



Design of Portable Optical Vein Finder

Graduation Team:

Ehab Qtet

Wesam Dababseh

Supervisor:

Eng. Ali Amro

Bachelor Degree in Biomedical Engineering

Palestine Polytechnic University

January 2018

Abstract

Several people are unlucky with veins that are hard to stick. Some of them just have small veins that are hard to feel for and hard to get a needle into, other fat people tend to have their veins buried deeper and are thus harder to find. In this case, phlebotomists need several tries to find the vein and stick it properly, wasting their time and effort, and creating pain to these patients.

This project aims to build a portable vein finder, that uses visible and near infrared radiations (NIR)light. The system will help the phlebotomists to explore the vein easily by applying a visible and NIR wavelengths on the patient's arm.it will use processing unit to control light intensity to provide the phlebotomists with the place of the patients vein within a one seconds. Hence, reducing the patient pain, and saving phlebotomists effort and time.

المخلص

معظم الاشخاص لسوء الحظ من الصعب ابراز الاورده لديهم , فبعضهم يملكون اورده صغيرة صعب ايجادها عند عملية حقن الإبرة , واخرون أشخاص دهنين يملكون اورده عميقة من الصعب ايجادها بسهولة. في هذه الحالة الشخص المختص بسحب الدم يحتاج للقيام بعدة اجراءات لايجاد الوريد وابرازه بشكل واضح , قد يضيع من وقته وجهده و يسبب الالم للمرضى.

يهدف هذا المشروع الى تصميم وبناء نموذج لكاشف وريد محمول, يستخدم اطوال ضوئية و اشعه تحت حمراء (قريبة) . هذا النظام سيساعد المختص لاكتشاف الوريد بسهولة عند تطبيق اشعة تحت حمراء بأطوال موجية مختلفة على ذراع المرضى, وسيستخدم وحدات معالجة للتحكم بشدة الاضاءة وذلك لتزويد المختصين بموقع اورده المرضى باقل وقت ممكن . وبالتالي يقل الم المريض , ويوفر وقت وجهد على المختصين .

"كن عالماً . . فإن لم تستطع فكن متعلماً ، فإن لم تستطع فأحب العلماء ، فإن لم تستطع فلا تبغضهم"

إلهي لا يطيب الليل إلا بشكرك ولا يطيب النهار إلا بطاعتك . . ولا تطيب اللحظات إلا بذكرك . . ولا تطيب الآخرة إلا بعفوك . .

ولا تطيب الجنة إلا برويتك. نحمد الله عز وجل على نعمه التي من بها علينا فهو العلي القدير

لا يسعنا إلا أن نخض بأسمى عبارات الشكر والتقدير للمهندس المشرف " علي عمرو" لما قدمه لنا من جهد ونصح ومعرفة طيلة

انجاز هذا البحث

كما نتقدم بالشكر الجزيل لكل من أسهم في تقديم يد العون لنا، إلى من زرعو التفاؤل في دربنا وقدموا لنا المساعدات والتسهيلات

والمعلومات ونخض بالذكر "أستاذتنا الكرام"

إلى من كلفه الله بالهيبة والوقار . . إلى من علمني العطاء بدون انتظار . . إلى من أحمل أسمه بكل افتخار . . أرجو من الله أن يمد

في عمرك لترى ثماراً قد حان قطافها بعد طول انتظار وستبقى كلماتك نجوم أهدي بها اليوم وفي الغد وإلى الأبد " ابي "

إلى ملاكي في الحياة . . إلى معنى الحب وإلى معنى الحنان والتقاني . . إلى بسمة الحياة وسر الوجود

إلى من كان دعائها سر نجاحي وحنانها بلسم جراحي إلى أغلى الحبايب " أمي الحبيبة"

إلى من رافقتني منذ أن حملنا حقائب صغيرة ومعك سرت الدرب خطوة بخطوة وما تزال ترافقني حتى الآن . . إلى شمعة متقدة تنير"

أختي "

إلى رفيق دربي في هذه الحياة ، معك أكون أنا وبدونك أكون مثل أي شيء ، إلى من أرى التفاؤل بعينه والسعادة في ضحكته . . في

نهاية مشواري أريد أن أشكر ك على مواقفك النبيلة إلى من تطلعت لتجاعي بنظرات الأمل " أخي "

إلى الإخوة و الأخوات ، إلى من تحلو بالإخاء وتميزوا بالوفاء والعطاء إلى ينابيع الصدق الصافي إلى من معهم سعدت ، وبرفتهم في دروب الحياة الحلوة والخزينة سرت إلى من كانوا معي على طريق النجاح والخير إلى من عرفت كيف أجدهم وعلموني أن لا أضيعهم"

أصدقائي"

Chapter 1

Introduction

1.1 Project Idea Description

1.2 Main Objective

1.3 List of Abbreviation

1.4 Economical Study

1.5 Schedule Time

Introduction

Several medical imaging purposes are based on using near-infrared (NIR) window ,such as spectroscopy and tomography.In the70s,visualization of peripheral blood vessels was explored by several researchers for the first time, using infrared (IR) photography or a TV infrascopes, these methods did not allow real-time visualization.

More recently, due to technological developments, new techniques have become available to make real-time NIR imaging possible, mostly due to intension arrow band visible and NIR light sources (light emitting diodes, LEDs) and cameras with a high sensitivity for NIR light. The new methods of visualization of blood vessels were not immediately used to facilitate peripheral venous or arterial access, but for biometric identifications by vein patterns, monitoring of physiological parameters such as local blood flow and oxygenation. However, more recently, several researchers have explored the possibility of using visualization of blood vessels to facilitate peripheral venous or arterial access.

At the start of the research described in this thesis, only the Vein finder at that moment still a bulky device, and the Vascular Viewer were available, but rather expensive. Therefore ,in this project the relatively low cost ,vascular imaging system based on trans illumination of visible and NIR light.

1.1 Project idea description

During blood draw in the hospitals and medical clinics, sometime phlebotomists cannot find properly the location of veins for dark skin and obesity patients. The idea of this project is to design a vascular access medical device that can helpphlebotomists in finding the optimal venipuncture site and avoid potential complications. The hemoglobin in our blood absorbs IR light. A vein finder that shines IR light on skin causes veins to become much more visible to the naked eye. IR is at the red of the color spectrum so we will design device include red lamps as well as IR to make the light visible.

we well designed affordable and very portable device, where its good to use on both children and adult. A small simulation of the original device by shedding wavelengths near IR on the patient's arm , to operate it has only an on/off switch and runs off a AA batteries ,the batteries are predicted to last between (5_8) hours of continuous use, when they begin to get low, the alarm on analog control it blinking .

1.2 Main objective

- Design of a portable medical device from the detection of veins in the for normal people arms.
- Help the medical staff find the vein easily when blood samples are drawn especially for people with dark to skin and obese.
- Reduce the patient's pain and side effects resulting from the traditional search on the vein.
- Provide the time and effort of medical staff lost in conventional vein search.

1.3 List of abbreviation

Table 1.1: List of Abbreviation

Abbreviation	Full Meaning
VV	VeinViewer
NIR	Near Infrared Red
LED	Light Emitting Diodes
IR	InfraRed
V	Voltage
nm	Nano meter
UV	Ultra violet
DC	Direct current

1.4 Budget

In this section a list of estimated cost of the project components is presented that are used in design device, this cost shown in table(1.2).

Type	Price	Quantity
Arduino Nano	40\$	1
LEDsCR5111A-WY	15\$	12
LED690-03AU	15\$	12
LEDs ELD-650	15\$	12
Datec-Pocket-Box	20\$	1
RESISTOR	5\$	36
Total price	\$110	

Table 1.2:project Components Cost.

1.5 Time schedule

In this part show plan for the work project tasks and time schedule in the semester ,this time plan shown in the table (1.3) and table (1.4)

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Task															
Collect Information	█	█	█	█											
Basic Design					█	█	█	█							
Specification Design									█	█	█	█	█		
Documentation				█	█	█	█	█	█	█	█	█	█	█	
													█	█	█

Table 1.3: Timing Schedule of the First Semester.

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Task																
Full Designing	█	█	█	█												
Purchasing the components				█	█	█	█	█								
System Implementation					█	█	█	█	█	█	█					
System analysis									█	█	█	█				
Documentation											█	█	█	█		

Table 1.4: Timing Schedule of the Second Semester.

Chapter 2

Anatomical and Physiological of the Skin

Skin is the outermost tissue of the body and the largest organ in terms of both weight and surface area. It has an area of approximately 16,000cm² for an adult and represents about 8% of the body weight. skin has a very complex structure that consists of many components as shown in fig(2.1) . Cells, fibers and other components make up several different layers that give skin a multi-layered structure. Veins, capillaries and nerves form vast networks inside this structure. In addition ,hairs stick out from the inside of skin. Numerous fine hair are scattered over the surface of skin.

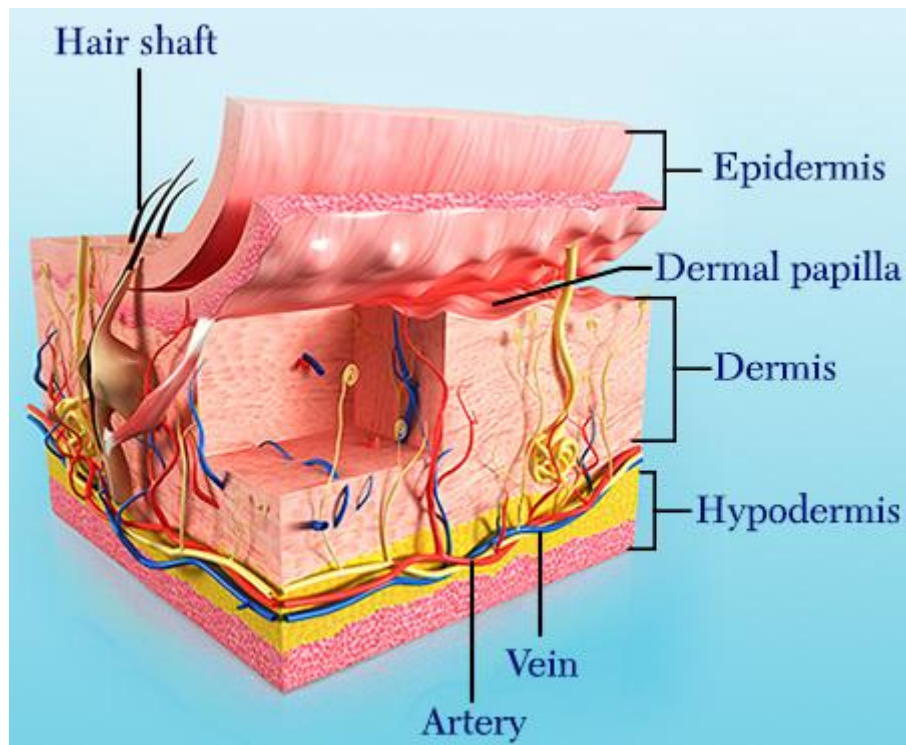


Fig 2.1: sectional schematic diagram of skin[1]

1.2 Skin anatomy

The largest organ of the body is the skin, which is multilayered with its three main layers being epidermis, dermis and the subcutaneous layer, also called the hypodermis. Fig

(2.2) shows the section of skin. The epidermis is the outermost layer and does not contain any blood vessels. It allows light to pass through it owing to its presence in the superficial section of skin. The middle layer known as the dermis contains capillaries, glands and hair

follicles. Diffusion takes place between the dermis and epidermis to provide nutrient supply. The hypodermis lying above the muscle and bone is the lowermost layer in the skin consisting of fat cells, veins, arteries and nerves. The amount of subcutaneous fat in this layer determines the penetration of light into tissue beneath it [2]. Children possess skin of lesser thickness as compared to adults. The depth of epidermis ranges from 0.027 – 0.15mm and that of dermis ranges from 0.6 – 3mm. The hypodermal thickness can be between 0 – 3mm with the maximum in the abdomen [3].

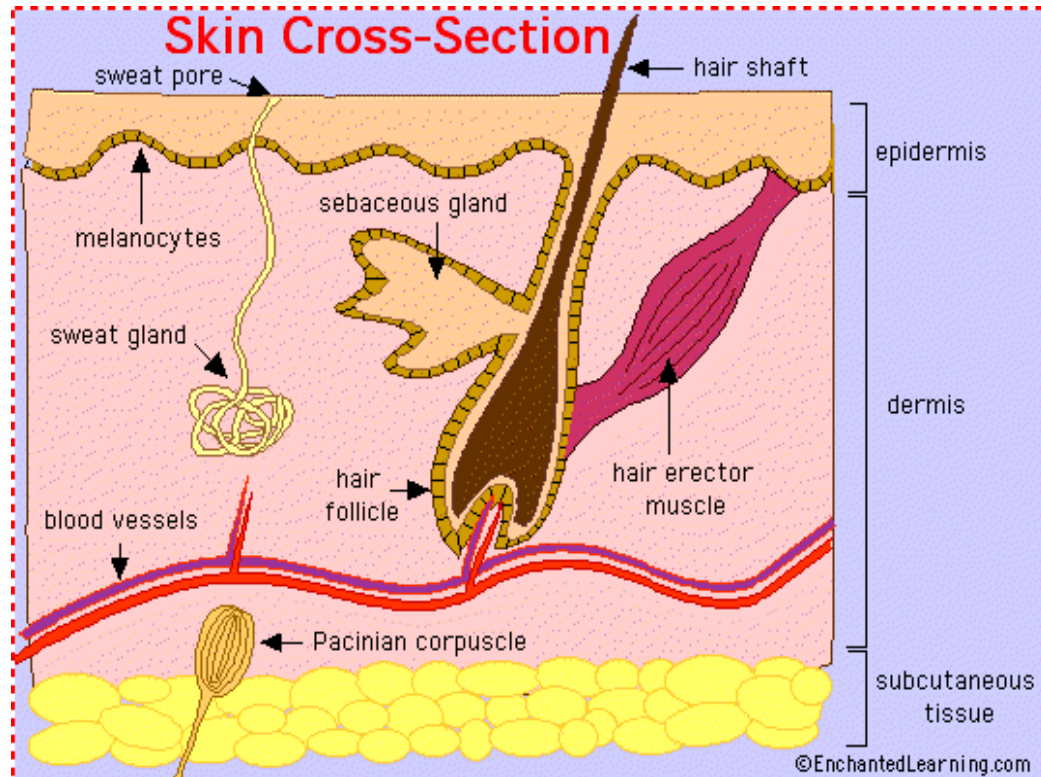


Fig 2.2: Section of human skin.[4]

2.1.1 Epidermis

The epidermis is the outer layer of skin. The thickness of the epidermis varies in different types of skin. It is the thinnest on the eyelids at 0.05 mm and the thickest on the palms and soles at 1.5 mm. [5]

The epidermis contains 5 layers. The layers are named from bottom to top as shown in figures (2.3):

- Stratum Basale
- Stratum Spinosum
- Stratum Granulosum
- Stratum Lucidum
- Stratum Corneum.

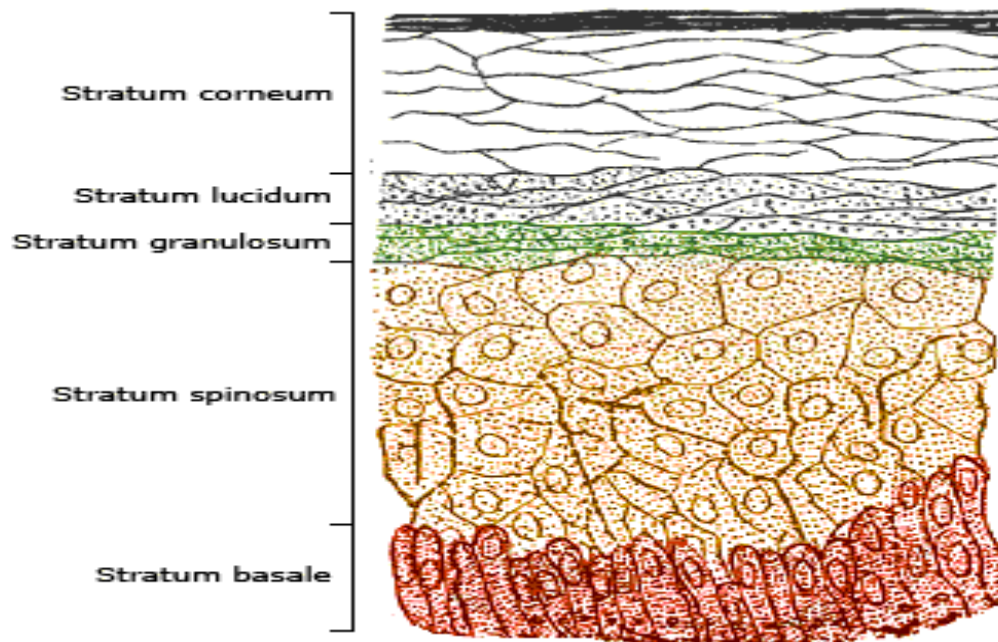


Fig 2.3: The Epidermis Layers[6]

2.1.2 Dermis

The dermis also varies in thickness depending on the location of the skin, as shown in figure(2.4). It is 0.3 mm on the eyelid and 3.0 mm on the back. The types of dermis are: [7]

- Collagen
- Elastic tissue
- Reticular fibers

The dermis has three layers, these layers are: two layers of the dermis are the papillary and reticular layers, the upper papillary layer, contains a thin arrangement of collagen fibers and the lower reticular layer, is thicker and made of thick collagen fibers that are arranged parallel to the surface of the skin.

