APPENDIX A flow chart of program

Start

Check LED rotor

If LED rotor
in zero
position?

NO

YES

Wait for user selection

Move rotor to selected
position

Read the sample

Move rotor to zero position

APPENDIX B spectrophotometer control program using basic language:

```
$regfile = "m32def.dat"
$crystal = 8000000
```

```
Config Lcd = 16 * 2
Config Lcdpin = Pin , Db4 =
Portb.4 , Db5 = Portb.5 , Db6 =
```

```
Portb.6 , Db7 = Portb.7 , Rs =
Portb.0 , E = Portb.1
Config Porta.0 = Output
Config Porta.1 = Output
Config Porta.2 = Output
Config Porta.3 = Output
Config Porta.4 = Input
Config Pina.5 = Input
Config Pina.6 = Input
Config Pina.7 = Input
Config Pind.0 = Input
Config Pind.1 = Input
Config Pind.2 = Input
Config Pind.3 = Input
Config Portd.4 = Output
Config Portc = Input

Dim D As Byte , I As Byte

Cursor Off:
Cls

Lcd "TESTING MODE."


Cursor Off:
Cls
Locate 1 , 1
Lcd "TO SELECT UV"
Locate 2 , 1
Lcd "FILTER PRESS SW1"
Waitms 200
Locate 1 , 1
Cls
Locate 1 , 1
Lcd "TO SELECT RED"
Locate 2 , 1
Lcd "FILTER PRESS SW2"
Waitms 200
Locate 1 , 1
Cls
Locate 1 , 1
Lcd "TO SELECT GREEN"
Locate 2 , 1
Lcd "FILTER PRESS SW3"
Waitms 200
Locate 1 , 1
Locate 1 , 1
Lcd "TO SELECT YELLOW"
Locate 2 , 1
Lcd "FILTER PRESS SW4"
Waitms 200
Locate 1 , 1
Cls
Locate 1 , 1
Lcd "TO SELECT BLUE"
Locate 2 , 1
Lcd "FILTER PRESS SW5"
Waitms 200
Locate 1 , 1
Lcd "error position"

While Pind.3 = 1

Porta.0 = 1
Waitms 100
Porta.0 = 0
Porta.1 = 1
Waitms 100
Porta.1 = 0
Porta.2 = 1
Waitms 100
Porta.2 = 0
Porta.3 = 1
Waitms 100
Porta.3 = 0
Wend

Do

Locate 1 , 1
Lcd "WELCOME"
```

```
If Pina.4 = 0 Then

Cls
Locate 1 , 1
Lcd "running motor"
For I = 1 To 2
Porta.0 = 1
Waitms 100
Porta.0 = 0
Porta.1 = 1
Waitms 100
Porta.1 = 0
Porta.2 = 1
Waitms 100
Porta.2 = 0
Porta.3 = 1
Waitms 100
Porta.3 = 0
Next
Cls
Lcd "UV filter"
Portd.4 = 1
Waitms 3000
Portd.4 = 0

Cls
Lcd "finish UV"
Locate 2 , 1
Lcd "test"
Waitms 200
Cls
End If



' Select RED filter
```

```
If Pina.5 = 0 Then

Cls
Locate 1 , 1
Lcd "running motor"
For I = 1 To 4

Porta.0 = 1
Waitms 100
Porta.0 = 0
Porta.1 = 1
Waitms 100
Porta.1 = 0
Porta.2 = 1
Waitms 100
Porta.2 = 0
Porta.3 = 1
Waitms 100
Porta.3 = 0
Waitms 50
Porta.3 = 0
Next
Cls
Lcd "RED filter"
Portd.4 = 1
Waitms 3000
Portd.4 = 0

Cls
Lcd "finish RED"
Locate 2 , 1
Lcd "test"
Waitms 200
Cls
End If



' Select GREEN filter
```

```
If Pina.6 = 0 Then

Cls
Locate 1 , 1
Lcd "running motor"

For I = 1 To 6
Porta.0 = 1
Waitms 100
Porta.0 = 0
Porta.1 = 1
Waitms 100
Porta.1 = 0
Porta.2 = 1
Waitms 100
Porta.2 = 0
Porta.3 = 1
Waitms 100
Porta.3 = 0
Next
Cls
Lcd "GREEN filter"
Portd.4 = 1
Waitms 3000
Portd.4 = 0

Cls
Locate 1 , 1
Lcd "finish GREEN"
Locate 2 , 1
Lcd "test"
Waitms 200
Cls

End If



' Select YELLOW filter
```

```
If Pina.7 = 0 Then

Cls
Lcd "running motor"
For I = 1 To 8
Locate 1 , 1
Porta.0 = 1
Waitms 100
Porta.0 = 0
Porta.1 = 1
Waitms 100
Porta.1 = 0
Porta.2 = 1
Waitms 100
Porta.2 = 0
Porta.3 = 1
Waitms 100
Porta.3 = 0
Next
Cls
Lcd "YELLOW filter"
Portd.4 = 1
Waitms 3000
Portd.4 = 0


Cls
Lcd "finish YELLOW"
Locate 2 , 1
Lcd "test"
Waitms 200
Cls

End If



' Select BLUE filter
```

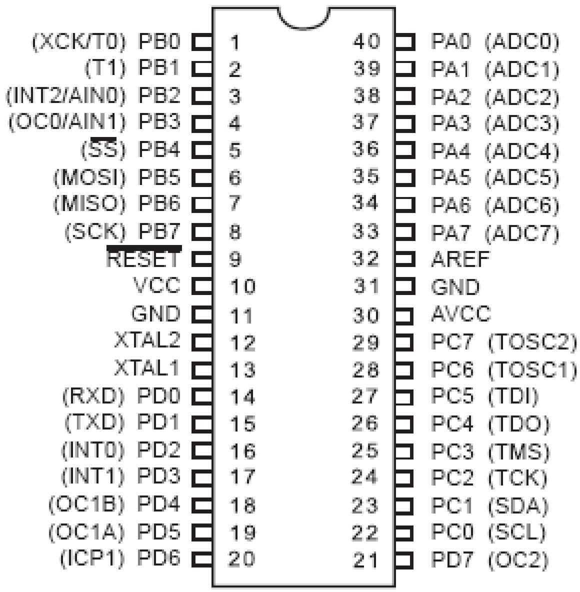
```
If Pinc.0 = 0 Then

Cls
Locate 1 , 1
Lcd "running motor"

For I = 1 To 10
Porta.0 = 1
Waitms 100
Porta.0 = 0
Porta.1 = 1
Waitms 100
Porta.1 = 0
Porta.2 = 1
Waitms 100
Porta.2 = 0
Porta.3 = 1
Waitms 100
Porta.3 = 0
Next
Cls
Lcd "BLUE filter"
Portd.4 = 1
Waitms 3000
Portd.4 = 0


Cls
Lcd "finish BLUE"
Locate 2 , 1
Lcd "test"
Waitms 200
Cls
End If

Loop
End
```

