

6. Appendix

```
#include <mega16.h>

#include <delay.h>

//#include<math.h>

unsigned intFWseq[]={8,4,2,1},BWseq[]={1,2,4,8};

int LDR1,LDR2,LDR3,LDR4,dt=0.1;

float Kp=1.0,Ki=1.0,Kd=1.0,error=0,setpoint=0.0,integral=0,derivative=0,previouserror=0,result=0,MEASUREDVALUE;;

signedintstepslimitEW=0,stepslimitNS=0;

unsignedintCWindexEW=0,CCWindexEW=0,CWindexNS=0,CCWindexNS=0;

voidturnCW(float );

voidturnCCW(float);

void turnCW2(float);

void turnCCW2(float);

float calculate(int);

void main(void)

{

floattempPIDout;

while (1)

{

LDR1=read_adc(0)/200;

LDR2=read_adc(1)/200;

MEASUREDVALUE=LDR1-LDR2;

if(MEASUREDVALUE>setpoint)

{

tempPIDout=calculate(MEASUREDVALUE);

turnCW(tempPIDout);
```

```

    }
    if(MEASUREDVALUE<setpoint)
    {
        MEASUREDVALUE=MEASUREDVALUE*-1;
        tempPIDout=calculate(MEASUREDVALUE);
        turnCCW(tempPIDout);
    }

    LDR3=read_adc(2)/200;
    LDR4=read_adc(3)/200;
    MEASUREDVALUE=LDR3-LDR4;
    if(MEASUREDVALUE>setpoint)
    {
        tempPIDout=calculate(MEASUREDVALUE);
        turnCW2(tempPIDout);
    }
    if(MEASUREDVALUE<setpoint)
    {
        MEASUREDVALUE=MEASUREDVALUE*-1;
        tempPIDout=calculate(MEASUREDVALUE);
        turnCCW2(tempPIDout);
    }
    delay_ms(dt);
}

}

float calculate(int MEASURED)
{
    error=setpoint-MEASURED;

```

```

integral=integral-(error*dt);

derivative=(error-previouserror)/dt;

result=Kp*error+Ki*integral+Kd*derivative;

previouserror=error;

return result;
}

voidturnCW(float PIDout)

{

while (PIDout>0.0)

{if(stepslimitEW<90)

{PORTC=FWseq[CWindexEW];

delay_ms(10);

if(CWindexEW==3)

CWindexEW=0;

else

CWindexEW++;

stepslimitEW++;

PIDout=PIDout-0.1;}

else

break;

}

}

voidturnCCW(float PIDout)

{

while(PIDout>0.0)

{

```

```

if(stepslimitEW>=90)

{PORTC=BWseq[CCWindexEW];

delay_ms(10);

if(CCWindexEW==3)

CCWindexEW=0;

else

CCWindexEW++;

stepslimitEW--;

PIDout=PIDout-0.1;}

else

break;

}

}

void turnCW2(float PIDout)

{

while(PIDout>0.0)

{

if(stepslimitNS<90)

{PORTD=FWseq[CWindexNS];

delay_ms(dt);

if(CWindexNS==3)

CWindexNS=0;

else

CWindexNS++;

stepslimitNS++;

PIDout=PIDout-0.1;}

```

```

else
break;
}
}

void turnCCW2(float PIDout)
{
while(PIDout>0.0)
{
if(stepslimitNS>-90)
{PORTD=BWseq[CCWindexNS];

delay_ms(dt);

if(CCWindexNS==3)

CCWindexNS=0;

else

CCWindexNS++;

stepslimitNS--;

PIDout=PIDout-0.1;}

else

break;

}

}

```

Features

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
 - 131 Powerful Instructions – Most Single-clock Cycle Execution
 - 32 x 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 16 MIPS Throughput at 16 MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
 - 16K Bytes of In-System Self-programmable Flash program memory
 - 512 Bytes EEPROM
 - 1K Byte Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
 - Data retention: 20 years at 85°C/100 years at 25°C⁽¹⁾
 - Optional Boot Code Section with Independent Lock Bits
 - In-System Programming by On-chip Boot Program
 - True Read-While-Write Operation
 - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
 - Boundary-scan Capabilities According to the JTAG Standard
 - Extensive On-chip Debug Support
 - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
 - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
 - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
 - Real Time Counter with Separate Oscillator
 - Four PWM Channels
 - 8-channel, 10-bit ADC
 - 8 Single-ended Channels
 - 7 Differential Channels in TQFP Package Only
 - 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
 - Byte-oriented Two-wire Serial Interface
 - Programmable Serial USART
 - Master/Slave SPI Serial Interface
 - Programmable Watchdog Timer with Separate On-chip Oscillator
 - On-chip Analog Comparator
- Special Microcontroller Features
 - Power-on Reset and Programmable Brown-out Detection
 - Internal Calibrated RC Oscillator
 - External and Internal Interrupt Sources
 - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
 - 32 Programmable I/O Lines
 - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Operating Voltages
 - 2.7 - 5.5V for ATmega16L
 - 4.5 - 5.5V for ATmega16
- Speed Grades
 - 0 - 8 MHz for ATmega16L
 - 0 - 16 MHz for ATmega16
- Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L
 - Active: 1.1 mA
 - Idle Mode: 0.35 mA
 - Power-down Mode: < 1 µA



28BYJ-48 – 12V Stepper Motor

The 28BYJ-48 is a small stepper motor suitable for a large range of applications.