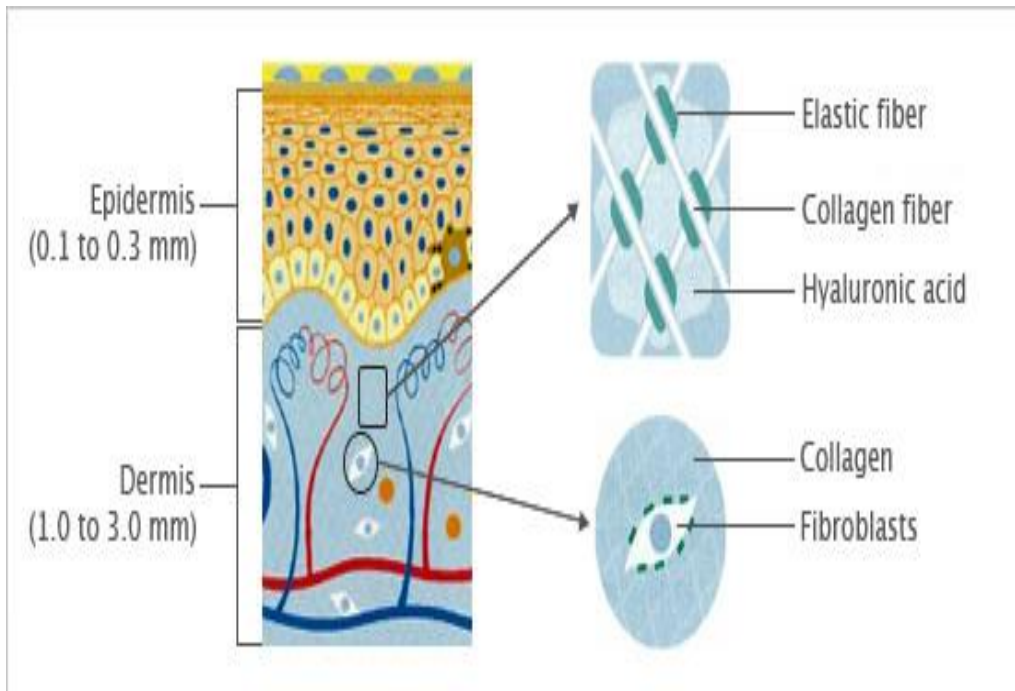


Fig 2.4: Dermis[8]

2.1.3 Subcutaneous tissue

Is a layer of fat and connective tissue that houses larger blood vessels and nerves. This layer is important in the regulation of temperature of the skin itself and the body. The size of this layer varies throughout the body and from person to person. The skin is a complicated structure with many functions. If any of the structures in the skin are not working properly, a rash or abnormal sensation is the result. The whole specialty of dermatology is devoted to understanding the skin, what can go wrong, and what to do if something does go wrong. [9]

2.2 Skin physiology

The skin performs five main functions:

1. Regulation of body temperature
2. Protection
3. Sensation
4. Excretion
5. Synthesis of vitamin D

2.3 Skin optics

Studying the phenomena of light transport in tissue will give a better understanding of the working of the Vein finder system. Fig(2.5) depicts the scattering of light in human tissue. The light beam that is incident on the skin undergoes absorption, scattering and reflection by the various layers of tissue at different depths. The characteristics of light propagation differ with respect to each layer in the skin. The reflection of light from the skin surface is called specular reflection. Light that is specularly reflected does not permit light to propagate through internal tissue and can thus add glare to a vein image.

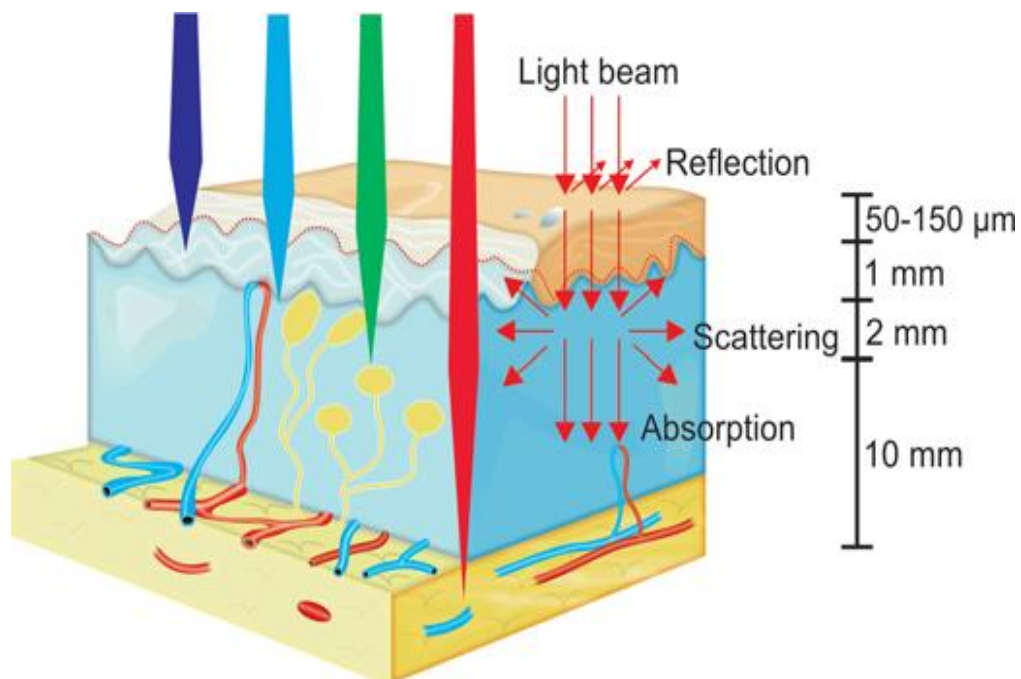


Fig 2.5: Propagation of light in various tissues.[10]

A three-compartment model of skin is considered which consists of epidermis, dermis and subcutaneous layer. The epidermal layer absorbs some light and transmits light into the tissue layers beneath it after scattering. A lot of scattering occurs in the dermis before it propagates to the hypodermal layer while a part of the light is absorbed. Fat scatters a major portion of light and absorbs very little. Some of the light reaching blood in the vessels is absorbed by the hemoglobin present in it, while some is scattered mostly in the forward direction due to

the large size of the red blood cells. It has been reported that the blood in the veins is dominated by deoxy-hemoglobin with the oxy-hemoglobin content concentration around 47% while that in the arteries contains more oxy-hemoglobin (90% – 95%) [2, 5]. Both types of hemoglobin possess different light absorption properties as shown in Fig (2.6) [11]. Both types exhibit almost the same absorption characteristics till the wavelength of 600nm. It can be understood that the absorption of light by veins is higher than that by arteries between the wavelengths of 600nm – 800nm. The curve falls rapidly for the deoxyhemoglobin while it rises a little and then falls for the oxy-hemoglobin.

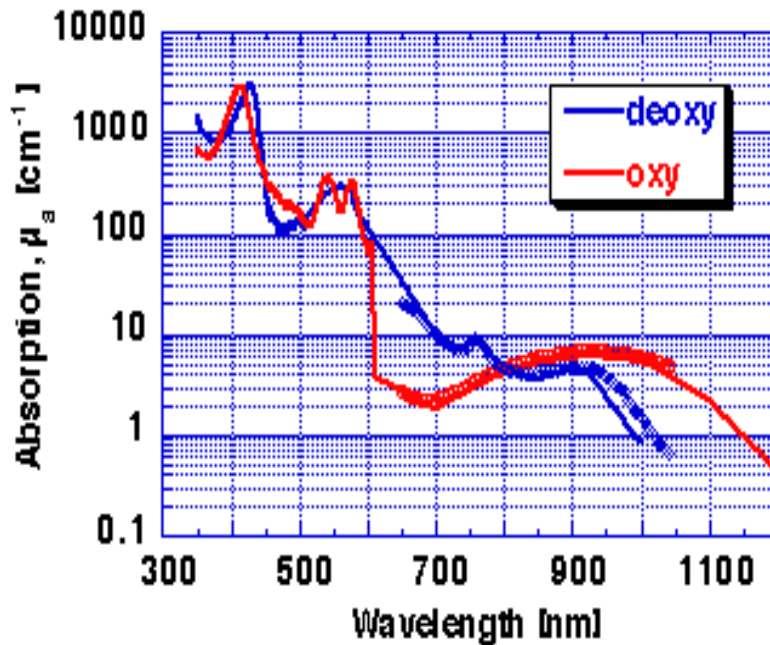


Fig 2.6: Absorption of oxy and deoxy-hemoglobin of whole blood.[12]

Light at different wavelengths reaches different depths when it travels through tissue as seen in Fig (2.7). The bars in Fig (2.7) indicate the extent of transmission of light in all

layers of the skin at various wavelengths. Visible light wavelengths range from 400nm – 700nm while infrared(IR) wavelengths range from 700nm – 1000 nm. Light at wavelengths between 300nm and 400nm reach only the epidermal and dermal sections of the skin which do not contain any veins. Light at near-infrared(NIR) wavelengths (700 – 1000nm) is less absorbed by other tissue and reaches the blood vessels in the subcutaneous tissue. The VV utilizes this phenomenon to view veins which cannot be visualized in visible light. The principle of working of the VV system is based on tissue-light interaction in the body. The clinical utility of the VV system determined from prior studies on pediatric subjects is also discussed.

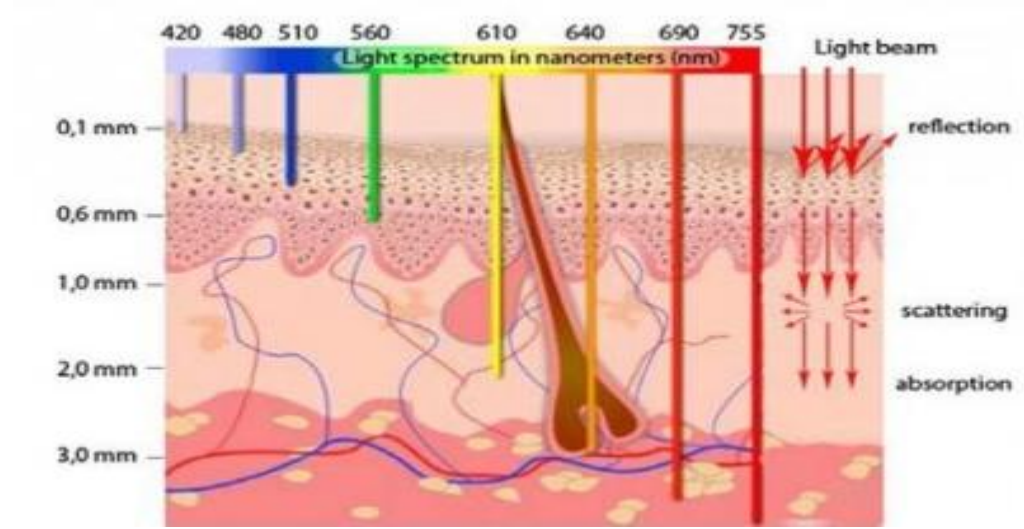


Fig2.7: Light propagation at different wavelengths in tissue.[13]

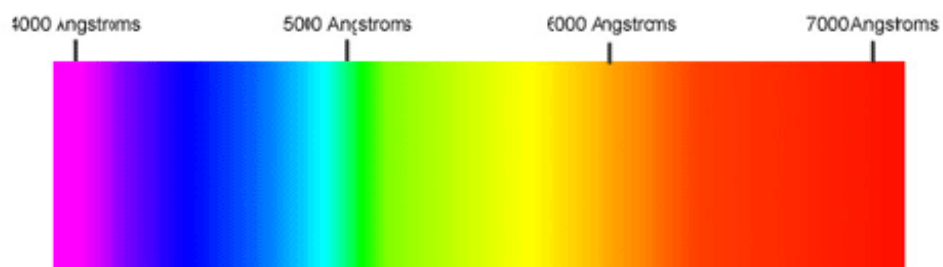
Chapter 3

Interaction of Near Infrared with Tissue in Vein Finder

3.1 Electromagnetic spectrum

Wavelength, distance between corresponding points of two consecutive waves. Corresponding points” refers to two points or particles in the same phase—i.e., points that have completed identical fractions of their periodic motion. Usually, in transverse waves (waves with points oscillating at right angles to the direction of their advance), wavelength is measured from crest to crest or from trough to trough; in longitudinal waves (waves with points vibrating in the same direction as their advance), it is measured from compression to compression or from rarefaction to rarefaction. Wavelength is usually denoted by the Greek letter lambda (λ); it is equal to the speed (v) of a wave train in a medium divided by its frequency (f): $\lambda = v/f$.

The order of colors in light, arranged from shortest wavelength to longest, is called the visible spectrum of light. The figure(3.1) shows light's visible spectrum, which runs from violet to red. You might recognize the spectrum as the order of colors in a rainbow.



But light waves can also have wavelengths lower or higher than the wavelengths in the visible spectrum, and many familiar types of radiation are just light waves with other wavelengths. Ultraviolet light and x-rays have wavelengths shorter than violet light, and infrared (heat) and radio waves have wavelengths longer than red light.

The full range of wavelengths for light is called the "electromagnetic spectrum." The figure(3.2) show which wavelength ranges in the electromagnetic spectrum correspond to light types.

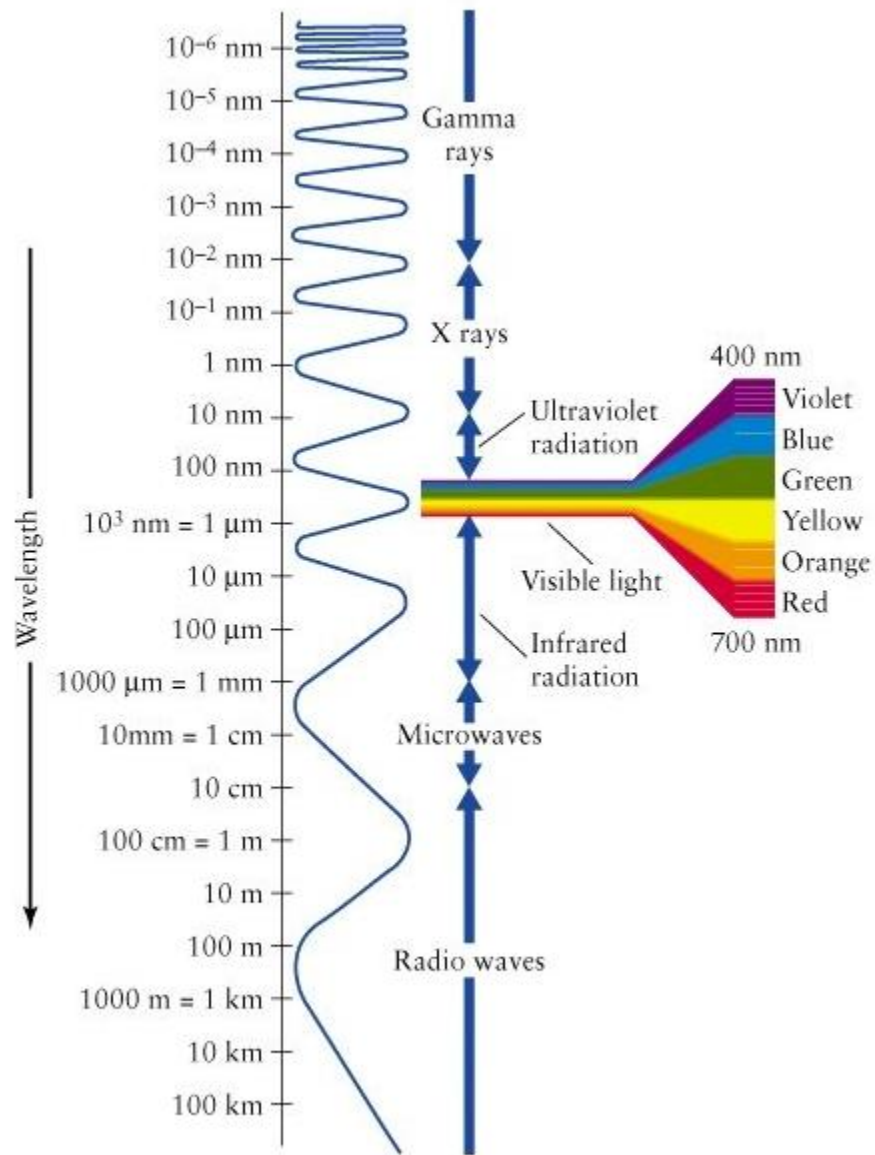


Figure 3.2: wavelength ranges in the electromagnetic spectrum correspond to which types of light.[14]

3.2 Near-Infrared Light

Near-infrared (NIR) light is electromagnetic radiation with a longer wavelength (from 650nm up to 3000nm) than visible light (350–660)nm, as depicted in figure (3.3) which

shows ultraviolet (UV) light, visible (VIS) light and near-infrared (NIR) light. The near-infrared window is shown in grey. It is invisible to the human eye.

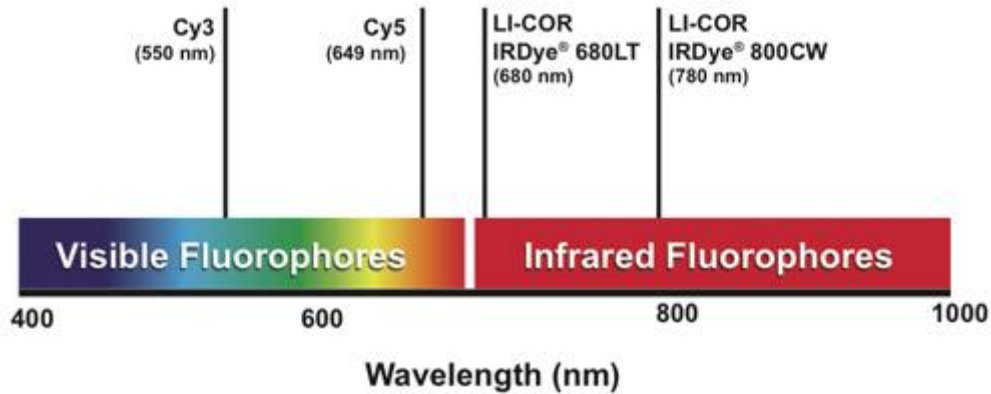


Figure 3.3: Part of the electromagnetic spectrum [15]

Infrared waves are longer than those of visible light, just beyond the red end of the visible spectrum. Infrared (IR) falls in the range of the (EM) spectrum between microwaves and visible light. It has frequencies from about 3 GHz up to about 400 THz and wavelengths of about 30 centimeters (12 inches) to 740 nanometers (0.00003 inches).