APPENDIX C ADC and USART program using basic language:

```
$regfile = "m32def.dat"

$crystal = 8000000

$baud = 19200

Config Adc = Single , Prescaler = Auto

Start Adc

Const X = 1000

Dim Y As Single

Dim Z As Single

Dim M As Single

Dim S As Single

Dim R As Single

Dim A As Word

Dim B As Word

Dim C As Word

Dim D As Word

While D =1

Do

A = Getadc(0)

Y = A

Y = Y / 0.01
```

```
Y = Y * X
Print "READING OF BLANK:" ;
Waitms 1000
B = Getadc(0)
Z = B
Z = Z / 0.01
Z = Z * X
Print "READING OF STANDARD:" ; Z
Waitms 1000
C = Getadc(0)
M = C
M = M / 0.01
M = M * X
Print "READING OF SAMPLE:" ; M
Waitms 1000
S = M / Z
Print "FINAL RESULT = " ; S
Waitms 1000
Loop
EndLoop
End
```

APPENDIX D Atmega32 &16 datasheet:



Pin out atmega32.

Features

• High-performance, Low-power AVR® 8-bit Microcontroller

• Advanced RISC Architecture

– 131 Powerful Instructions – Most Single-clock Cycle Execution

– 32 × 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

– 32 Kbytes of In-System Self-programmable Flash program memory

– 1024 Bytes EEPROM

– 2 Kbytes Internal SRAM

– Write/Erase Cycles: 10,000 Flash/100,000 EEPROM

– Data retention: 20 years at 85°C/100 years at 25°C

– 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

– 2.7V - 5.5V for ATmega32L

– 4.5V - 5.5V for ATmega32

• Speed Grades

– 0 - 8 MHz for ATmega32L

– 0 - 16 MHz for ATmega32

• Power Consumption at 1 MHz, 3V, 25°C for ATmega32L

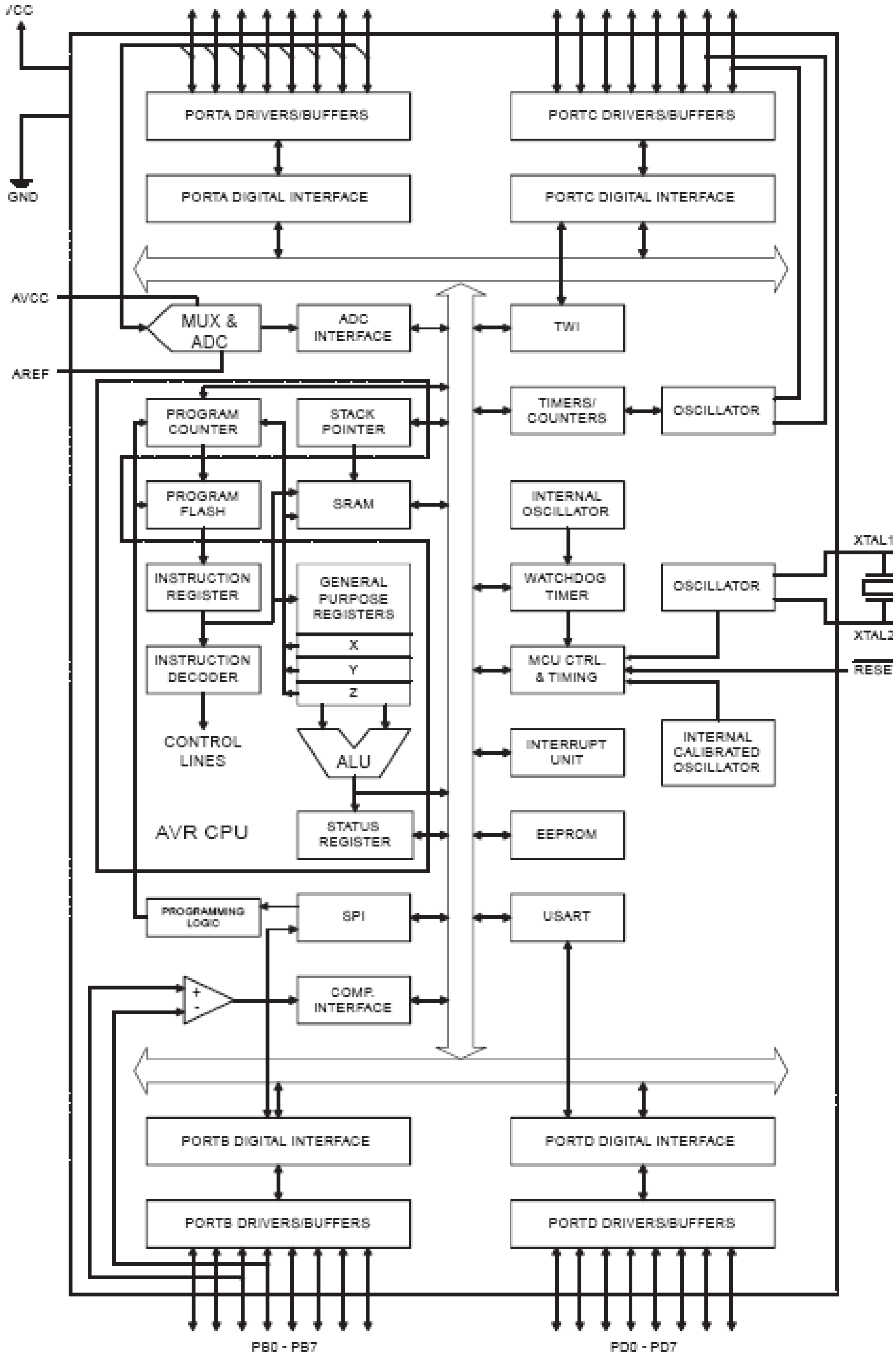
– Active: 1.1 mA

– Idle Mode: 0.35 mA

– Power-down Mode: < 1 µA

Overview

The ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing s



Atmega32 block diagram.

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic

Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega32 provides the following features: 32 Kbytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 1024 bytes EEPROM, 2K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for Boundary scan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the USART, Two-wire interface, A/D Converter, SRAM; Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next External Interrupt or Hardware Reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run. The device is manufactured using Atmel’s high density nonvolatile memory technology. The On chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega32 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega32 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

Pin Descriptions

VCC: Digital supply voltage.

GND: Ground.

Port A (PA7...PA0) Port A serves as the analog inputs to the A/D Converter.

Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, the y will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7...PB0) Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port B also serves the functions of various special features of the ATmega32.