Rated voltage : 12VDC

Number of Phase 4

Speed Variation Ratio 1/64

Stride Angle 5.625° /64

Frequency 100Hz

DC resistance $50\Omega \pm 7\%$ (25°C)

Idle In-traction Frequency > 600Hz

Idle Out-traction Frequency > 1000Hz

In-traction Torque > 34.3mN.m(120Hz)

Self-positioning Torque > 34.3mN.m

Friction torque 600-1200 gf.cm

Pull in torque 300 gf.cm

Insulated resistance > 10M Ω (500V)

Insulated electricity power 600VAC/1mA/1s

Insulation grade A

Rise in Temperature < 40K(120Hz)

Noise < 35dB(120Hz, No load, 10cm)

Light Dependent Resistor - LDR

Two cadmium sulphide(cds) photoconductive cells with spectral responses similar to that of the human eye. The cell resistance falls with increasing light intensity. Applications include smoke detection, automatic lighting control, batch counting and burglar alarm systems.



Applications

Photoconductive cells are used in many different types of circuits and applications.

Analog Applications

- Camera Exposure Control
- Auto Slide Focus - dual cell
- Photocopy Machines - density of toner
- Colorimetric Test Equipment
- Densitometer
- Electronic Scales - dual cell
- Automatic Gain Control – modulated light source
- Automated Rear View Mirror

Digital Applications

- Automatic Headlight Dimmer
- Night Light Control
- Oil Burner Flame Out
- Street Light Control
- Absence / Presence (beam breaker)
- Position Sensor

Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Unit
Cell resistance	1000 LUX	-	400	-	Ohm
	10 LUX	-	9	-	K Ohm
Dark Resistance	-	-	1	-	M Ohm
Dark Capacitance	-	-	3.5	-	pF
Rise Time	1000 LUX	-	2.8	-	ms
	10 LUX	-	18	-	ms
Fall Time	1000 LUX	-	48	-	ms
	10 LUX	-	120	-	ms
Voltage AC/DC Peak		-	-	320	V max
Current		-	-	75	mA max
Power Dissipation				100	mW max
Operating Temperature		-60	-	+75	Deg. C



ULN2001A, ULN2002A, ULN2003A, ULN2004A DARLINGTON TRANSISTOR ARRAYS

SLRS027 – DECEMBER 1976 – REVISED APRIL 1993

electrical characteristics, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST FIGURE	TEST CONDITIONS	ULN2001A			ULN2002A			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$ On-state input voltage	6	$V_{CE} = 2\text{ V}$, $I_C = 300\text{ mA}$						13	V
$V_{CE(sat)}$ Collector-emitter saturation voltage	5	$I_I = 250\text{ }\mu\text{A}$, $I_C = 100\text{ mA}$		0.9	1.1		0.9	1.1	V
		$I_I = 350\text{ }\mu\text{A}$, $I_C = 200\text{ mA}$		1	1.3		1	1.3	
		$I_I = 500\text{ }\mu\text{A}$, $I_C = 350\text{ mA}$		1.2	1.6		1.2	1.6	
V_F Clamp forward voltage	8	$I_F = 350\text{ mA}$		1.7	2		1.7	2	V
I_{CEX} Collector cutoff current	1	$V_{CE} = 50\text{ V}$, $I_I = 0$			50			50	μA
	2	$V_{CE} = 50\text{ V}$, $T_A = 70^\circ\text{C}$, $I_I = 0$			100			100	
		$V_I = 6\text{ V}$						500	
$I_{I(off)}$ Off-state input current	3	$V_{CE} = 50\text{ V}$, $I_C = 500\text{ }\mu\text{A}$, $T_A = 70^\circ\text{C}$	50	65		50	65		μA
I_I Input current	4	$V_I = 17\text{ V}$					0.82	1.25	mA
I_R Clamp reverse current	7	$V_R = 50\text{ V}$, $T_A = 70^\circ\text{C}$			100			100	μA
		$V_R = 50\text{ V}$			50			50	
h_{FE} Static forward current transfer ratio	5	$V_{CE} = 2\text{ V}$, $I_C = 350\text{ mA}$	1000						
C_i Input capacitance		$V_I = 0$, $f = 1\text{ MHz}$		15	25		15	25	pF