3.2.1 Visible light and near-Infrared Light interaction with biological tissues

Behavior of (near-infrared) light in tissue is characterized mainly by two phenomena: absorption and scattering as shown in figure (3.4). A light particle (photon) can be absorbed by molecules known as chromophores during interaction with tissue the photon can also be redirected during interaction with molecules, which is called scattering. The amount of absorption and scattering is wavelength and tissue (chromophore) dependent and is determined respectively by the absorption coefficient μ_a and the scattering coefficient μ_s [1]. There is a preferred direction of scattering depending on wavelength and size of the chromophores, described by anisotropy factor g (mean cosine scattering angle) [16]. For the

amount of forward scattering, the reduced scattering coefficient μ_0 is used, which is defined as $\mu_s(1-g)$. Figure (3.4) shows a schematic view of an absorption event and a scattering event when a photon interacts with a molecule.

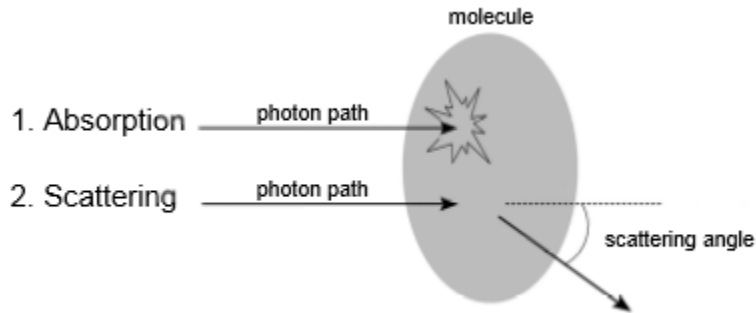


Figure 3. 4:Schematic view of an absorption event and a scattering event [16]

Blood vessels are covered by a layer of subcutaneous fat, followed by the dermis and finally the epidermis. The epidermis is typically 0.1mm thick, while the dermis is about 0.5mm to a few millimeters thick, depending on anatomical location and patient characteristics. The blood vessels are buried in the subcutaneous fat at a depth of up to a few millimeters. The main chromophores are melanin ('brown' pigment) and lipids in the epidermis, and hemoglobin (in the red blood cells), water and lipids in the dermis and subcutaneous fat[17]. Absorption by most of these chromophores is far less in the near-infrared part as compared to the visible part of the spectrum. However, absorption by water typically starts to increase above 900nm as shown in figure (3.5). The scattering behavior of photons in tissue is usually described by Mie and Rayleigh scattering. Rayleigh scattering is scattering by particles smaller than a tenth of the wavelength (such as cell organelles) and is isotropic, while Mie scattering is scattering by particles larger than the wavelength (such as collagen fibers) and is mainly forwardly orientated [18]. The amount of Mie and Rayleigh scattering is inversely related to wavelength, but Rayleigh scattering decreases more rapidly. Mie scattering is dominant in the near infrared spectrum and therefore most relevant to the project purpose. The most important scatterers are collagen and fat in skin and hemoglobin in blood[17]. If scattering is much higher than absorption, which is the case in most types of tissue in the near-infrared spectrum, light becomes quickly isotropic, allowing for diffusion theory to be used to calculate light transport in tissue [19].

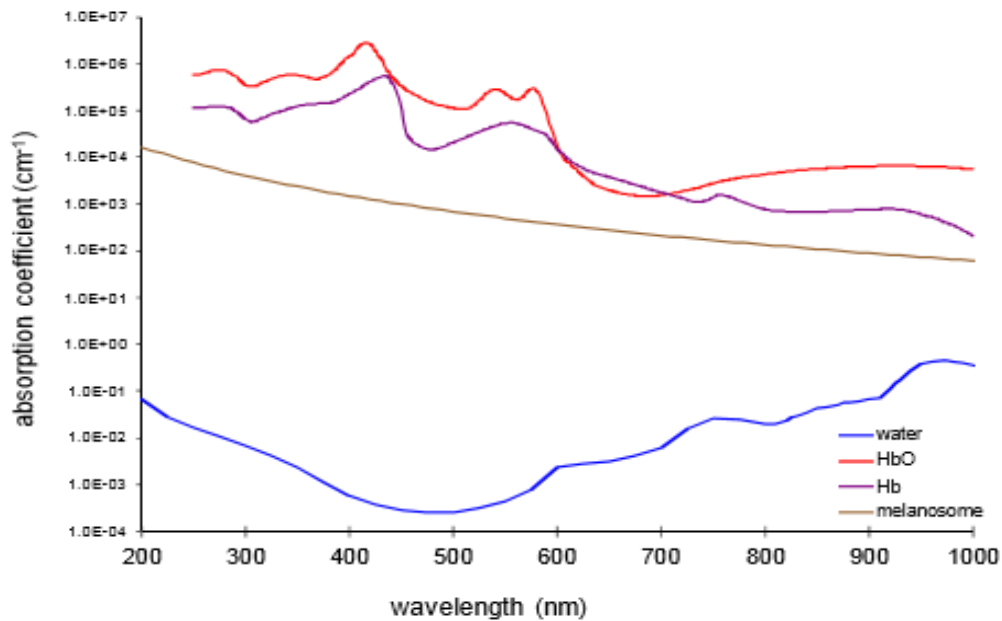


Figure 3.5: Absorption coefficient about wavelength[20]

The decreased absorption and scattering of chromophores, described above, leads to a wavelength region between 650 to 1100 nm in which deep tissue penetration is possible as discussed in figure (3.3). At the low end of this region, absorption of hemoglobin and melanin and scattering are high, while at the high end absorption of water is increasing rapidly [21]. The region in between is called the near-infrared window and enables visualization of blood vessels, since the concentration of hemoglobin in blood vessels is high enough to generate a large contrast between tissue and blood vessels.

3.2.2 Optimal wavelength for subsurface visualization of blood vessels

Blood vessels that are used for peripheral venous and arterial access are typically located up to a few millimeters below the skin surface. The blood vessels are embedded in a layer of subcutaneous adipose tissue, at a depth of 1 mm to several millimeters. On top, the epidermis (0.1 mm) is situated, followed by the dermis (1 mm).

The main chromophores in epidermis, dermis and subcutaneous adipose tissue are melanin, blood (mostly hemoglobin), lipids and water. In the visible part of the spectrum, melanin and hemoglobin are highly absorptive, counteracting deep tissue penetration. In the Visible light and near infrared light part of the spectrum (600–880 nm), there is much less absorption by

melanin and hemoglobin. However, above 900 nm, absorption of water is increasing, again preventing deep tissue penetration. This creates a so-called “window” between 600 to

880 nm, where deep tissue penetration with light is possible [22]. Scattering of light by tissue is also an important factor in characterizing the depth of tissue penetration. In the NIR region scattering is less than in the visible region, but it still causes a larger light attenuation than absorption in light-tissue interaction.

The NIR window can be used to penetrate skin and subcutaneous adipose tissue up to a depth of several centimeters. The absorption of NIR light by blood (hemoglobin) in the blood vessels is still sufficient to generate a high contrast between blood vessels and surrounding tissue, as can be seen in figure(3.6). A detailed description of the equations used to calculate transmission of light through tissue.

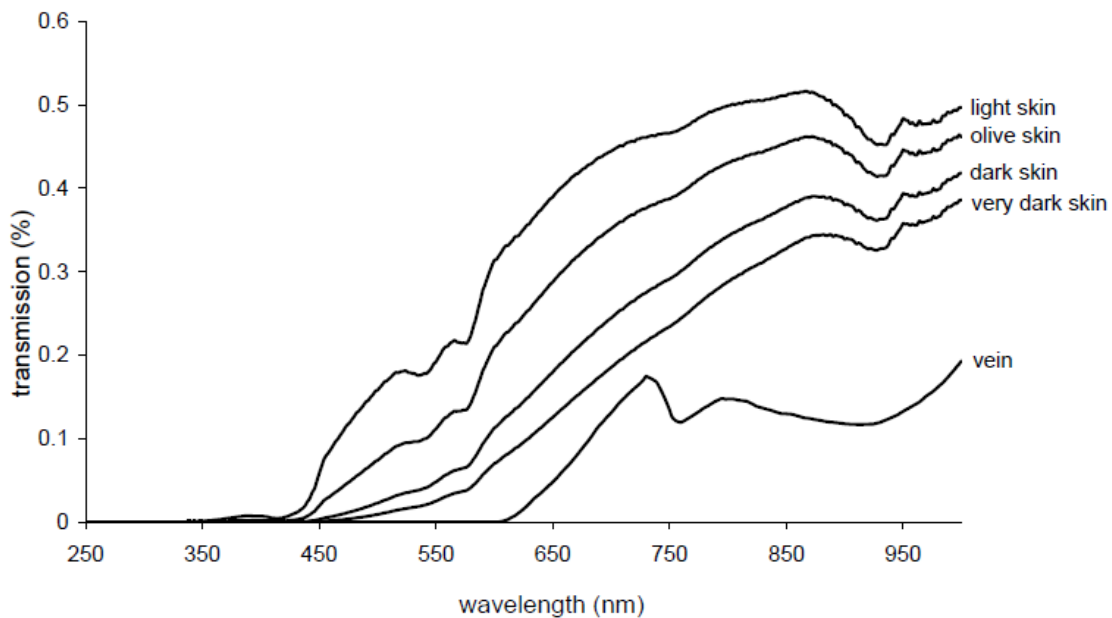


Figure 3.6. Transmission (%) of light through different skin types [22]

3.2.3 Visualization of Blood Vessels with Visible Light and NIR Infrared

The Visible Light window is used for several medical imaging purposes ,such as spectroscopy and tomography .In the 70s,visualization of peripheral blood vessels was

explored by several researchers for the first time, using infrared photography or a TV infra scope [23].The used methods did not allow real-time visualization.

More recently, due to technological developments, new techniques have become available to make real-time NIR imaging possible, mostly due to intense narrow band visible NIR light sources (light emitting diodes, LEDs) and cameras with a high sensitivity for NIR light. The new methods of visualization of blood vessels were not immediately used to facilitate

peripheral venous or arterial access, but for biometric identifications by vein patterns, monitoring of physiological parameters such as local blood flow and oxygenation [24, 25]. However, more recently, several researchers have explored the possibility of using visualization of blood vessels to facilitate peripheral venous or arterial access.

At the start of the research described in this thesis, only the VV, at that moment still a bulky device, and the Vascular Viewer were available, but rather expensive. Therefore, in this project the relatively low cost, vascular imaging system based on trans illumination of visible NIR light figure (3.6).



Figure 3.7 Veins in the hand of an adult woman, skin type II, with (left to right) the VeinViewer, the AccuVein and the Vasculuminator[25]

3.2.4 Safety of Visible Light and NIR Light for Skin

Figure(3.7) shows the rise in temperature both by the NIR light itself, using a light guide, and by the NIR LED in direct contact with the skin. As can be seen only a slight rise in temperature of $\sim 1^{\circ}\text{C}$ is observed when the light guide was used. However, when the NIR LED was placed directly in contact with the skin, the temperature rise is much higher (7°C), because the LED itself generates much heat[26].

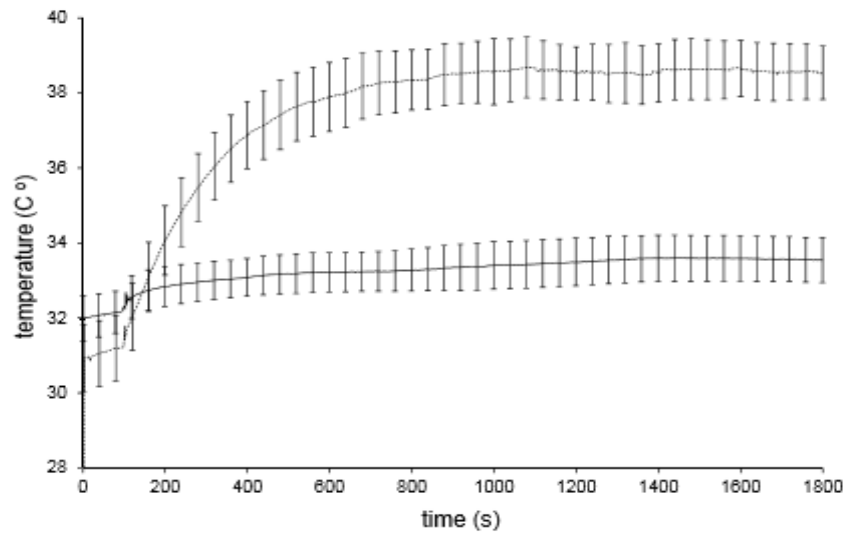


Figure 3.8 Temperature rise of the tissue by NIR light guide and by the visible light in direct contact. [26]

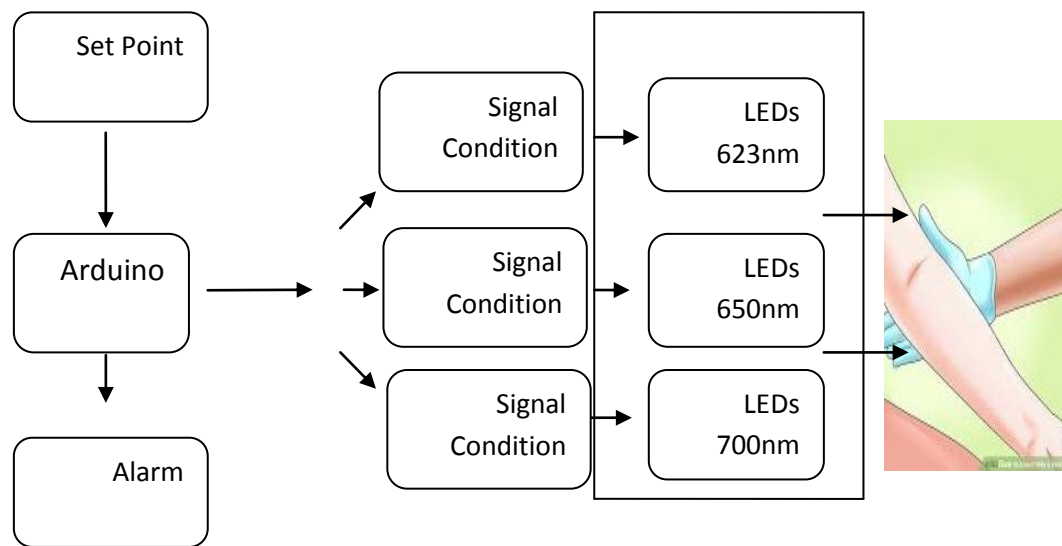
Temperature rise of the tissue by NIR light guide and by the visible light in direct skin contact. Measurement of the light guide is shown by the solid line and of the LED in skin contact by the dotted line. Vertical lines show the SD values. The light source was turned on at 100 s. Environmental temperature was stable at 22.

Chapter 4

System Design and Implementation

In this chapter, standard and recommended requirements of vein viewer circuit are presented. Then according to these requirement, component selection criteria and brief explanation of the selected component are discussed. Figure(4.1) depicts the main stages of the system including NIR, visible light, power control, Analog control, Arduino and alarm .

The following section explain the selected component in each stage:



Power
Supply 5V


Fig4.1:System Block Diagram

4.1 Hardware design

4.1.1 Arduino

The Arduino Nano shown in fig (4.2) is chosen. It is an electronic board with a microcontroller on the computer, but with less capabilities, outputs and inputs for digital and analog signals, as well as a USB port for programming.

The Arduino Nano is programmed to fulfill several tasks in the system, such as ,the first function controlling the intensity of lighting to fat or black skin patients higher intensity of light than the person with white skin or thin skin layer, we will design the program Arduino to control the intensity of lighting, the second task is use to giving a warning when the battery voltage is reduced and need replacement .

Arduino Nano V 3.0 GRBL Pinout		Pin diagram for Grbl v0.8 and v0.9	
ATmega 328P			
Pinout Ref			Pinout Ref
D13	Spindle Direction	D13	D12 Spindle Enable
3V3	Not Used	3V3	D11 Limit Z-Axis
VREF	Not Used	VREF	D10 Limit Y-Axis
A0	Reset/ Abort	A0	D9 Limit X-Axis
A1	Feed Hold	A1	D8 Stepper Enable/Disable
A2	Cycle Star/ Resume	A2	D7 Direction Z Axis
A3	Coolant Enable	A3	D6 Direction Y Axis
A4	(Not Used/ Reserve)	A4	D5 Direction X Axis
A5	Probe	A5	D4 Step Pulse Z Axis
A6	Not Used	A6	D3 Step Pulse Y Axis
A7	Not Used	A7	D2 Step Pulse X Axis
		5V	GND
		RST	RST
		GND	RX1
		VIN	TX1

With the traditional layout: (NOTE: The probe A5 pin is only available in Grbl v0.9.)

Fig4.2:Arduino Nano [Appendix A]

The main hardware Specifications of controller that taken in the account during the design are :

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended):7-12V
- Input Voltage (limits): 6-20V

- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- Clock Speed: 16 MHz

4.1.2 Analog control

In order to control the lighting in the circuit, a Potentiometer is chosen and connected to the analog part in Arduino Nano as shown in FIG(4.3), the Arduino Nano is programmed to control the lighting by raising and lowering the value of the Potentiometer voltage.