Port C (PC7...PC0) Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5 (TDI), PC3 (TMS) and PC2 (TCK) will be activated even if a reset occurs. The TD0 pin is tri-stated unless TAP states that shift out data are entered. Port C also serves the functions of the JTAG interface and other special features of theATmega32.

Port D (PD7...PD0) Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port D also serves the functions of various special features of the ATmega32.

RESET: Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a reset.

XTAL1: Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2: Output from the inverting Oscillator amplifier.

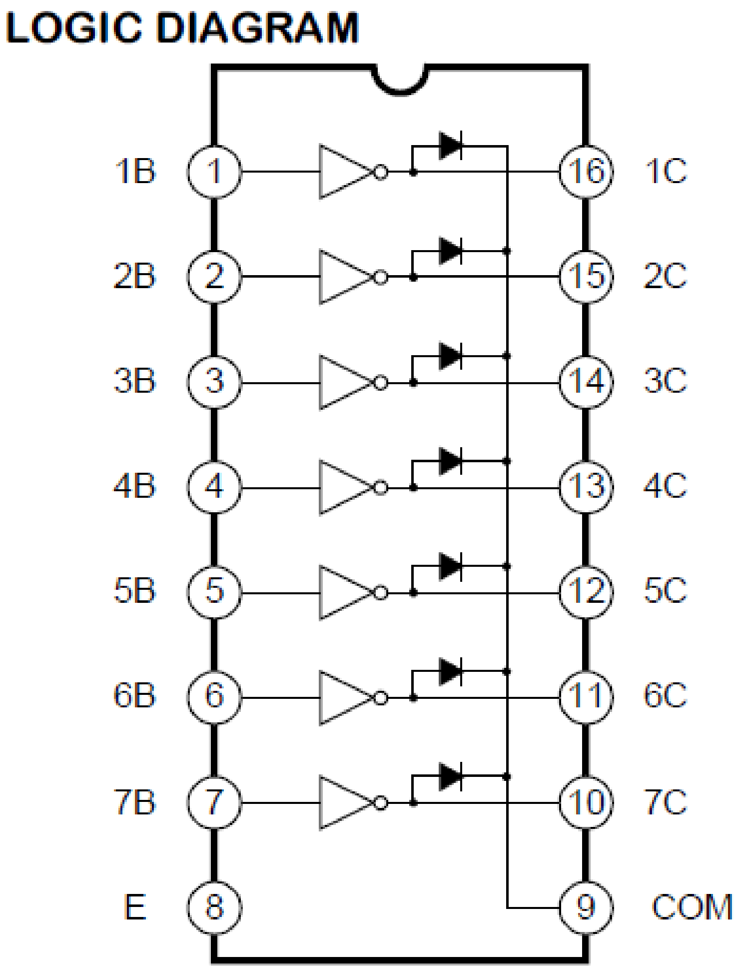
AVCC: AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF: AREF is the analog reference pin for the A/D Converter.

ULN2003 datasheet:

DESCRIPTION:

The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current Darlington arrays each containing seven open collector Darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite outputs to simplify board layout. The four versions interface to all common logic families: These versatile devices are useful for driving a wide loads including solenoids, relays DC motors, LED displays filament lamps, thermal print heads and high power buffers. The ULN2001A/2002A/2003A and 2004A are supplied in 16 pin plastic DIP packages with a copper lead frame to reduce thermal resistance.



Pin connection of ULN2003.

APPENDIX E USART interface code using MATLAB:

```
% Set serial port mode

!mode com3:9600, n, 8, 1

% open com port for data transfer

fid = fopen('com3:','w');

fwrite(fid,'data','int8');

% send reset pulse

fwrite(fid,255,'int8');

% close com port connection

fclose(fid);
```

APPENDIX F unipolar motor datasheet:

PM35L_048 datasheet:

- Motor Size: PM35L-048.
- Number of Steps per Rotation 48(7.5°/Step).
- Drive Method: 2-2 PHASE.
- Drive Circuit: UNIPOLAR CONST. VOLT.
- Drive Voltage: 24[V].
- Current/Phase: 500[mA].
- Coil Resistance/Phase: 30[Ω].
- Drive IC: 2SC3346.
- Magnet Material: Ferrite plastic magnet (MSPL) Polar anisotropy ferrite sintered magnet (MS50) Nd-Fe-B bonded magnet (MS70).
- Insulation Resistance: 100M[Ω] MIN.
- Dielectric Strength: AC 500[V] 1[min].
- Class of Insulation: CLASS E.
- Operating Temp: -10[°C] ~ 50[°C].
- Storage Temp. -30[°C] ~ 80[°C].
- Operating Hum. 20[%] RH ~ 90[%] RH.

Applications:

- OA Equipment: Printers / Scanners.
- Automotive: Meters / Optic axis control device.
- Industrial equipment: Flow control valves.
- Home automation appliances: Sewing machines.

APPENDIX G temperature sensor:

BPX 65 datasheet:

Features:

• Especially suitable for applications from 350 nm to 1100 nm.

• BPX 65: high photosensitivity.

• Hermetically sealed metal package (TO-18), suitable up to 125 $C^{0.}$

Applications:

• Fast optical sensor of high modulation bandwidth.

18 A3 DIN 41870, flat glass lens, hermetically sealed package, solder tabs 2.54 mm (2/10”) lead spacing, anode marking: projection at package bottom.

- Operating and storage temperature range (*T*stg): – 40 ... + 125 C^0.
- Soldering temperature in 2 mm distance from case bottom (t ≤3 ms) (*T*S): 230C^0.
- Reverse voltage (*V*R): 50 V.
- Total power dissipation (*P*tot): 250 mW.

APPENDIX H Max232 datasheet:

- Meet or Exceed TIA/EIA-232-F and ITU Recommendation V.28
- Operate With Single 5-V Power Supply
- Operate Up to 120 kbit/s
- Two Drivers and Two Receivers
- ±30-V Input Levels
- Low Supply Current . . . 8 mA Typical
- Designed to be Interchangeable With Maxim MAX232
- ESD Protection Exceeds JESD 22 – 2000-V Human-Body Model (A114-A)
- Applications

TIA/EIA-232-F

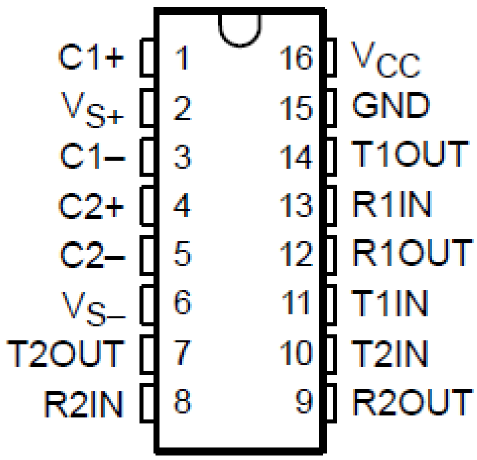
Battery-Powered Systems

Terminals

Modems

Computers

Description/ordering information:



The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply EIA-232 voltage levels from a single 5-V supply. Each receiver converts EIA-232 inputs to 5-V TTL/CMOS levels. These receivers have a typical threshold of 1.3 V and a typical hysteresis of 0.5 V, and can accept ±30-V inputs. Each driver converts TTL/CMOS input levels into EIA-232 levels. The driver, receiver, and voltage-generator functions are available as cells in the Texas Instruments LinASIC™ library.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP (N)	Tube	MAX232N	MAX232N
	SOIC (D)	Tube	MAX232D	MAX232
		Tape and reel	MAX232DR	
	SOIC (DW)	Tube	MAX232DW	MAX232
		Tape and reel	MAX232DWR	
	SOP (NS)	Tape and reel	MAX232NSR	MAX232
–40°C to 85°C	PDIP (N)	Tube	MAX232IN	MAX232IN
	SOIC (D)	Tube	MAX232ID	MAX232I
		Tape and reel	MAX232IDR	
	SOIC (DW)	Tube	MAX232IDW	MAX232I
		Tape and reel	MAX232IDWR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

Function Tables

EACH DRIVER

INPUT TIN	OUTPUT TOUT
L	H
H	L

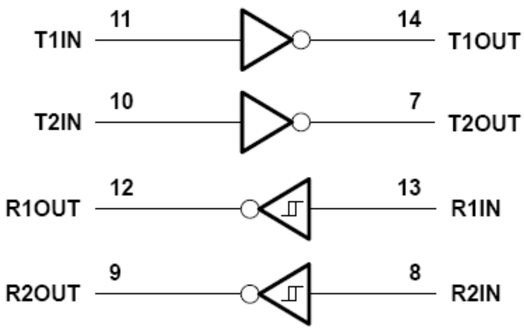
H = high level, L = low level

EACH RECEIVER

INPUT RIN	OUTPUT ROUT
L	H
H	L

H = high level, L = low level

logic diagram (positive logic)



Absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Input supply voltage range, VCC (see Note 1) . . . . –0.3 V to 6 V

Positive output supply voltage range, VS+ . . . . VCC – 0.3 V to 15 V

Negative output supply voltage range, VS– . . .. –0.3 V to –15 V

Input voltage range, VI: Driver . . . . –0.3 V to VCC + 0.3 V

Receiver . . . . ±30 V

Output voltage range, VO: T1OUT, T2OUT . . VS – 0.3 V to VS+ + 0.3 V

R1OUT, R2OUT . . . . –0.3 V to VCC + 0.3 V

Short-circuit duration: T1OUT, T2OUT . . . . Unlimited

Package thermal impedance, θJA (see Note 2): D package . . . . . . 73°C/W

DW package . . . . 57°C/W

N package . . . . 67°C/W

NS package . . . . 64°C/W

Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . 260°C

Storage temperature range, Tstg . . . . –65°C to 150°C

Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltage values are with respect to network ground terminal.

2. The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended operating conditions:

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		4.5	5	5.5	V
V_{IH}	High-level input voltage (T1IN,T2IN)		2			V
V_{IL}	Low-level input voltage (T1IN, T2IN)				0.8	V
R1IN, R2IN	Receiver input voltage				±30	V
T_A	Operating free-air temperature	MAX232	0		70	°C
		MAX232I	–40		85	

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 3 and Figure 4)

PARAMETER		TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
I_{CC}	Supply current	V_{CC} = 5.5 V, All outputs open, T_A = 25°C		8	10	mA

‡ All typical values are at V_{CC} = 5 V and T_A = 25°C.

NOTE 3: Test conditions are C1–C4 = 1 μF at V_{CC} = 5 V ± 0.5 V.

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature range (see Note 3)

PARAMETER			TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	T1OUT, T2OUT	R_L = 3 kΩ to GND	5	7		V
V_{OL}	Low-level output voltage‡	T1OUT, T2OUT	R_L = 3 kΩ to GND		–7	–5	V
r_o	Output resistance	T1OUT, T2OUT	V_{S+} = V_{S-} = 0, V_O = ±2 V	300			Ω
I_{OS}§	Short-circuit output current	T1OUT, T2OUT	V_{CC} = 5.5 V, V_O = 0		±10		mA
I_{IS}	Short-circuit input current	T1IN, T2IN	V_I = 0			200	µA

† All typical values are at V_{CC} = 5 V, T_A = 25°C.
‡ The algebraic convention, in which the least positive (most negative) value is designated minimum, is used in this data sheet for logic voltage levels only.
§ Not more than one output should be shorted at a time.
NOTE 3: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Note 3)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Driver slew rate	R_L = 3 kΩ to 7 kΩ, See Figure 2			30	V/µs
SR(t)	Driver transition region slew rate	See Figure 3		3		V/µs
	Data rate	One TOUT switching		120		kbit/s

NOTE 3: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

RECEIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature range (see Note 3)

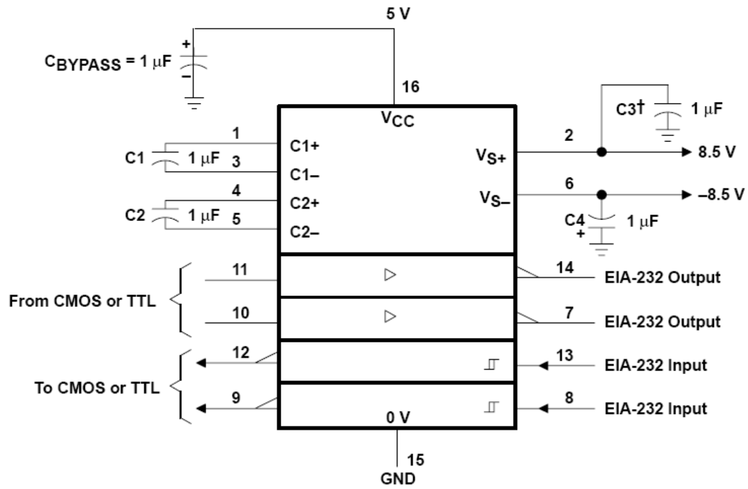
PARAMETER			TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	R1OUT, R2OUT	I_{OH} = –1 mA	3.5			V
V_{OL}	Low-level output voltage‡	R1OUT, R2OUT	I_{OL} = 3.2 mA			0.4	V
V_{IT+}	Receiver positive-going input threshold voltage	R1IN, R2IN	V_{CC} = 5 V, T_A = 25°C		1.7	2.4	V
V_{IT-}	Receiver negative-going input threshold voltage	R1IN, R2IN	V_{CC} = 5 V, T_A = 25°C	0.8	1.2		V
V_{hys}	Input hysteresis voltage	R1IN, R2IN	V_{CC} = 5 V	0.2	0.5	1	V
r_i	Receiver input resistance	R1IN, R2IN	V_{CC} = 5, T_A = 25°C	3	5	7	kΩ

† All typical values are at V_{CC} = 5 V, T_A = 25°C.
‡ The algebraic convention, in which the least positive (most negative) value is designated minimum, is used in this data sheet for logic voltage levels only.
NOTE 3: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Note 3 and Figure 1)

PARAMETER		TYP	UNIT
$t_{PLH(R)}$	Receiver propagation delay time, low- to high-level output	500	ns
$t_{PHL(R)}$	Receiver propagation delay time, high- to low-level output	500	ns

NOTE 3: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.



