {
   //stop
  digitalWrite(in1,LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4,LOW);
 }

 M1 = analogRead(A1);
  Serial.write(M1/4);
  //send back data to the sender
  Serial.write("");
   //compulsory for separating M1 and M2 data
     delay(10);

  M2 = analogRead(A2);
  Serial.write(M2/4);

  delay(20);
 }
```

CONCLUSION

The possibility to control two DC motors at long distance with feedback was tested with HC 12 transceiver. These modules are driven by two Arduino UNO boards. Economic and elegant solution for the sender is the use of the LCD keypad Arduino compatible shield. The feedback action was performed collecting the voltage on the ends of the DC motor trough a resistive voltage divider and sending back to the sender. This task is performed using adequate codes for sender and receiver.

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