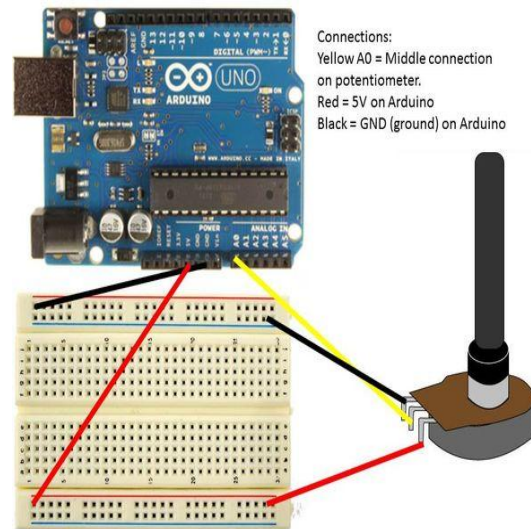


Fig4.3:Potentiometer connected to in analog part of Arduino

Flow chart of designed system of Arduino shown in Fig(4.4):

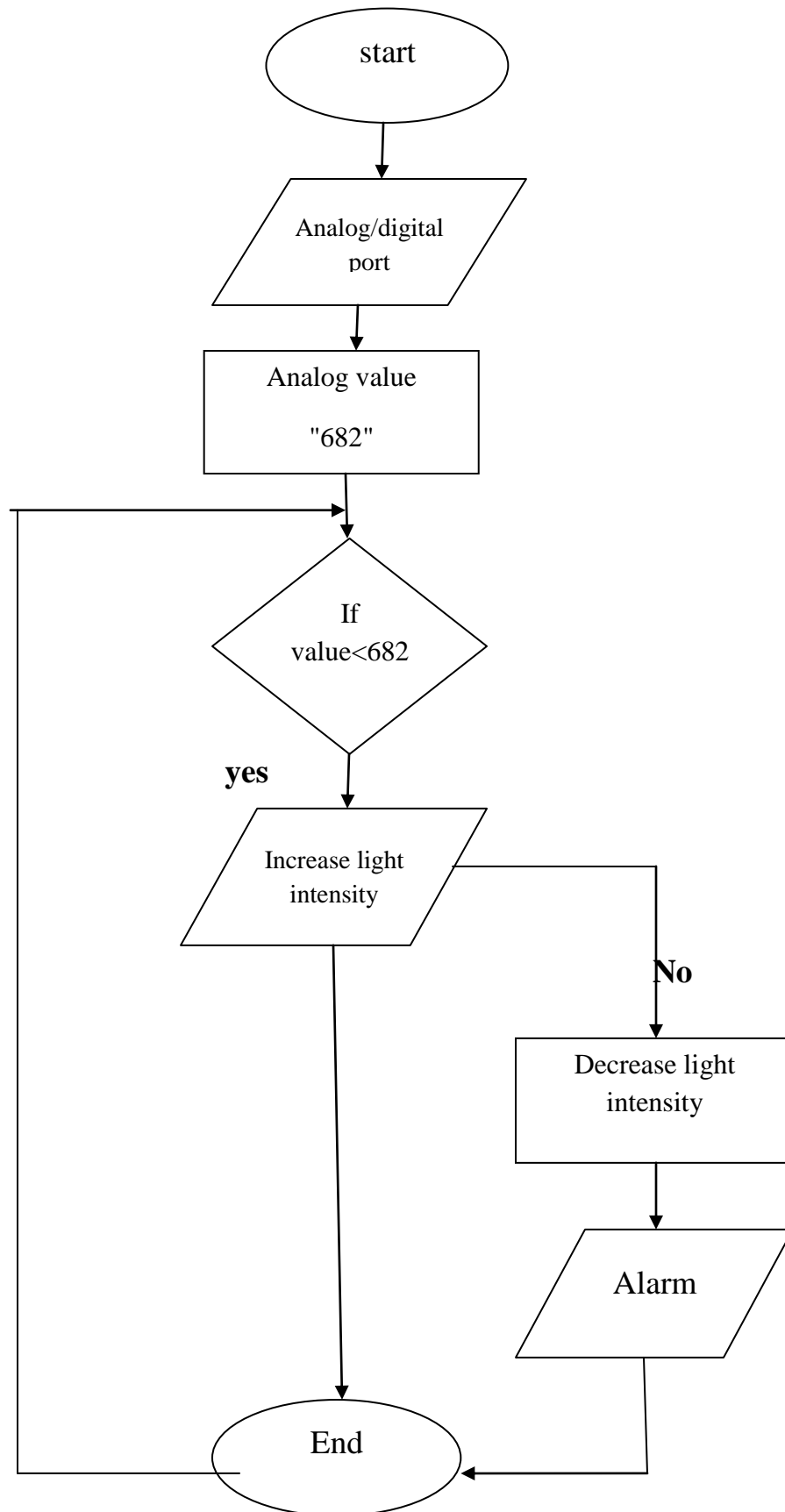


Fig 4.4: Flow chart design system of arduino

4.1.3 NIF and visible LEDs (Digital Control)

According to the preceding study in Chapter 3, the best wavelength to penetrate the forearm skin and reach the vein is 623 -700 nm giving comfortable radiation to human body .

(CR5111A-WY, and (ELD-650) and (LED690-03AU) LEDs are chosen , visible and infrared light emitting diode uses high reliability liquid phase epitaxial grown GaAlAs. Optimized for high power, high efficiency and provides the required wavelength(625-700) nm, the LEDs connect in digital part of Arduino to give him power 5V and controller the LEDs light intensity.

The (CR5111A-WY) from Optec Technology is a round shape, high intensity red color LED made of AlInGaP material 5*5mm and LED give the wave length 625nm. Its UV resistant epoxy lens makes this LED an optimal solution for outdoor applications. To other information review [Appendix B] .

The (ELD-650) is a reliable high speed red LED in standard 5*5 mm package with lens for optimal beam focusing , and LED give the wave length 650nm. To other information review [Appendix C] .

The (LED690-03AU) is an AlGaInP LEDs mounted on a lead frame and encapsulated in an epoxy lens. On forward bias, and LED give the wave length 690nm. To other information review [Appendix D] .

A set of three LEDs was designed as shown in Fig (4.5), to sets of the same act is used in final Design

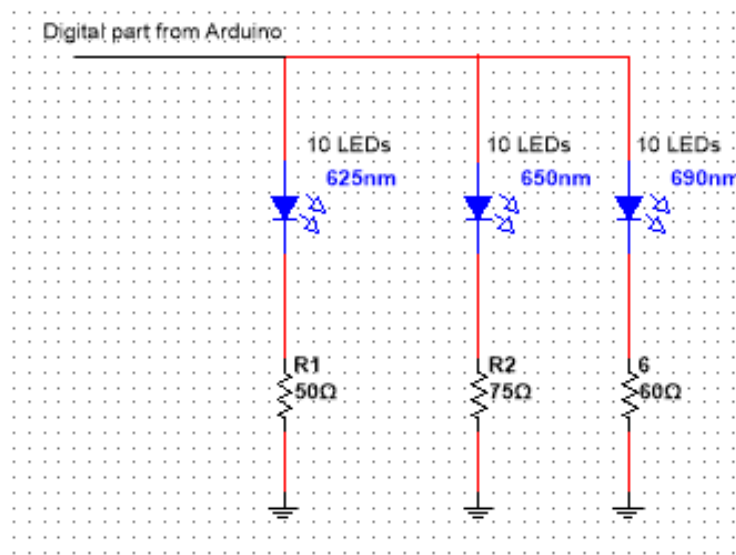


Fig 4.5: Circuit LED's connect with digital part from Arduino

The resistance are required to CR5111A-WY is :

$$R = V_{\max} \frac{2.0}{I_{\max}}$$

$$R = 5 - \frac{2.0}{70\text{mA}}$$

R=42.8 Ω approximately **50 Ω**

The resistance are required to ELD-650-523 is :

$$R = V_{\max} \frac{1.9}{I_{\max}}$$

$$R = 5 - \frac{1.9}{40\text{mA}}$$

R=77.5 Ω approximately **75 Ω**

The resistance are required to LED690-03AU is :

$$R = V_{\max} \frac{1.8}{I_{\max}}$$

$$R = 5 - \frac{1.8}{50\text{mA}}$$

R=64Ω approximately **60 Ω**

Then when designed the coded of Arduino ,the voltage required between (2.5V-5V), so Less of these voltages will cause this alarm to run.

4.1.4 Power supply and Datec-Pocket-Box

The voltage requirement of every major component is within the range of (3 volts to 36 volts ,therefore for portability, a (6-9V) is input to Arduino from DC chargeable battery is used to power the circuit. Shown fig(4.7),and form Arduino get it 5V to turn on the LEDs.



Figure(4.6):battery 1.5Volts

The datec- pocket box is chosen, The attractive pocket-sized DATEC-POCKET-BOX plastic enclosures offer a remarkable amount of technology in a minimum of space, as well as sturdy construction.

Small pocket-box, robust, with high sealing capacity. Recessed control area for membrane keyboards. Two screw pillars prepared for mounting PCBs in the base. Integrated battery compartment for two 1.5 V lady cells (N). Protection class IP 54 for version with sealing and sealing rings to be used in connection with the screw hole.

Battery Spacer This spacer, cut 50 x 25 mm, 4 mm thick, as shown in Fig (4.5) ,is made of PE foam with one-sided adhesive coating. It serves to compensate for the differences in height and to lock the mignon cells (AA) within the battery compartments which can also hold a 9 V flat battery (PP3). Suitable for Datec-Pocket BOX.



Figure(4.7):Datec-Pocket-Box

4.5.1 Control switch

It turn(on/off) the system , is chosen a switch and chosen a rocker switch 65112-BB-1V to control the device.

The 651122-BB-1V is a single-pole single-throw (SPST) sub-miniature Rocker Switch with 0.187-inch tab terminal, vertical molded-in legend and ON-OFF functions shown on Figure(4.7) The 651 series switch fits in a standard rectangular cut-out and is designed to provide ease of insertion along with superior panel retention qualities. A high profile rocker contacts provide the user with a crisp positive-type feel.

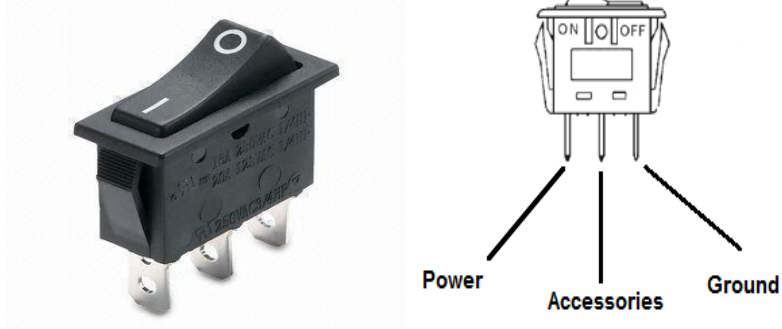


Fig 4.8: Rocker Switch

4.2 Software code

In this section implemented the Arduino Nano coded used to build system in Appendix [E]

Chapter 5

System Implementation and Testing

In this chapter we discuss the construction and the results of the project are discussed, a prototype system is implemented and tested in this chapter, the system architecture of the project is shown in figure (5.1), core the dimension are 50mm long, and 47mm wide begin the hole about 30mm above the battery holder, make it roughly centered on the horizontal, and cut the front of enclosure, a rectangular hole 30mm*45mm in the front cover of the enclosure, position the hole its bottom is about 7cm from the end of the enclosure.

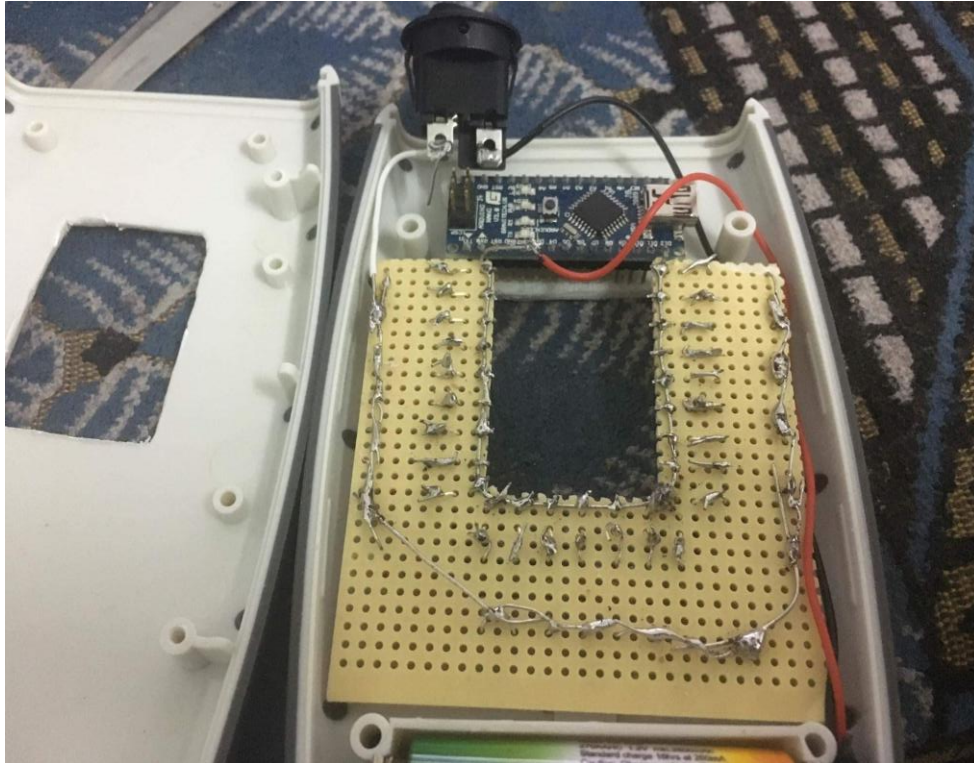


Fig5.1 Image of prototype system.

The full design of device when connected all component, and connect the system with rocker switch to turn on/off the system and collect the component inside the Datec-Pocket-Box.

An implementation of each stage in the system is performed according to the system requirements , initial implementation of the vein viewer was on board shown in figure (5.2).

The hardware and software components are then examined by doing the appropriate test for each stage as will be discussed in the following sections.

5.1 LEDs and Resistors

The board is cut shape of like “U” and the LEDs are connected in the inner edge of it to give suitable area to detect the vein and put it in the PCB board along the inner edge of the center of hole, the anode lead nearest the center and connected him with Vcc from Arduino , The resistors connected with the cathode LEDs , initial implementation of the vein viewer was on board shown in figure (5.2).

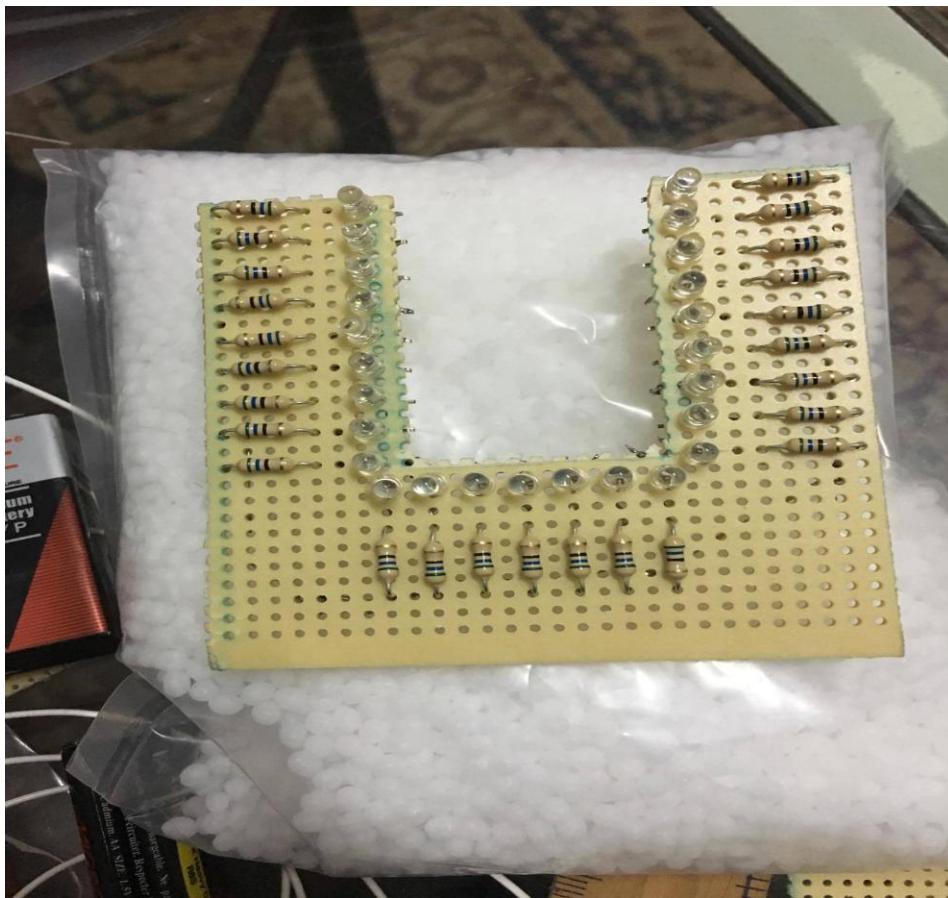


Fig 5.2:The LEDs on the blanc circuit board

5.2: Arduino connection test

The Arduino Nano used in the system to control the system by controlling the light LED up/down where the depth of vein, and give a warning when the battery value is decreased and need replacement. The code first task stage the potentiometer is connect to analog part in Arduino Nano (A0) and is programmed connect to source and ground from the Arduino ..

The second task is use to give a warning when the value of the battery of a certain amount to be replaced or returned or up the light by potentiometer.