† C3 can be connected to V_{CC} or GND.

Figure 4. Typical Operating Circuit

IMPORTANT NOTICE

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APPENDIX I operation amplifier datasheet:

ICL7611 datasheet:

The ICL761X/762X/764X series is a family of monolithic CMOS operational amplifiers. These devices provide the designer with high performance operation at low supply voltages and selectable quiescent currents, and are an ideal design tool when ultra low input current and low power dissipation are desired. The basic amplifier will operate at supply voltages ranging from ˆ} 1V to ˆ} 8V, and may be operated from a single Lithium cell.

A unique quiescent current programming pin allows setting of standby current to 1mA, 100µA, or 10µA, with no external components. This results in power consumption as low as 20µW. The output swing ranges to within a few millivolts of the supply voltages.\

Of particular significance is the extremely low (1pA) input current, input noise current of 0.01pA/√Hz, and 1012Ω input impedance. These features optimize performance in very high source impedance applications.

The inputs are internally protected. Outputs are fully protected against short circuits to ground or to either supply. AC performance is excellent, with a slew rate of 1.6V/µs, and unity gain bandwidth of 1MHz at IQ = 1mA. Because of the low power dissipation, junction temperature rise and drift are quite low. Applications utilizing these features may include stable instruments, extended life designs, or high density packages.

Features

• Wide Operating Voltage Range . . . . ˆ}1V to ˆ}8V

• High Input Impedance 1012Ω

• Programmable Power Consumption. . . . . . Low as 20µW

• Input Current Lower Than BIFETs . . . . 1pA (Typ)

• Output Voltage Swing . . . . V+ and V-

• Input Common Mode Voltage Range Greater Than Supply Rails (ICL7612)

Applications

• Portable Instruments

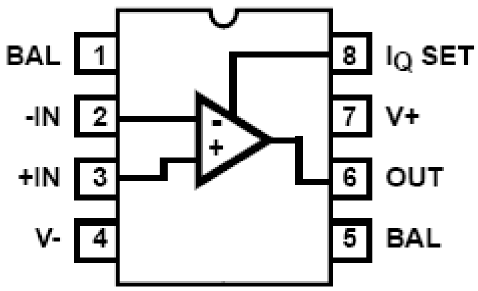
• Telephone Headsets

• Hearing Aid/Microphone Amplifiers

• Meter Amplifiers

• Medical Instruments

• High Impedance Buffers



Absolute Maximum Ratings Thermal Information:

Supply Voltage V+ to V- 18V

Input Voltage . . . . V- -0.3 to V+ +0.3V

Differential Input Voltage (Note 1) . . . . [(V+ +0.3) - (V- -0.3)]V

Duration of Output Short Circuit (Note 2). . . . . Unlimited

Operating Conditions:

Temperature Range

ICL76XXC . . . . $0C^0$ to $70C^0$

CAUTION: Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

1. Long term offset voltage stability will be degraded if large input differential voltages are applied for long periods of time.

2. The outputs may be shorted to ground or to either supply, for VSUPPLY ≤10V. Care must be taken to insure that the dissipation rating is not exceeded.

3. θJA is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications V_{SUPPLY} = ±5V, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	ICL7611B, ICL7612B			ICL7611D, ICL7612D			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	$R_S \le 100k\Omega$	25	-	-	5	-	-	15	mV
			Full	-	-	7	-	-	20	mV
Temperature Coefficient of V_{OS}	$\Delta V_{OS}/\Delta T$	$R_S \le 100k\Omega$	-	-	15	-	-	25	-	μV/°C
Input Offset Current	I_{OS}		25	-	0.5	30	-	0.5	30	pA
			Full	-	-	300	-	-	300	pA
Input Bias Current	I_{BIAS}		25	-	1.0	50	-	1.0	50	pA
			Full	-	-	400	-	-	400	pA
Common Mode Voltage Range (Except ICL7612)	V_{CMR}	I_Q = 10μA	25	±4.4	-	-	±4.4	-	-	V
		I_Q = 100μA	25	±4.2	-	-	±4.2	-	-	V
		I_Q = 1mA	25	±3.7	-	-	±3.7	-	-	V
Extended Common Mode Voltage Range (ICL7612 Only)	V_{CMR}	I_Q = 10μA	25	±5.3	-	-	±5.3	-	-	V
		I_Q = 100μA	25	+5.3, -5.1	-	-	+5.3, -5.1	-	-	V
		I_Q = 1mA	25	+5.3, -4.5	-	-	+5.3, -4.5	-	-	V
Output Voltage Swing	V_{OUT}	I_Q = 10μA, R_L = 1MΩ	25	±4.9	-	-	±4.9	-	-	V
			Full	±4.8	-	-	±4.8	-	-	V
		I_Q = 100μA, R_L = 100kΩ	25	±4.9	-	-	±4.9	-	-	V
			Full	±4.8	-	-	±4.8	-	-	V
		I_Q = 1mA, R_L = 10kΩ	25	±4.5	-	-	±4.5	-	-	V
			Full	±4.3	-	-	±4.3	-	-	V
Large Signal Voltage Gain	A_{VOL}	V_O = ±4.0V, R_L = 1MΩ, I_Q = 10μA	25	80	104	-	80	104	-	dB
			Full	75	-	-	75	-	-	dB
		V_O = ±4.0V, R_L = 100kΩ, I_Q = 100μA	25	80	102	-	80	102	-	dB
			Full	75	-	-	75	-	-	dB
		V_O = ±4.0V, R_L = 10kΩ, I_Q = 1mA	25	76	83	-	76	83	-	dB
			Full	72	-	-	72	-	-	dB

