

**ДОДАТОК А**  
Лістинг коду

```

#define fsk 10

const byte U_PWMP = 5; // Pin 5, PWM output u(t)
const byte Out_PWMP = 6; // Pin 6, PWM output,
const byte adcPin = 0; // A0 - analog input y(t)
const float fs = 1000.00; // sampling frequency
const float Ts = 1/fs; // sampling period
const float Kc = 10.0; // controller gain
const float Ti = 3.0;//2.5; // integral time
volatile float x = 0.2; //setpoint value, range 0...1
const float Td = 1.0; // derivative time
volatile float y; // measured process value, range 0...1
volatile float u; // control variable, range 0...1
volatile int upwm=0;
volatile int out=0;
volatile float e=0; // error value, range -1...1
volatile float e_1=0; // error from the previous cycle, range 0...1
volatile float ui=0; // integral value, range -1...1
volatile float ud=0; // derivative value, range
volatile float ui_1=0; // value of the integral from the previous cycle, range -1...1

const int Nk=500;
int counter = 0;
int a_vol = 0;

void setup() {
  Serial.begin(115200);

  pinMode(LED_BUILTIN, OUTPUT);
  pinMode(U_PWMP, OUTPUT);

```

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pinMode(Out_PWMP, OUTPUT);
pinMode(adcPin, INPUT);

}

void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage
level)
  a_vol = analogRead(adcPin);
  y=float(a_vol/1024.0); // range of ADC 0...1023,
  if (counter++>Nk) {
    Serial.print("max:");
    Serial.print("1");
    Serial.print(",");
    Serial.print("min:");
    Serial.print("0");
    Serial.print(",");
    Serial.print("y:");
    Serial.println(y);
    counter=0;
  }

  // ---PID controller-----
  e=(x-y);
  ui=Kc/Ti*Ts/2*(e+e_1)+ui_1; // integral term
  if(ui>1) ui=1; else if(ui<-1) ui=-1;
  ud=Kc*Td/Ts*(e-e_1); // derivative term
  u=e*Kc+ui+ud;
  u=u+x; // works faster
  ui_1=ui;

```

```
e_1=e;
// --- end of PID controler

if(u>1) u=1;
else if(u<0) u=0;
upwm=(int)(u*255+0.5);
out=(int)((e+1)*127+0.5 );
analogWrite(U_PWMP, upwm);
analogWrite(Out_PWMP, out);
digitalWrite(LED_BUILTIN, LOW);

delay(1);

}
```

## **ДОДАТОК Б**

Демонстраційний матеріал у вигляді презентації