The value in Analog part in Arduino from (0-1023) when written the code and calculate the typical and max current for LEDs, we found the rang value is suitable to work between (672-1023) in analog part of Arduino to give me suitable light intensity show the Fig (5.3).

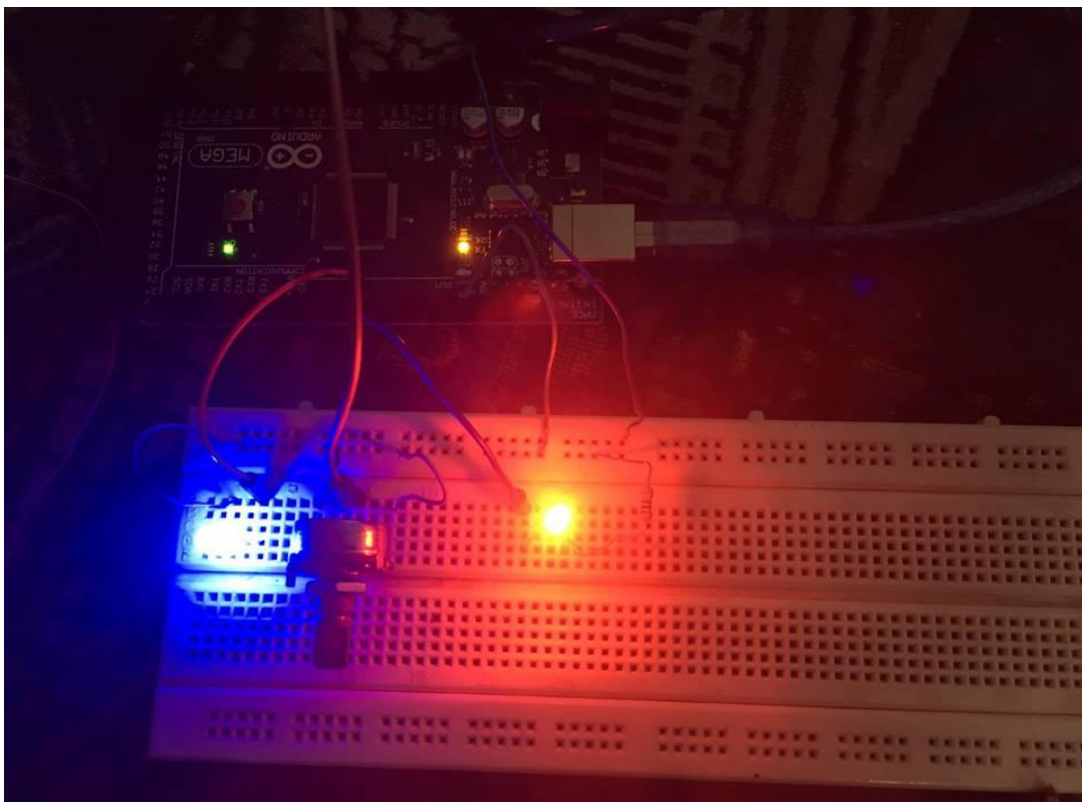


Fig.5.3: controlling light intensity and voltage using Arduino.

Chapter 6

SOFTWARE IMPLEMENTATION

Image contrast enhancement plays a very important role in digital image processing. The aim of image contrast enhancement is to produce the better image quality with improved interpretability by changing the characteristics of original input image

In this chapter we will be shown processing images that resulting in ch5, using the matlab software.

The processing step served two main purposes, the first was noise removal & smoothing ,the second was contrast enhancement, which was necessary as the vein pattern was faint.

Histogram equalization is the most popular and widely used contrast enhancement technique due to its accuracy and easy implementation. This technique flattens the probability distributions and improves contrast of an input image by stretching the dynamic range of gray levels

The processe by algorithm, this involves real time image acquisition followed by histogram equalization bring out the region of interest, We tested the algorithm in MATLAB, The corresponding VHDL code for color's to grey scale conversion and histogram equalization, The flowchart of the algorithm tested in MATLAB simulation is given in fig (6.1).

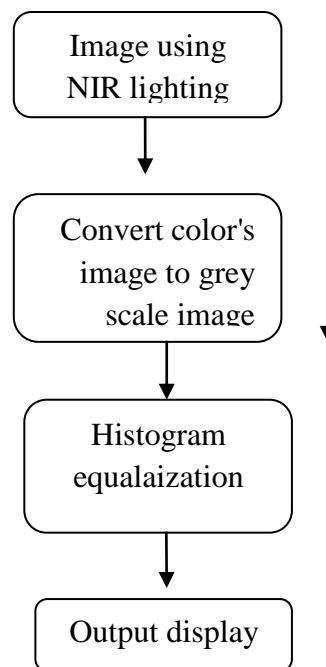


Fig 6.1: flowchart of algorithm.

The code for color's image to grey scale conversion and histogram equalization is :

```
% histogram equalisation

filename= 'vein.jpg'; % the filename to be read
im=imread(filename);
im=imresize(im,[256,256]);
im=rgb2gray(im);
figure(1);
subplot(2,2,1);
imshow(im);

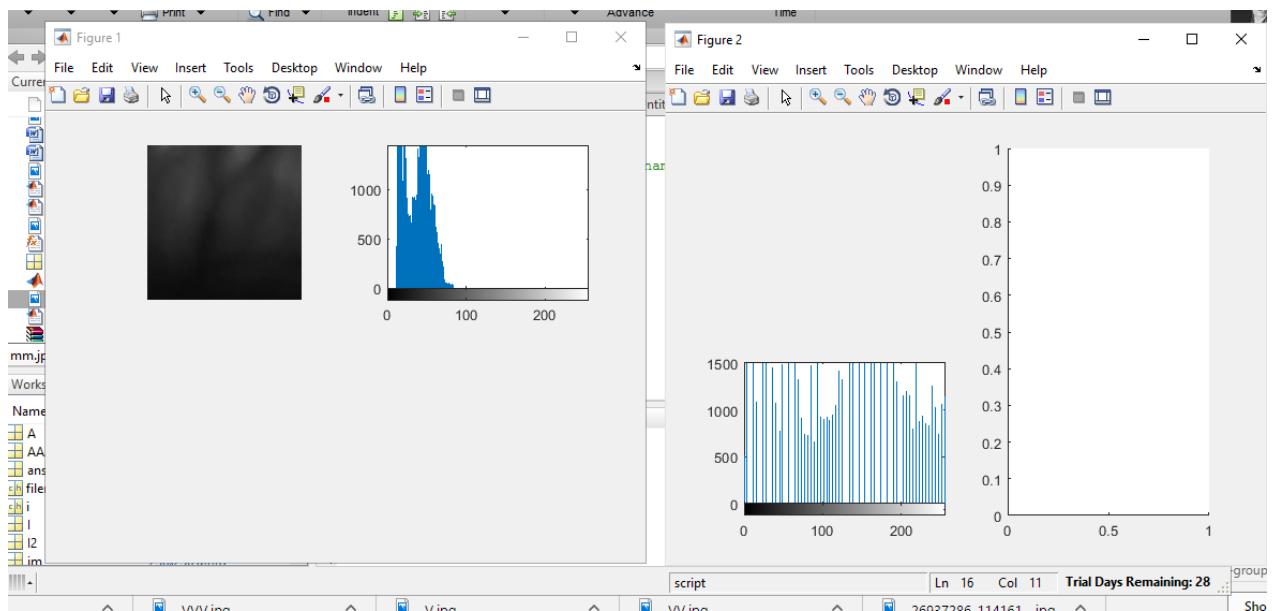
subplot(2,2,2);
axis('square');
colormap('gray');
imhist(im);
im_histeq=histeq(im);
figure(2);
subplot(1,2,1);
imshow(im_histeq); % display
%axis('square');
colormap('gray');

subplot(2,2,3);
imhist(im_histeq);
```

the original image & image processing shown in fig (6.2) & (6.3):



Fig 6.2:original image



6.3: histogram image.

Histogram equalization is a process aimed at making image histogram more uniform and thus improving image contrast.

We while apply the Gama Correction to increase the brightness level of a low contrast image and this modifying the probability distribution of luminance pixels.

Adaptive gamma correction plays an effective role in further enhancement of medical images after histogram equalization.

the process of gamma shown in code 6.2 and the results shown in fig(6.4):

```
I=imread('mm.jpg');
J1=imadjust(I, [], [], 4);
J2=imadjust(I, [], [], 2);
J3=imadjust(I, [], [], 0.2);
imshow(J1);
subplot(221), imshow(I)
title('original Image');
subplot(2,2,2), imshow(J1)
title('Gamma=4 ');
subplot(2,2,3), imshow(J2)
title('Gamma=2 ');
subplot(2,2,4), imshow(J3)
title('Gamma=0.2 ');
imhist(J2)
```

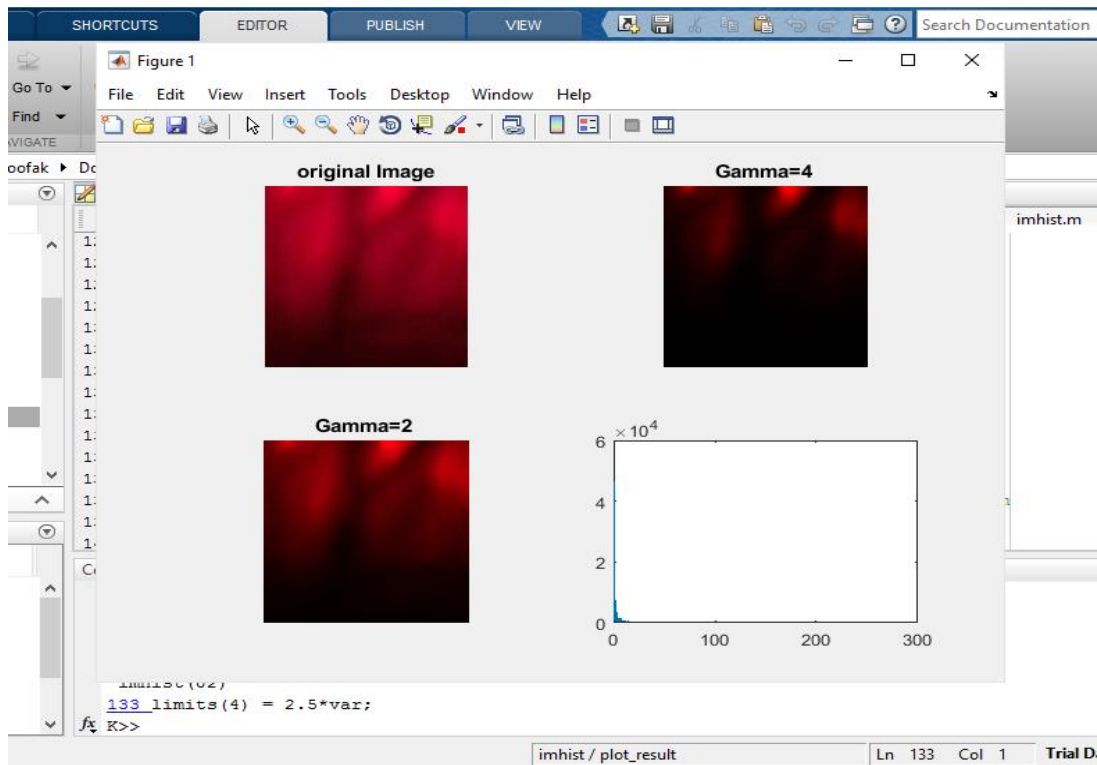



Fig 6.4: gamma implamentation

Adaptive gamma correction plays an effective role in further enhancement of medical images after histogram equalization.

Chapter 7

Results and Conclusions

7.1 Results and analysis

The output from the design can be seen as shown figure (6.1)



Fig 7.1:Test of the final shape of device

The device was tested on a patient arm and gives a positive results and showed the vein as shown in Figure (6.2) the black line in red area is the vein, the figure is small resolution because the LEDs affect the negatively to the camera .

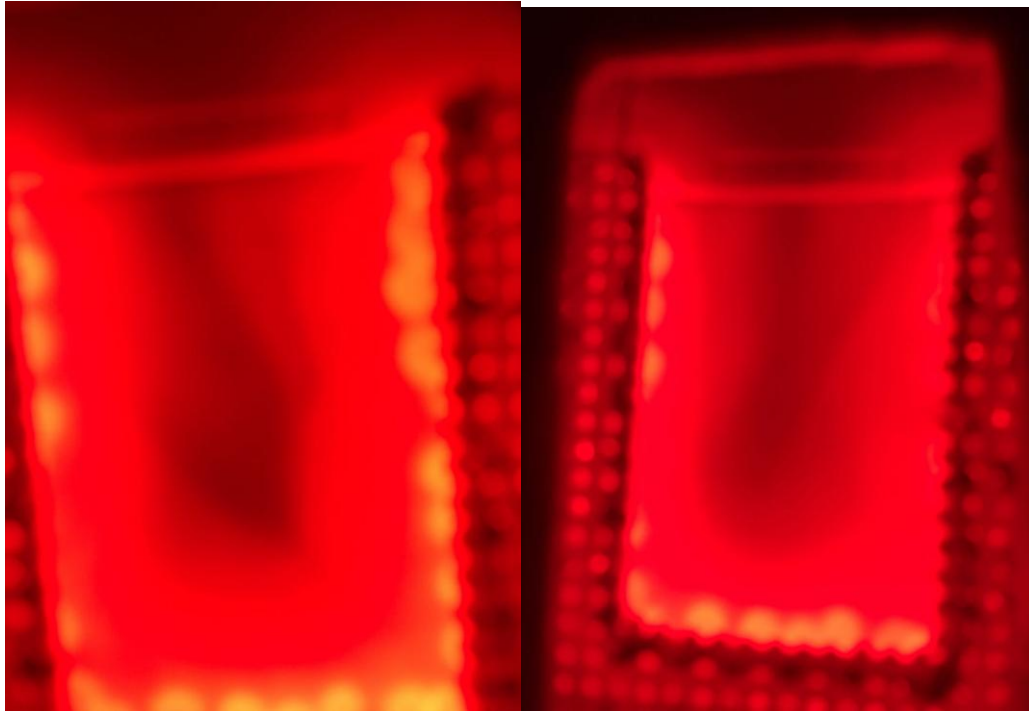


Fig 7.2: result of output device.

7.2 Discussions and conclusions

This technique has been found to be especially useful in different type skin where veins are difficult to identify.

It's feasible to consider routine use of these device to improve the safety dermal of pain and any side effect about injections.

In conclusion the imaging in NIR range (650_700)nm provides relative good contrast of subcutaneous veins , and the use of NIR light vein viewer device for vascular access in critically ill children can decrease the total medical time and cost , the device was well received by our patients,, their families and staff.

7.3 Future work

- Portable robot venipuncture
- Vein finder device for android
- IR VV camera with software

Reference

[1] Function of Dermal <https://en.wikipedia.org/wiki/Dermis>

[2] Glantz S A: Primer of biostatistics. McGraw-Hill, New York, NY, 1997.

[3] Charles Sturt University: Medical Physics, Ultrasound. <http://hsc.csu.edu.au/physics/options/medical/3016/PHY961netdraft.html#3> Accessed May 26, 2006.

[4] <http://www.enchantedlearning.com/subjects/anatomy/skin>

[5] P. Driscoll, Skin and Skin Substitutes in Wound Management, 2013. Available at <http://www.mediligence.com>

[6] Epidermis Skin Anatomy

[/https://www.ncbi.nlm.nih.gov/pubmedhealth/PMHT0022668](https://www.ncbi.nlm.nih.gov/pubmedhealth/PMHT0022668) last visited 15/3/2017

[7] echt H, Muller G, Philipp C: State-of-the-art of safety technology in medical uses of lasers. <http://info.tuwien.ac.at/iflt/safety/refs/albre91.htm> Accessed July 3, 2006.

[8] structure and function of the skin

<http://www.heimat-ltd.com/en/research/skin/about-skin.html> last visited 15/3/2017

[9] Zeman H D, Lovhoiden G, Deshmukh H: Design of a clinical vein contrast enhancing projector. SPIE 4254:204-215, Bellingham, WA, 2001.

[10] <http://omlc.org/news/jan98/skinoptics.html> Skin Optics

[11] De Ritis S: Collecting the best specimen. <http://laboratorian.advanceweb.com/common/editorial/editorial.aspx?CC=34103> Accessed July 1, 2006.

[12] https://www.researchgate.net/figure/256458949_fig1_Fig-1-Light-propagation-through-the-tissues Light propagation through the tissues . last visited 17/3/2017

[13] <http://mappingignorance.org/2016/05/04/nanotechnology-inspired-by-nature/> . last visited 16/3/2017

[13] https://en.wikipedia.org/wiki/Visible_spectrum last visited 20/3/2017

[14] <https://sites.google.com/a/alleghey.edu/cleanenergy/carrhallsolar/basics> . Last visited 23/3/2017

[15] <http://www.onestopgrowshop.co.uk/blog/2017/01/grow-lights-part-1-light-growing>. Last visited 23/3/2017

[16] Bohren CF, Hu_man DR. Absorption and scattering of light by small particles.

[17] Bashkatov AN, Genina EA, Kochubey VI, Tuchin VV. Optical properties of human skin, subcutaneous and mucous tissues in the wavelength range from

400 to 2000 nm. J Phys. 2005 Aug;38(15):2543–2555. 14, 15, 56

[18] Anderson RR, Parrish JA. The optics of human skin. J Invest Dermatol. 1981

Jul;77(1):13–19. 15

[19] Star WM, Marijnissen JP, van Gemert MJ. Light dosimetry in optical phantoms and in tissues: I Multiple flux and transport theory. Phys Med Biol. 1988

Apr;33(4):437–454. 15, 56

[20] Last <https://www.researchgate.net>
visited 25/3/2017

[21] Jobsis FF. Noninvasive, infrared monitoring of cerebral and myocardial oxygen su_cieny and circulatory parameters. Science. 1977 Dec;198(4323):1264–1267.