Electrical Specifications V_{SUPPLY} = ±5V, Unless Otherwise Specified **(Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	ICL7611B, ICL7612B MIN	TYP	MAX	ICL7611D, ICL7612D MIN	TYP	MAX	UNITS
Unity Gain Bandwidth	GBW	I_Q = 10μA	25	-	0.044	-	-	0.044	-	MHz
		I_Q = 100μA	25	-	0.48	-	-	0.48	-	MHz
		I_Q = 1mA	25	-	1.4	-	-	1.4	-	MHz
Input Resistance	R_{IN}		25	-	10^{12}	-	-	10^{12}	-	Ω
Common Mode Rejection Ratio	CMRR	R_S ≤ 100kΩ, I_Q = 10μA	25	70	96	-	70	96	-	dB
		R_S ≤ 100kΩ, I_Q = 100μA	25	70	91	-	70	91	-	dB
		R_S ≤ 100kΩ, I_Q = 1mA	25	60	87	-	60	87	-	dB
Power Supply Rejection Ratio (V_{SUPPLY} = ±8V to ±2V)	PSRR	R_S ≤ 100kΩ, I_Q = 10μA	25	80	94	-	80	94	-	dB
		R_S ≤ 100kΩ, I_Q = 100μA	25	80	86	-	80	86	-	dB
		R_S ≤ 100kΩ, I_Q = 1mA	25	70	77	-	70	77	-	dB
Input Referred Noise Voltage	e_N	R_S = 100Ω, f = 1kHz	25	-	100	-	-	100	-	nV/√Hz
Input Referred Noise Current	i_N	R_S = 100Ω, f = 1kHz	25	-	0.01	-	-	0.01	-	pA/√Hz
Supply Current (No Signal, No Load)	I_{SUPPLY}	I_Q SET = +5V, Low Bias	25	-	0.01	0.02	-	0.01	0.02	mA
		I_Q SET = 0V, Medium Bias	25	-	0.1	0.25	-	0.1	0.25	mA
		I_Q SET = -5V, High Bias	25	-	1.0	2.5	-	1.0	2.5	mA
Channel Separation	V_{O1}/V_{O2}	A_V = 100	25	-	120	-	-	120	-	dB
Slew Rate (A_V = 1, C_L = 100pF, V_{IN} = $8V_{P-P}$)	SR	I_Q = 10μA, R_L = 1MΩ	25	-	0.016	-	-	0.016	-	V/μs
		I_Q = 100μA, R_L = 100kΩ	25	-	0.16	-	-	0.16	-	V/μs
		I_Q = 1mA, R_L = 10kΩ	25	-	1.6	-	-	1.6	-	V/μs
Rise Time (V_{IN} = 50mV, C_L = 100pF)	t_r	I_Q = 10μA, R_L = 1MΩ	25	-	20	-	-	20	-	μs
		I_Q = 100μA, R_L = 100kΩ	25	-	2	-	-	2	-	μs
		I_Q = 1mA, R_L = 10kΩ	25	-	0.9	-	-	0.9	-	μs
Overshoot Factor (V_{IN} = 50mV, C_L = 100pF)	OS	I_Q = 10μA, R_L = 1MΩ	25	-	5	-	-	5	-	%
		I_Q = 100μA, R_L = 100kΩ	25	-	10	-	-	10	-	%
		I_Q = 1mA, R_L = 10kΩ	25	-	40	-	-	40	-	%

Electrical Specifications V_{SUPPLY} = ±1V, I_Q = 10μA, Unless Otherwise Specified

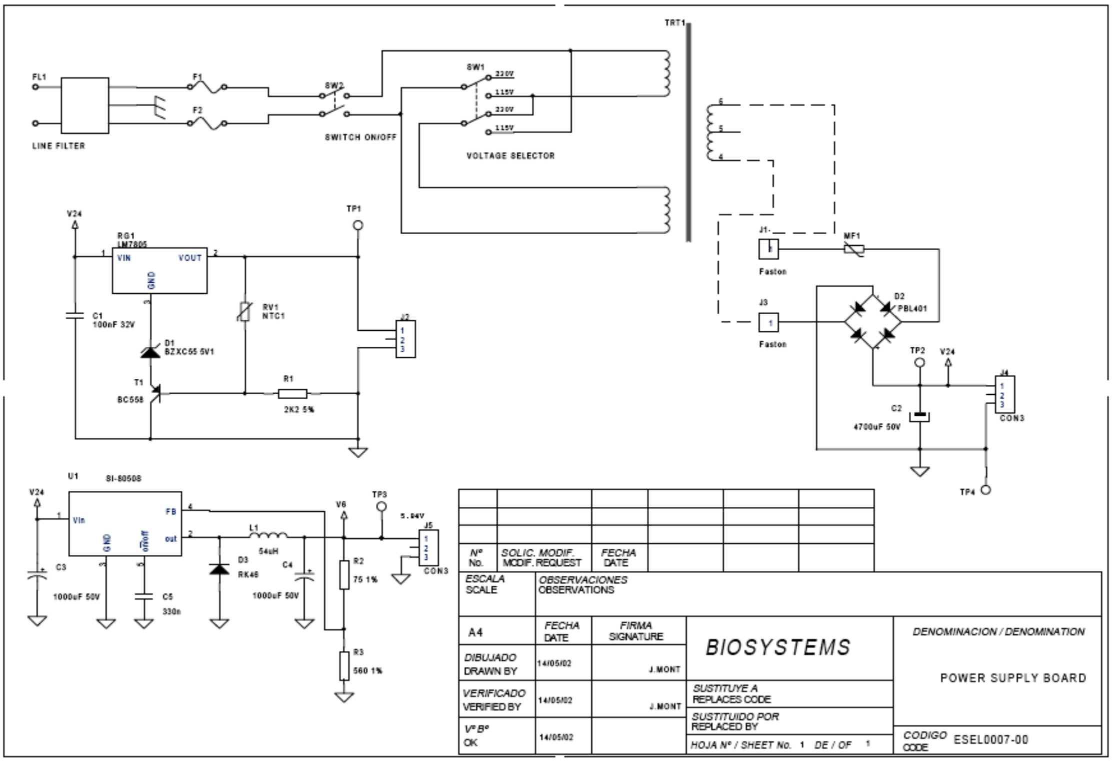
PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	ICL7611B, ICL7612B MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}	R_S ≤ 100kΩ	25	-	-	5	mV
			Full	-	-	7	mV
Temperature Coefficient of V_{OS}	$\Delta V_{OS}/\Delta T$	R_S ≤ 100kΩ	-	-	15	-	μV/°C
Input Offset Current	I_{OS}		25	-	0.5	30	pA
			Full	-	-	300	pA
Input Bias Current	I_{BIAS}		25	-	1.0	50	pA
			Full	-	-	500	pA
Common Mode Voltage Range (Except ICL7612)	V_{CMR}		25	±0.6	-	-	V

Electrical Specifications V_{SUPPLY} = ±1V, I_Q = 10µA, Unless Otherwise Specified **(Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	ICL7611B, ICL7612B MIN	TYP	MAX	UNITS
Extended Common Mode Voltage Range (ICL7612 Only)	V_{CMR}		25	+0.6 to -1.1	-	-	V
Output Voltage Swing	V_{OUT}	R_L = 1MΩ	25	±0.98	-	-	V
			Full	±0.96	-	-	V
Large Signal Voltage Gain	A_{VOL}	V_O = ±0.1V, R_L = 1MΩ	25	-	90	-	dB
			Full	-	80	-	dB
Unity Gain Bandwidth	GBW		25	-	0.044	-	MHz
Input Resistance	R_{IN}		25	-	10^{12}	-	Ω
Common Mode Rejection Ratio	CMRR	R_S ≤ 100kΩ	25	-	80	-	dB
Power Supply Rejection Ratio	PSRR	R_S ≤ 100kΩ	25	-	80	-	dB
Input Referred Noise Voltage	e_N	R_S = 100Ω, f = 1kHz	25	-	100	-	nV/√Hz
Input Referred Noise Current	i_N	R_S = 100Ω, f = 1kHz	25	-	0.01	-	pA/√Hz
Supply Current	I_{SUPPLY}	No Signal, No Load	25	-	6	15	µA
Slew Rate	SR	A_V = 1, C_L = 100pF, V_{IN} = 0.2V_{P-P}, R_L = 1MΩ	25	-	0.016	-	V/µs
Rise Time	t_r	V_{IN} = 50mV, C_L = 100pF R_L = 1MΩ	25	-	20	-	µs
Overshoot Factor	OS	V_{IN} = 50mV, C_L = 100pF, R_L = 1MΩ	25	-	5	-	%

APPENDIX J the Wavelengths of absorbed and observed colors:

Solution color	**Absorbed color**	**λ absorbed (nm)**
Green-Yellow	Violet	380-420
Yellow	Violet-blue	420-440
Orange	Blue	440-470
Red	Blue-Green	470-500
Purple-Red	Green	500-520
Violet	Yellow-Green	520-550
Violet-Blue	Yellow	550-580
Blue	Orange	580-620
Blue-Green	Red	620-680
Gree	Red	680-780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F1
F2
SW2
SWITCH ON/OFF
SW1
220V
115V
VOLTAGE SELECTOR
J1
Faston
J3
MF1
D2
PBL401
TP2
V24
C2
4700uF 50V
J4
CON3
TP4
V24
RG1
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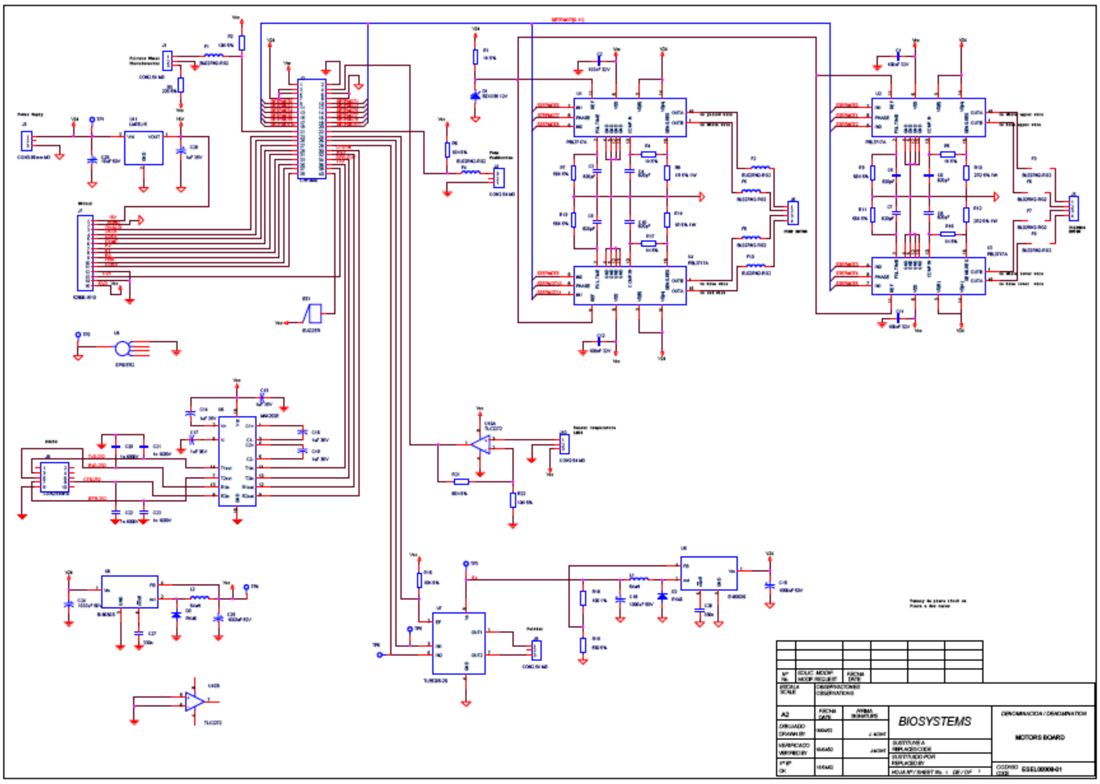
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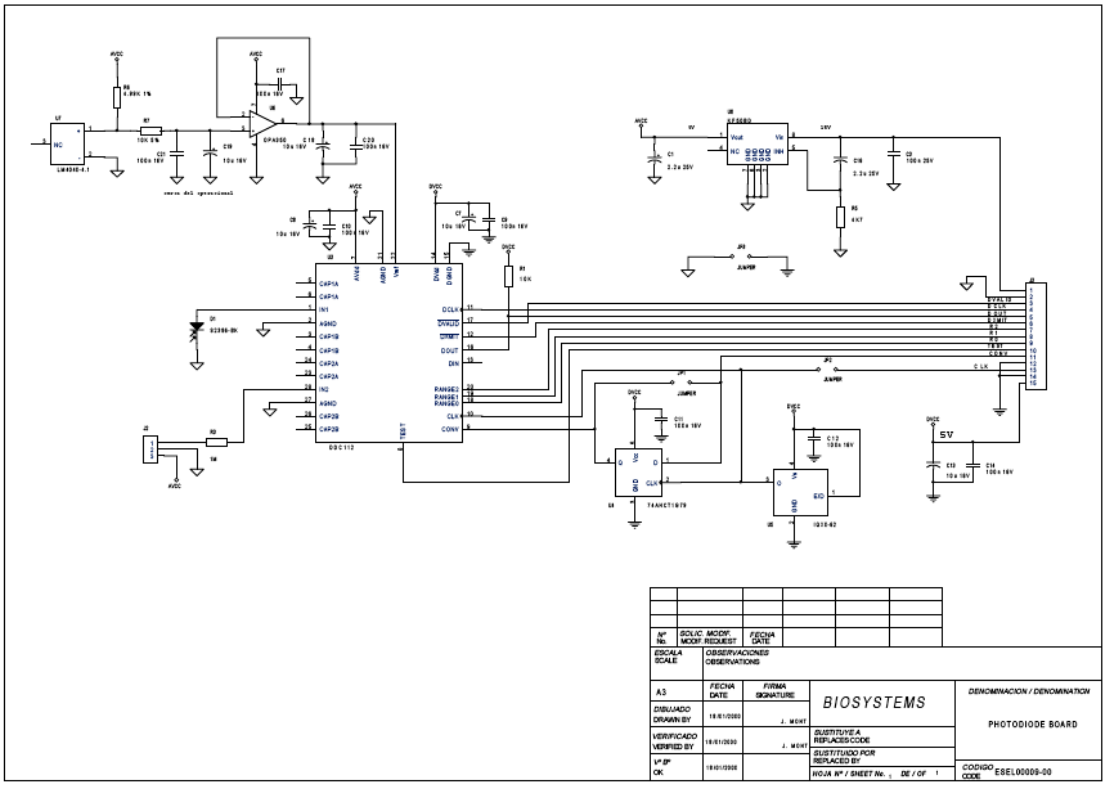
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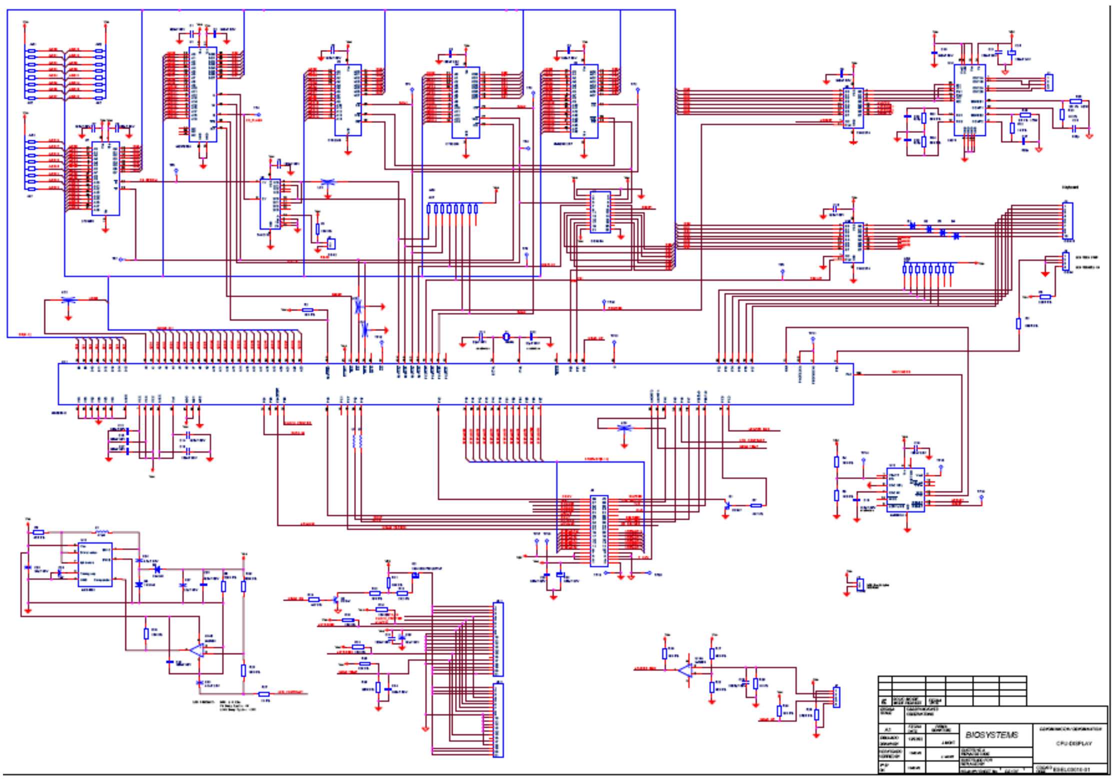
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APPENDIX K normal and pathological reading