15, 42, 118

[22] Jobsis FF. Noninvasive, infrared monitoring of cerebral and myocardial oxygen su_cieny and circulatory parameters. Science. 1977 Dec;198(4323):1264–1267.

15, 42, 118

[23] Star WM, Marijnissen JP, van Gemert MJ. Light dosimetry in optical phantoms and in tissues: I Multiple flux and transport theory. Phys Med Biol. 1988

[24] Jobsis FF. Noninvasive, infrared monitoring of cerebral and myocardial oxygen su_cieny and circulatory parameters. *Science*. 1977 Dec;198(4323):1264–1267.

15, 42, 118

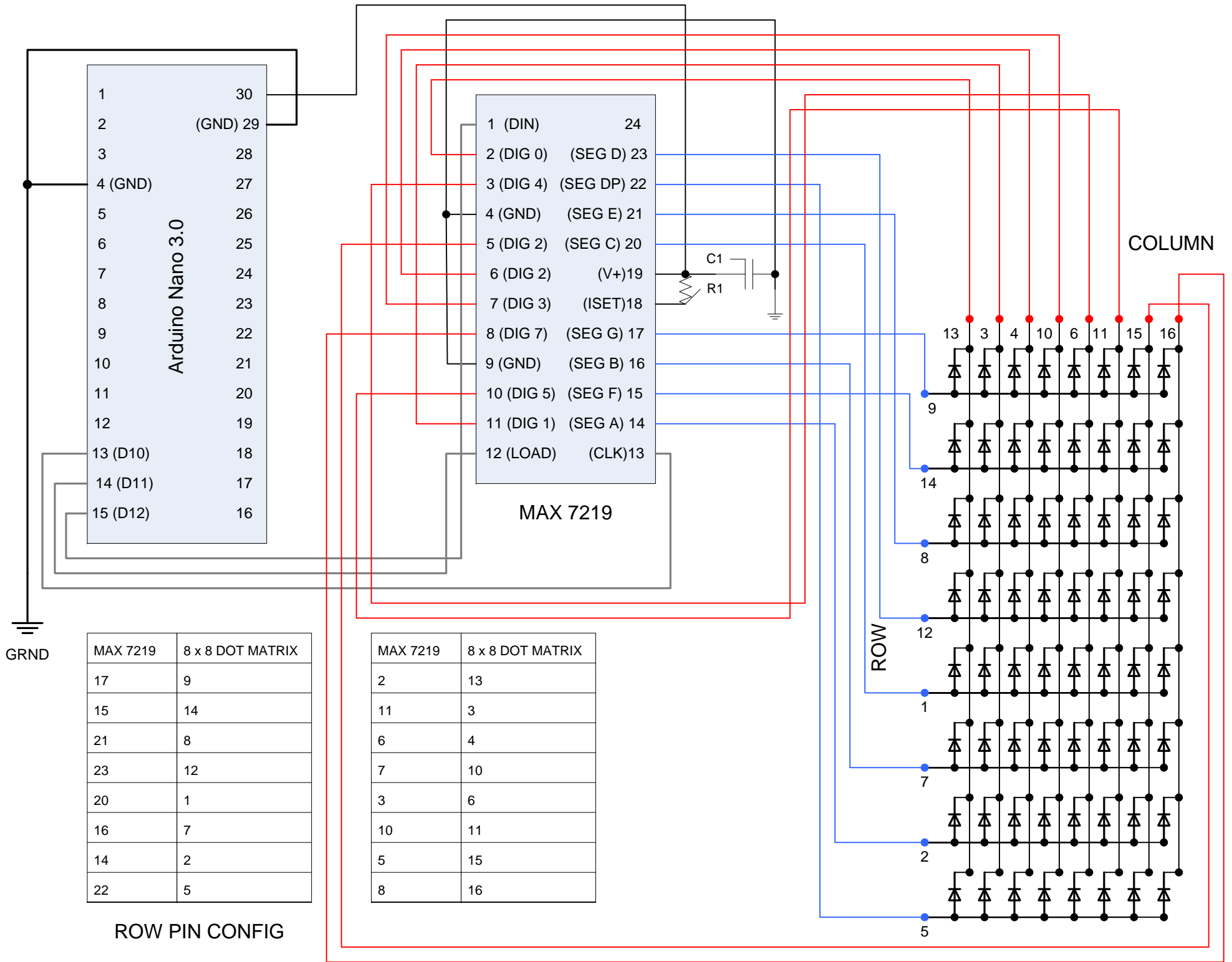
[25] Varanovskii I, Lev ID, Shalumovich VN. [On the use of infrared rays for studies of the superficial veins in man under normal and pathological conditions]. *Arkh*

AnatGistolEmbriol. 1965 Oct;49(10):83–89. 16

[26] Ontikova NM, Iaroslavtsev DA, Lirman AV. [Increase in the information content of the image of the surface veins by using a television infrascopel]. *Med Tekh*.

Appendices

Appendix A



MAX 7219	8 x 8 DOT MATRIX
17	9
15	14
21	8
23	12
20	1
16	7
14	2
22	5

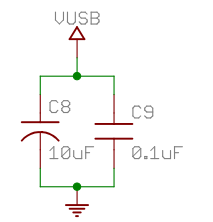
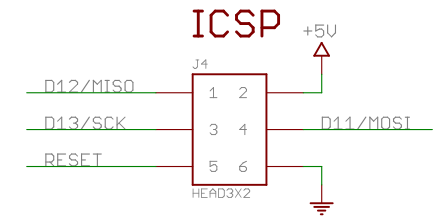
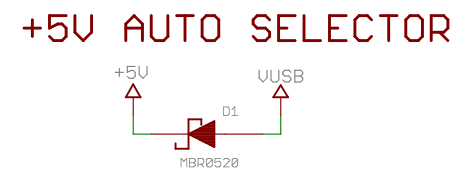
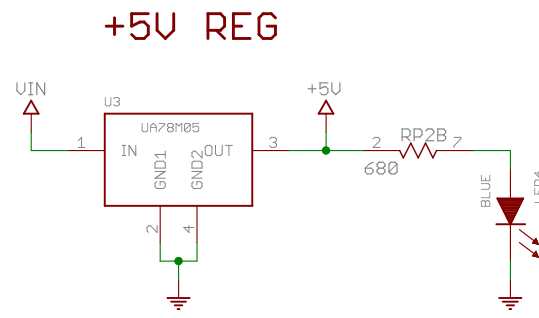
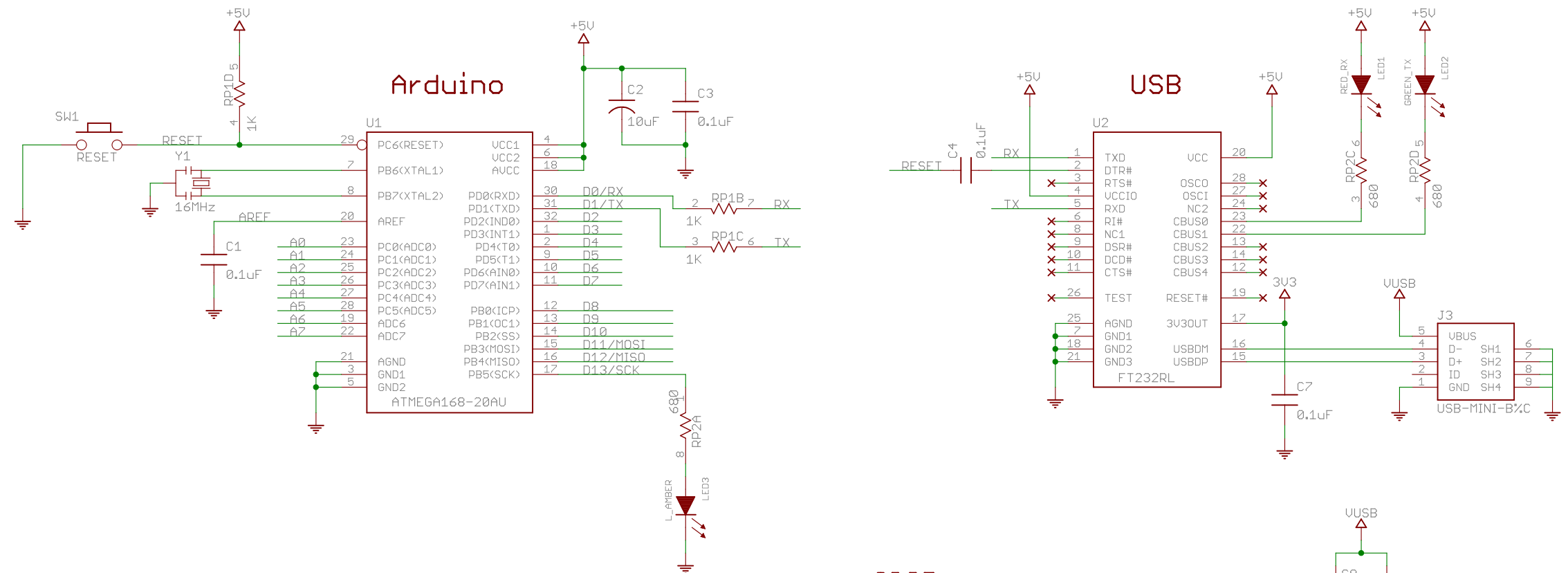
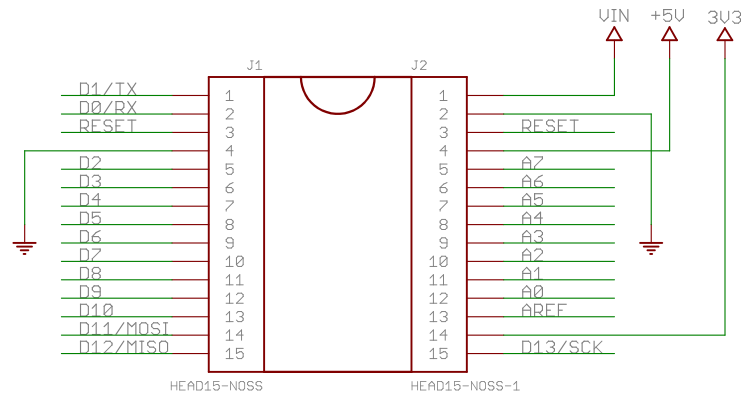
ROW PIN CONFIG

MAX 7219	8 x 8 DOT MATRIX
2	13
11	3
6	4
7	10
3	6
10	11
5	15
8	16

Arduino Nano v3.0

Copyright 2009 under the Creative Commons Attribution Share-Alike 2.5 License

<http://creativecommons.org/licenses/by-sa/2.5/>

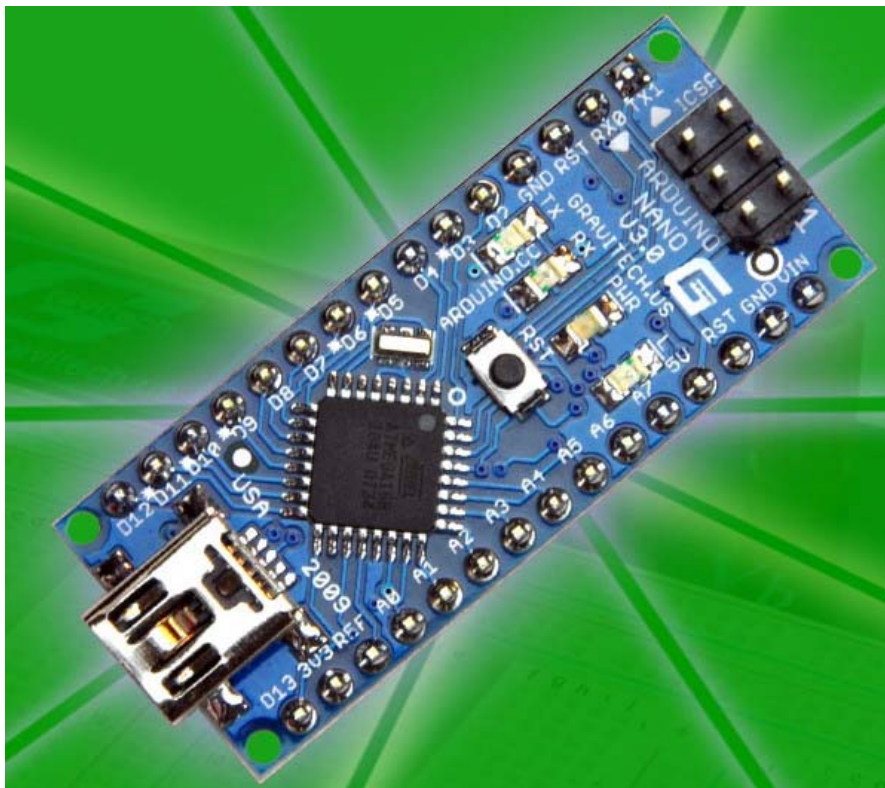


G ⊗ ⊗ ⊗ ⊗

TITLE: Arduino Nano2	
Document Number:	REU: 3.0
Date: 7/21/2009 12:32:59 PM	Sheet: 1/1

Arduino Nano (V3.0)

User Manual



Released under the Creative Commons Attribution Share-Alike 2.5 License

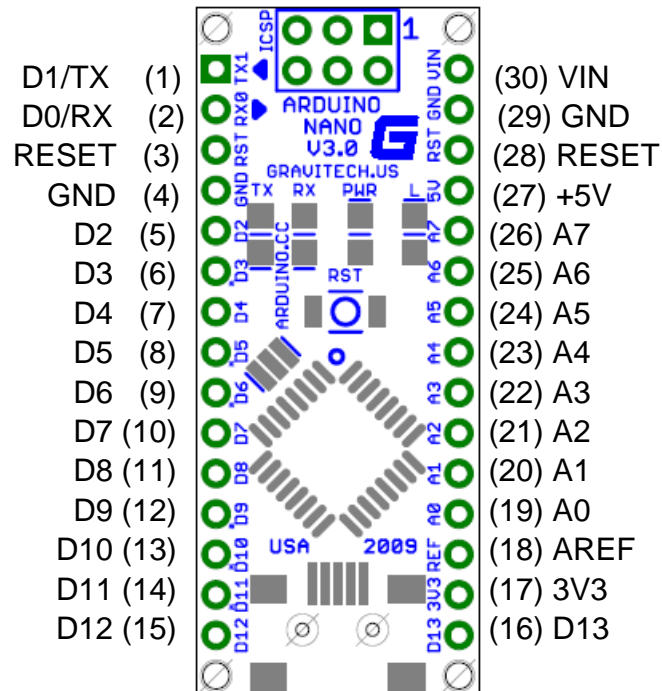
<http://creativecommons.org/licenses/by-sa/2.5/>

More information:

www.arduino.cc

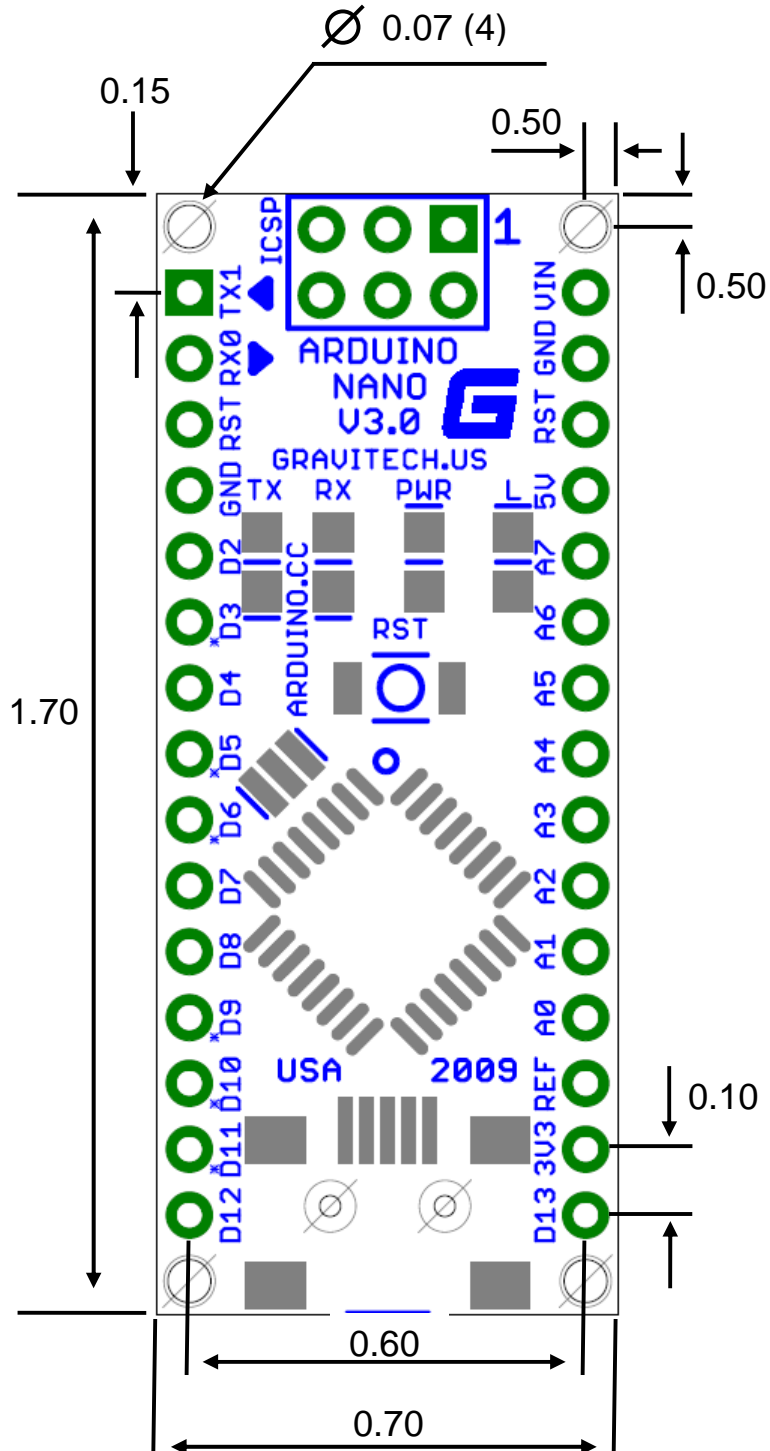
Rev 3.0

Arduino Nano Pin Layout



Pin No.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3, 28	RESET	Input	Reset (active low)
4, 29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A0-A7	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)
30	VIN	PWR	Supply voltage

Arduino Nano Mechanical Drawing





Serially Interfaced, 8-Digit LED Display Drivers

MAX7219/MAX7221

General Description

The MAX7219/MAX7221 are compact, serial input/output common-cathode display drivers that interface microprocessors (μ Ps) to 7-segment numeric LED displays of up to 8 digits, bar-graph displays, or 64 individual LEDs. Included on-chip are a BCD code-B decoder, multiplex scan circuitry, segment and digit drivers, and an 8x8 static RAM that stores each digit. Only one external resistor is required to set the segment current for all LEDs. The MAX7221 is compatible with SPI™, QSPI™, and MICROWIRE™, and has slew-rate-limited segment drivers to reduce EMI.