Normal reading

	Phosphate	Urea	Uric acid	Albumin	Glucose	Control Phosphate	Control Urea	Control Uric acid	Control Albumin	Control Glucose
1	7.30	26.00	6.40	28.00	90.50	7.31	26.70	5.93	24.90	86.50
2	7.32	26.40	5.80	20.50	74.20	7.31	26.70	5.93	24.90	86.50
3	7.36	24.00	6.20	27.80	86.50	7.31	26.70	5.93	24.90	86.50
4	6.90	26.50	6.30	26.00	74.00	7.31	26.70	5.93	24.90	86.50
5	7.35	26.70	5.20	26.50	92.30	7.31	26.70	5.93	24.90	86.5

										0
6	7.80	29.65	6.45	28.80	88.60	7.31	26.70	5.93	24.90	86.50
7	7.37	26.40	6.56	27.00	75.50	7.31	26.70	5.93	24.90	86.50
8	7.00	23.40	5.30	26.00	98.50	7.31	26.70	5.93	24.90	86.50
9	7.00	26.50	6.89	27.00	75.90	7.31	26.70	5.93	24.90	86.50
10	10.00	26.50	6.90	26.50	99.00	7.31	26.70	5.93	24.90	86.50

Pathological reading

	Phosphate	**Urea**	**Uric acid**	**Albumin**	**Glucose**	**Control Phosphate**	**Control Urea**	**Control Uric acid**	**Control Albumin**	**Control Glucose**
1	35.90	20.50	9.60	37.50	12.90	22.90	25.80	37.50	9.68	14.70

2	25.50	22.90	9.00	30.90	14.70	22.90	25.80	37.50	9.68	14.70
3	25.50	19.50	9.60	44.00	14.00	22.90	25.80	37.50	9.68	14.70
4	38.50	26.00	8.50	37.50	16.90	22.90	25.80	37.50	9.68	14.70
5	13.00	22.90	9.60	30.80	15.00	22.90	25.80	37.50	9.68	14.70
6	25.50	24.50	10.50	35.00	14.70	22.90	25.80	37.50	9.68	14.70
7	30.00	23.00	9.60	39.50	16.50	22.90	25.80	37.50	9.68	14.70
8	25.50	22.90	11.00	38.00	14.90	22.90	25.80	37.50	9.68	14.70
9	33.50	25.50	10.50	40.50	15.50	22.90	25.80	37.50	9.68	14.70
10	25.50	22.90	8.50	37.50	14.70	22.90	25.80	37.50	9.68	14.70

APPENDIX L Bio-system reagent datasheet