A convenient 4-wire serial interface connects to all common μ Ps. Individual digits may be addressed and updated without rewriting the entire display. The MAX7219/MAX7221 also allow the user to select code-B decoding or no-decode for each digit.

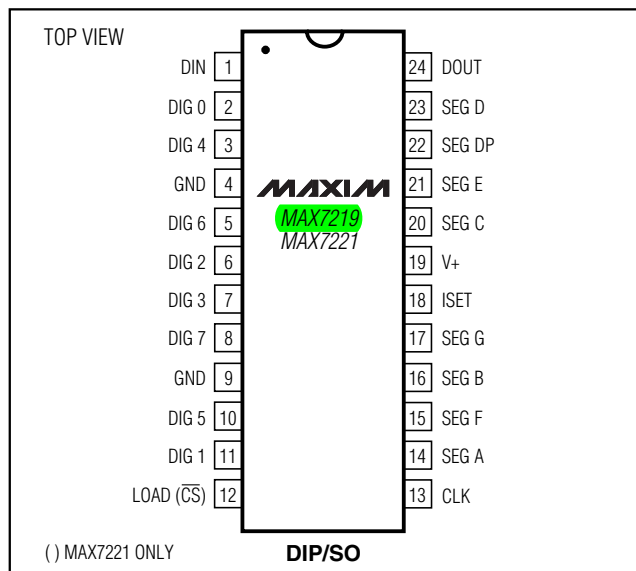
The devices include a 150 μ A low-power shutdown mode, analog and digital brightness control, a scan-limit register that allows the user to display from 1 to 8 digits, and a test mode that forces all LEDs on.

For applications requiring 3V operation or segment blinking, refer to the MAX6951 data sheet.

Applications

- Bar-Graph Displays Panel Meters
- Industrial Controllers LED Matrix Displays

Pin Configuration



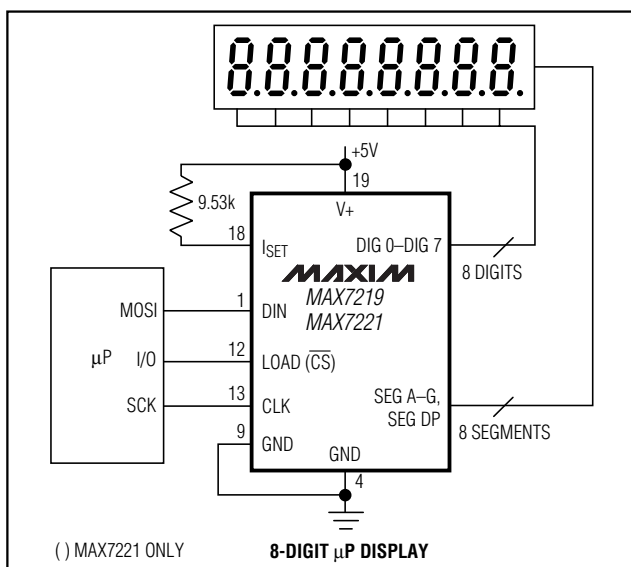
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX7219CNG	0°C to +70°C	24 Narrow Plastic DIP
MAX7219CWG	0°C to +70°C	24 Wide SO
MAX7219C/D	0°C to +70°C	Dice*
MAX7219ENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX7219EWG	-40°C to +85°C	24 Wide SO
MAX7219ERG	-40°C to +85°C	24 Narrow Cerdip

Ordering Information continued at end of data sheet.

*Dice are specified at $T_A = +25^\circ\text{C}$.

Typical Application Circuit



SPI and QSPI are trademarks of Motorola Inc. MICROWIRE is a trademark of National Semiconductor Corp.



For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Serially Interfaced, 8-Digit LED Display Drivers

ABSOLUTE MAXIMUM RATINGS

Voltage (with respect to GND)

V+	-0.3V to 6V
DIN, CLK, LOAD, \overline{CS}	-0.3V to 6V
All Other Pins	-0.3V to (V+ + 0.3V)

Current

DIG0–DIG7 Sink Current	500mA
SEGA–G, DP Source Current	100mA

Continuous Power Dissipation ($T_A = +85^\circ\text{C}$)

Narrow Plastic DIP (derate 13.3mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)	1066mW
Wide SO (derate 11.8mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)	941mW
Narrow CERDIP (derate 12.5mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)	1000mW

Operating Temperature Ranges (T_{MIN} to T_{MAX})

MAX7219C_G/MAX7221C_G	0 $^\circ\text{C}$ to $+70^\circ\text{C}$
MAX7219E_G/MAX7221E_G	-40 $^\circ\text{C}$ to $+85^\circ\text{C}$
Storage Temperature Range	-65 $^\circ\text{C}$ to $+160^\circ\text{C}$
Lead Temperature (soldering, 10s)	$+300^\circ\text{C}$

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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

($V_+ = 5V \pm 10\%$, $R_{\text{SET}} = 9.53\text{k}\Omega \pm 1\%$, $T_A = T_{\text{MIN}}$ to T_{MAX} , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Supply Voltage	V+		4.0		5.5	V
Shutdown Supply Current	I+	All digital inputs at V+ or GND, $T_A = +25^\circ\text{C}$			150	μA
Operating Supply Current	I+	$R_{\text{SET}} = \text{open circuit}$			8	mA
		All segments and decimal point on, $I_{\text{SEG}_-} = -40\text{mA}$		330		
Display Scan Rate	f _{OSC}	8 digits scanned	500	800	1300	Hz
Digit Drive Sink Current	I _{DIGIT}	$V_+ = 5V$, $V_{\text{OUT}} = 0.65V$	320			mA
Segment Drive Source Current	I _{SEG}	$T_A = +25^\circ\text{C}$, $V_+ = 5V$, $V_{\text{OUT}} = (V_+ - 1V)$	-30	-40	-45	mA
Segment Current Slew Rate (MAX7221 only)	$\Delta I_{\text{SEG}}/\Delta t$	$T_A = +25^\circ\text{C}$, $V_+ = 5V$, $V_{\text{OUT}} = (V_+ - 1V)$	10	20	50	mA/ μs
Segment Drive Current Matching	ΔI_{SEG}			3.0		%
Digit Drive Leakage (MAX7221 only)	I _{DIGIT}	Digit off, $V_{\text{DIGIT}} = V_+$			-10	μA
Segment Drive Leakage (MAX7221 only)	I _{SEG}	Segment off, $V_{\text{SEG}} = 0V$			1	μA
Digit Drive Source Current (MAX7219 only)	I _{DIGIT}	Digit off, $V_{\text{DIGIT}} = (V_+ - 0.3V)$	-2			mA
Segment Drive Sink Current (MAX7219 only)	I _{SEG}	Segment off, $V_{\text{SEG}} = 0.3V$	5			mA

Serially Interfaced, 8-Digit LED Display Drivers

MAX7219/MAX7221

ELECTRICAL CHARACTERISTICS (continued)

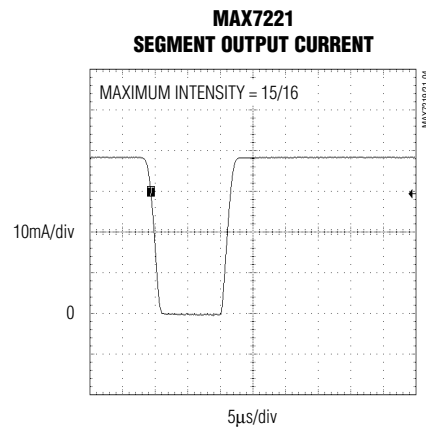
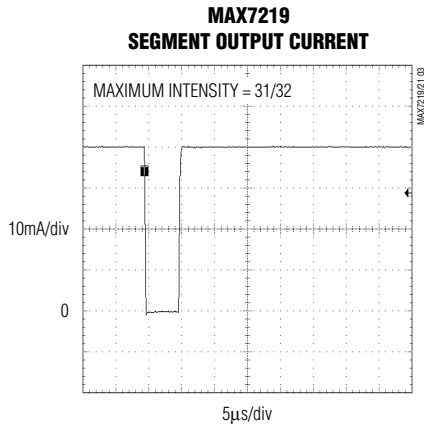
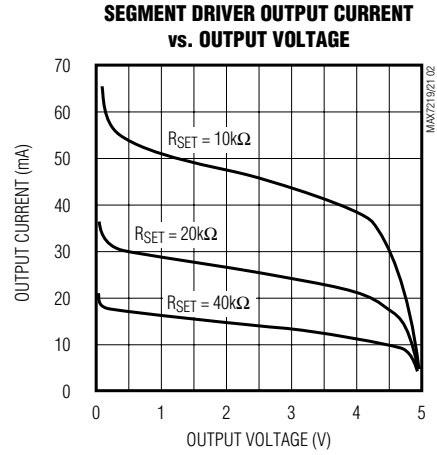
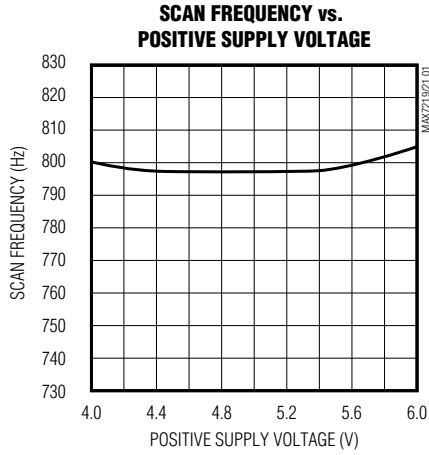
(V+ = 5V ±10%, RSET = 9.53kΩ ±1%, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LOGIC INPUTS						
Input Current DIN, CLK, LOAD, CS	I _{IH} , I _{IL}	V _{IN} = 0V or V+	-1		1	μA
Logic High Input Voltage	V _{IH}		3.5			V
Logic Low Input Voltage	V _{IL}				0.8	V
Output High Voltage	V _{OH}	DOUT, I _{SOURCE} = -1mA	V+ - 1			V
Output Low Voltage	V _{OL}	DOUT, I _{SINK} = 1.6mA			0.4	V
Hysteresis Voltage	ΔV _I	DIN, CLK, LOAD, CS		1		V
TIMING CHARACTERISTICS						
CLK Clock Period	t _{CP}		100			ns
CLK Pulse Width High	t _{CH}		50			ns
CLK Pulse Width Low	t _{CL}		50			ns
CS Fall to SCLK Rise Setup Time (MAX7221 only)	t _{CSS}		25			ns
CLK Rise to CS or LOAD Rise Hold Time	t _{CSH}		0			ns
DIN Setup Time	t _{DS}		25			ns
DIN Hold Time	t _{DH}		0			ns
Output Data Propagation Delay	t _{DO}	C _{LOAD} = 50pF			25	ns
Load-Rising Edge to Next Clock Rising Edge (MAX7219 only)	t _{LDCK}		50			ns
Minimum CS or LOAD Pulse High	t _{Csw}		50			ns
Data-to-Segment Delay	t _{DSPD}				2.25	ms

Serially Interfaced, 8-Digit LED Display Drivers

Typical Operating Characteristics

(V+ = +5V, T_A = +25°C, unless otherwise noted.)



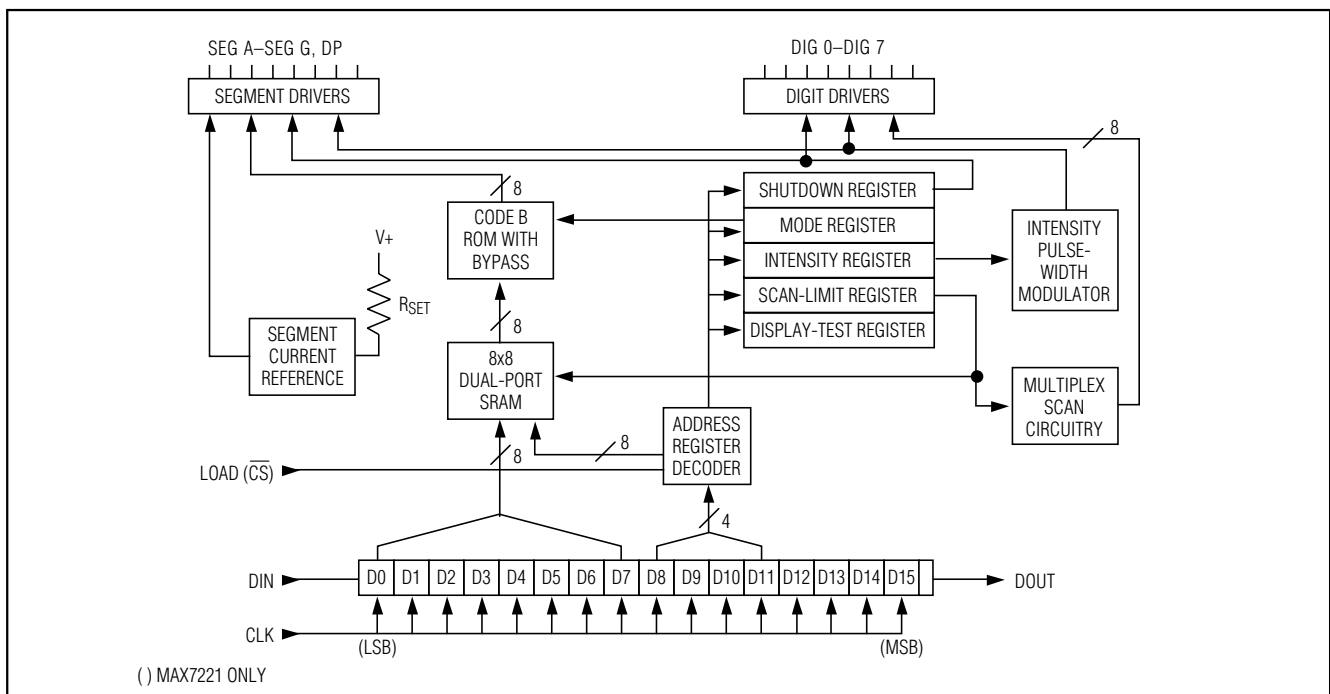
Serially Interfaced, 8-Digit LED Display Drivers

Pin Description

MAX7219/MAX7221

PIN	NAME	FUNCTION
1	DIN	Serial-Data Input. Data is loaded into the internal 16-bit shift register on CLK's rising edge.
2, 3, 5–8, 10, 11	DIG 0–DIG 7	Eight-Digit Drive Lines that sink current from the display common cathode. The MAX7219 pulls the digit outputs to V+ when turned off. The MAX7221's digit drivers are high-impedance when turned off.
4, 9	GND	Ground (both GND pins must be connected)
12	LOAD (MAX7219)	Load-Data Input. The last 16 bits of serial data are latched on LOAD's rising edge.
	\overline{CS} (MAX7221)	Chip-Select Input. Serial data is loaded into the shift register while \overline{CS} is low. The last 16 bits of serial data are latched on \overline{CS} 's rising edge.
13	CLK	Serial-Clock Input. 10MHz maximum rate. On CLK's rising edge, data is shifted into the internal shift register. On CLK's falling edge, data is clocked out of DOUT. On the MAX7221, the CLK input is active only while \overline{CS} is low.
14–17, 20–23	SEG A–SEG G, DP	Seven Segment Drives and Decimal Point Drive that source current to the display. On the MAX7219, when a segment driver is turned off it is pulled to GND. The MAX7221 segment drivers are high-impedance when turned off.
18	ISET	Connect to V _{DD} through a resistor (R _{SET}) to set the peak segment current (Refer to <i>Selecting R_{SET} Resistor</i> section).
19	V+	Positive Supply Voltage. Connect to +5V.
24	DOUT	Serial-Data Output. The data into DIN is valid at DOUT 16.5 clock cycles later. This pin is used to daisy-chain several MAX7219/MAX7221's and is never high-impedance.

Functional Diagram



Serially Interfaced, 8-Digit LED Display Drivers

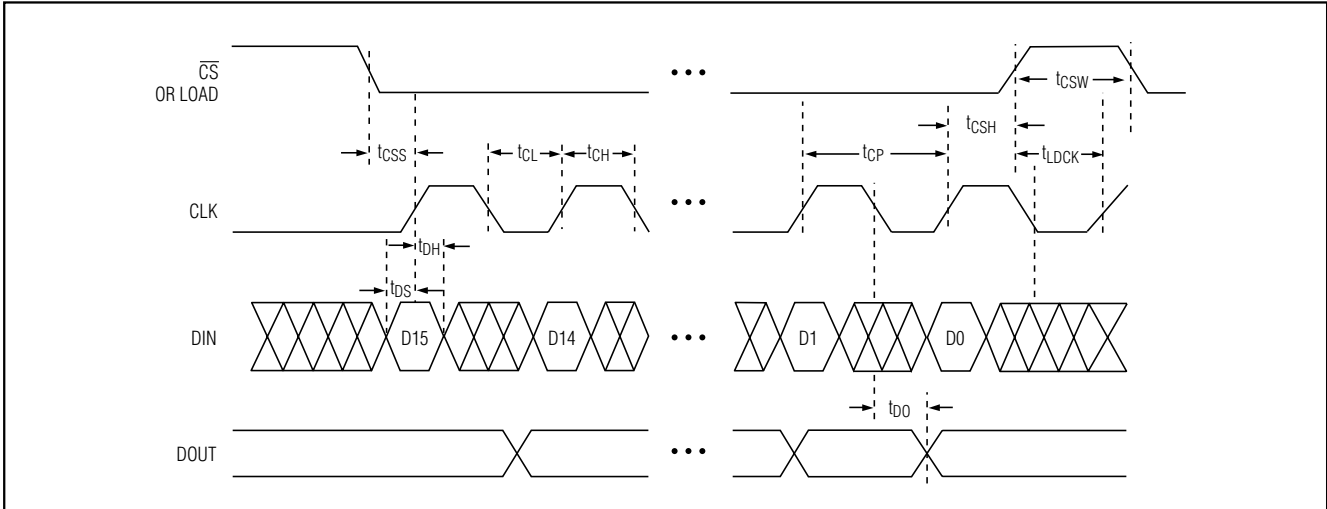


Figure 1. Timing Diagram

Table 1. Serial-Data Format (16 Bits)

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	
X	X	X	X	ADDRESS				MSB				DATA				LSB

Detailed Description

MAX7219/MAX7221 Differences

The MAX7219 and MAX7221 are identical except for two parameters: the MAX7221 segment drivers are slew-rate limited to reduce electromagnetic interference (EMI), and its serial interface is fully SPI compatible.

Serial-Addressing Modes

For the MAX7219, serial data at DIN, sent in 16-bit packets, is shifted into the internal 16-bit shift register with each rising edge of CLK regardless of the state of LOAD. For the MAX7221, CS must be low to clock data in or out. The data is then latched into either the digit or control registers on the rising edge of LOAD/CS. LOAD/CS must go high concurrently with or after the 16th rising clock edge, but before the next rising clock edge or data will be lost. Data at DIN is propagated through the shift register and appears at DOUT 16.5 clock cycles later. Data is clocked out on the falling edge of CLK. Data bits are labeled D0–D15 (Table 1). D8–D11 contain the register address. D0–D7 contain the data, and D12–D15 are “don’t care” bits. The first received is D15, the most significant bit (MSB).

Digit and Control Registers

Table 2 lists the 14 addressable digit and control registers. The digit registers are realized with an on-chip, 8x8 dual-port SRAM. They are addressed directly so that individual digits can be updated and retain data as long as V+ typically exceeds 2V. The control registers consist of decode mode, display intensity, scan limit (number of scanned digits), shutdown, and display test (all LEDs on).

Shutdown Mode

When the MAX7219 is in shutdown mode, the scan oscillator is halted, all segment current sources are pulled to ground, and all digit drivers are pulled to V+, thereby blanking the display. The MAX7221 is identical, except the drivers are high-impedance. Data in the digit and control registers remains unaltered. Shutdown can be used to save power or as an alarm to flash the display by successively entering and leaving shutdown mode. For minimum supply current in shutdown mode, logic inputs should be at ground or V+ (CMOS-logic levels).

Typically, it takes less than 250µs for the MAX7219/MAX7221 to leave shutdown mode. The display driver can be programmed while in shutdown mode, and shutdown mode can be overridden by the display-test function.

Serially Interfaced, 8-Digit LED Display Drivers

Table 2. Register Address Map

REGISTER	ADDRESS					HEX CODE
	D15–D12	D11	D10	D9	D8	
No-Op	X	0	0	0	0	0xX0
Digit 0	X	0	0	0	1	0xX1
Digit 1	X	0	0	1	0	0xX2
Digit 2	X	0	0	1	1	0xX3
Digit 3	X	0	1	0	0	0xX4
Digit 4	X	0	1	0	1	0xX5
Digit 5	X	0	1	1	0	0xX6
Digit 6	X	0	1	1	1	0xX7
Digit 7	X	1	0	0	0	0xX8
Decode Mode	X	1	0	0	1	0xX9
Intensity	X	1	0	1	0	0xXA
Scan Limit	X	1	0	1	1	0xXB
Shutdown	X	1	1	0	0	0xXC
Display Test	X	1	1	1	1	0xFF

Initial Power-Up

On initial power-up, all control registers are reset, the display is blanked, and the MAX7219/MAX7221 enter shutdown mode. Program the display driver prior to display use. Otherwise, it will initially be set to scan one digit, it will not decode data in the data registers, and the intensity register will be set to its minimum value.

Decode-Mode Register

The decode-mode register sets BCD code B (0-9, E, H, L, P, and -) or no-decode operation for each digit. Each bit in the register corresponds to one digit. A logic high selects code B decoding while logic low bypasses the decoder. Examples of the decode mode control-register format are shown in Table 4.

When the code B decode mode is used, the decoder looks only at the lower nibble of the data in the digit registers (D3–D0), disregarding bits D4–D6. D7, which sets the decimal point (SEG DP), is independent of the decoder and is positive logic (D7 = 1 turns the decimal point on). Table 5 lists the code B font.

When no-decode is selected, data bits D7–D0 correspond to the segment lines of the MAX7219/MAX7221. Table 6 shows the one-to-one pairing of each data bit to the appropriate segment line.

Table 3. Shutdown Register Format (Address (Hex) = 0xXC)

MODE	ADDRESS CODE (HEX)	REGISTER DATA							
		D7	D6	D5	D4	D3	D2	D1	D0
Shutdown Mode	0xXC	X	X	X	X	X	X	X	0
Normal Operation	0xXC	X	X	X	X	X	X	X	1

Table 4. Decode-Mode Register Examples (Address (Hex) = 0xX9)

DECODE MODE	REGISTER DATA								HEX CODE
	D7	D6	D5	D4	D3	D2	D1	D0	
No decode for digits 7–0	0	0	0	0	0	0	0	0	0x00
Code B decode for digit 0 No decode for digits 7–1	0	0	0	0	0	0	0	1	0x01
Code B decode for digits 3–0 No decode for digits 7–4	0	0	0	0	1	1	1	1	0x0F
Code B decode for digits 7–0	1	1	1	1	1	1	1	1	0xFF

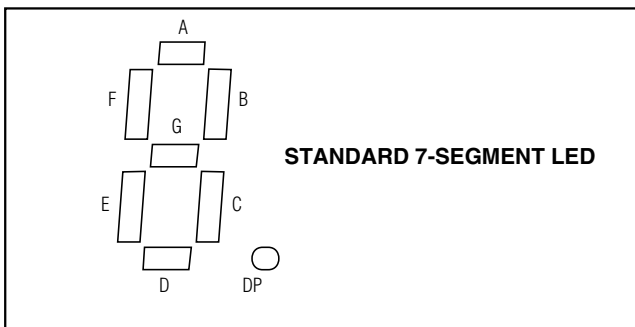
Serially Interfaced, 8-Digit LED Display Drivers

Table 5. Code B Font

7-SEGMENT CHARACTER	REGISTER DATA						ON SEGMENTS = 1							
	D7*	D6–D4	D3	D2	D1	D0	DP*	A	B	C	D	E	F	G
0		X	0	0	0	0		1	1	1	1	1	1	0
1		X	0	0	0	1		0	1	1	0	0	0	0
2		X	0	0	1	0		1	1	0	1	1	0	1
3		X	0	0	1	1		1	1	1	1	0	0	1
4		X	0	1	0	0		0	1	1	0	0	1	1
5		X	0	1	0	1		1	0	1	1	0	1	1
6		X	0	1	1	0		1	0	1	1	1	1	1
7		X	0	1	1	1		1	1	1	0	0	0	0
8		X	1	0	0	0		1	1	1	1	1	1	1
9		X	1	0	0	1		1	1	1	1	0	1	1
—		X	1	0	1	0		0	0	0	0	0	0	1
E		X	1	0	1	1		1	0	0	1	1	1	1
H		X	1	1	0	0		0	1	1	0	1	1	1
L		X	1	1	0	1		0	0	0	1	1	1	0
P		X	1	1	1	0		1	1	0	0	1	1	1
blank		X	1	1	1	1		0	0	0	0	0	0	0

*The decimal point is set by bit D7 = 1

Table 6. No-Decode Mode Data Bits and Corresponding Segment Lines



	REGISTER DATA							
	D7	D6	D5	D4	D3	D2	D1	D0
Corresponding Segment Line	DP	A	B	C	D	E	F	G

Intensity Control and Interdigit Blanking

The MAX7219/MAX7221 allow display brightness to be controlled with an external resistor (R_{SET}) connected between V₊ and ISET. The peak current sourced from the segment drivers is nominally 100 times the current entering ISET. This resistor can either be fixed or variable to allow brightness adjustment from the front panel. Its minimum value should be 9.53kΩ, which typically sets the segment current at 40mA. Display brightness can also be controlled digitally by using the intensity register.

Digital control of display brightness is provided by an internal pulse-width modulator, which is controlled by the lower nibble of the intensity register. The modulator scales the average segment current in 16 steps from a maximum of 31/32 down to 1/32 of the peak current set by R_{SET} (15/16 to 1/16 on MAX7221). Table 7 lists the intensity register format. The minimum interdigit blanking time is set to 1/32 of a cycle.

Serially Interfaced, 8-Digit LED Display Drivers

Table 7. Intensity Register Format (Address (Hex) = 0xXA)

DUTY CYCLE		D7	D6	D5	D4	D3	D2	D1	D0	HEX CODE
MAX7219	MAX7221									
1/32 (min on)	1/16 (min on)	X	X	X	X	0	0	0	0	0xX0
3/32	2/16	X	X	X	X	0	0	0	1	0xX1
5/32	3/16	X	X	X	X	0	0	1	0	0xX2
7/32	4/16	X	X	X	X	0	0	1	1	0xX3
9/32	5/16	X	X	X	X	0	1	0	0	0xX4
11/32	6/16	X	X	X	X	0	1	0	1	0xX5
13/32	7/16	X	X	X	X	0	1	1	0	0xX6
15/32	8/16	X	X	X	X	0	1	1	1	0xX7
17/32	9/16	X	X	X	X	1	0	0	0	0xX8
19/32	10/16	X	X	X	X	1	0	0	1	0xX9
21/32	11/16	X	X	X	X	1	0	1	0	0xXA
23/32	12/16	X	X	X	X	1	0	1	1	0xXB
25/32	13/16	X	X	X	X	1	1	0	0	0xXC
27/32	14/16	X	X	X	X	1	1	0	1	0xDD
29/32	15/16	X	X	X	X	1	1	1	0	0xXE
31/32	15/16 (max on)	X	X	X	X	1	1	1	1	0xFF

Table 8. Scan-Limit Register Format (Address (Hex) = 0xXB)

SCAN LIMIT	REGISTER DATA								HEX CODE
	D7	D6	D5	D4	D3	D2	D1	D0	
Display digit 0 only*	X	X	X	X	X	0	0	0	0xX0
Display digits 0 & 1*	X	X	X	X	X	0	0	1	0xX1
Display digits 0 1 2*	X	X	X	X	X	0	1	0	0xX2
Display digits 0 1 2 3	X	X	X	X	X	0	1	1	0xX3
Display digits 0 1 2 3 4	X	X	X	X	X	1	0	0	0xX4
Display digits 0 1 2 3 4 5	X	X	X	X	X	1	0	1	0xX5
Display digits 0 1 2 3 4 5 6	X	X	X	X	X	1	1	0	0xX6
Display digits 0 1 2 3 4 5 6 7	X	X	X	X	X	1	1	1	0xX7

*See *Scan-Limit Register* section for application.

Scan-Limit Register

The scan-limit register sets how many digits are displayed, from 1 to 8. They are displayed in a multiplexed manner with a typical display scan rate of 800Hz with 8 digits displayed. If fewer digits are displayed, the scan rate is $8f_{OSC}/N$, where N is the number of digits

scanned. Since the number of scanned digits affects the display brightness, the scan-limit register should not be used to blank portions of the display (such as leading zero suppression). Table 8 lists the scan-limit register format.

Serially Interfaced, 8-Digit LED Display Drivers

If the scan-limit register is set for three digits or less, individual digit drivers will dissipate excessive amounts of power. Consequently, the value of the RSET resistor must be adjusted according to the number of digits displayed, to limit individual digit driver power dissipation. Table 9 lists the number of digits displayed and the corresponding maximum recommended segment current when the digit drivers are used.

Display-Test Register

The display-test register operates in two modes: normal and display test. Display-test mode turns all LEDs on by overriding, but not altering, all controls and digit registers (including the shutdown register). In display-test mode, 8 digits are scanned and the duty cycle is 31/32 (15/16 for MAX7221). Table 10 lists the display-test register format.

Table 9. Maximum Segment Current for 1-, 2-, or 3-Digit Displays

NUMBER OF DIGITS DISPLAYED	MAXIMUM SEGMENT CURRENT (mA)
1	10
2	20
3	30

Table 10. Display-Test Register Format (Address (Hex) = 0xXF)

MODE	REGISTER DATA							
	D7	D6	D5	D4	D3	D2	D1	D0
Normal Operation	X	X	X	X	X	X	X	0
Display Test Mode	X	X	X	X	X	X	X	1

Note: The MAX7219/MAX7221 remain in display-test mode (all LEDs on) until the display-test register is reconfigured for normal operation.

No-Op Register

The no-op register is used when cascading MAX7219s or MAX7221s. Connect all devices' LOAD/CS inputs together and connect DOUT to DIN on adjacent devices. DOUT is a CMOS logic-level output that easily drives DIN of successively cascaded parts. (Refer to the *Serial Addressing Modes* section for detailed information on serial input/output timing.) For example, if four MAX7219s are cascaded, then to write to the

fourth chip, sent the desired 16-bit word, followed by three no-op codes (hex 0xXX0X, see Table 2). When LOAD/CS goes high, data is latched in all devices. The first three chips receive no-op commands, and the fourth receives the intended data.

Applications Information

Supply Bypassing and Wiring

To minimize power-supply ripple due to the peak digit driver currents, connect a 10 μ F electrolytic and a 0.1 μ F ceramic capacitor between V+ and GND as close to the device as possible. The MAX7219/MAX7221 should be placed in close proximity to the LED display, and connections should be kept as short as possible to minimize the effects of wiring inductance and electro-magnetic interference. Also, both GND pins must be connected to ground.

Selecting RSET Resistor and Using External Drivers

The current per segment is approximately 100 times the current in ISET. To select RSET, see Table 11. The MAX7219/MAX7221's maximum recommended segment current is 40mA. For segment current levels above these levels, external digit drivers will be needed. In this application, the MAX7219/MAX7221 serve only as controllers for other high-current drivers or transistors. Therefore, to conserve power, use RSET = 47k Ω when using external current sources as segment drivers.

The example in Figure 2 uses the MAX7219/MAX7221's segment drivers, a MAX394 single-pole double-throw analog switch, and external transistors to drive 2.3" AND2307SLC common-cathode displays. The 5.6V zener diode has been added in series with the decimal point LED because the decimal point LED forward voltage is typically 4.2V. For all other segments the LED forward voltage is typically 8V. Since external transistors are used to sink current (DIG 0 and DIG 1 are used as logic switches), peak segment currents of 45mA are allowed even though only two digits are displayed. In applications where the MAX7219/MAX7221's digit drivers are used to sink current and fewer than four digits are displayed, Table 9 specifies the maximum allowable segment current. RSET must be selected accordingly (Table 11).

Refer to the Power Dissipation section of the Absolute Maximum Ratings to calculate acceptable limits for ambient temperature, segment current, and the LED forward-voltage drop.

Serially Interfaced, 8-Digit LED Display Drivers

MAX7219/MAX7221

Table 11. RSET vs. Segment Current and LED Forward Voltage

ISEG (mA)	VLED (V)				
	1.5	2.0	2.5	3.0	3.5
40	12.2	11.8	11.0	10.6	9.69
30	17.8	17.1	15.8	15.0	14.0
20	29.8	28.0	25.9	24.5	22.6
10	66.7	63.7	59.3	55.4	51.2

Table 12. Package Thermal Resistance Data

PACKAGE	THERMAL RESISTANCE (θJA)
24 Narrow DIP	+75°C/W
24 Wide SO	+85°C/W
24 CERDIP	+80°C/W
Maximum Junction Temperature (Tj) = +150°C	
Maximum Ambient Temperature (TA) = +85°C	

Computing Power Dissipation

The upper limit for power dissipation (PD) for the MAX7219/MAX7221 is determined from the following equation:

$$PD = (V+ \times I_{SEG}) + (V+ - V_{LED})(DUTY \times I_{SEG} \times N)$$

where:

V+ = supply voltage

DUTY = duty cycle set by intensity register

N = number of segments driven (worst case is 8)

VLED = LED forward voltage

ISEG = segment current set by RSET

Dissipation Example:

ISEG = 40mA, N = 8, DUTY = 31/32, VLED = 1.8V at 40mA, V+ = 5.25V

$$PD = 5.25V(40mA) + (5.25V - 1.8V)(31/32 \times 40mA \times 8) = 1.11W$$

Thus, for a CERDIP package (θJA = +80°C/W from Table 12), the maximum allowed ambient temperature TA is given by:

$$T_{J(MAX)} = T_A + PD \times \theta_{JA} + 150^\circ C = T_A + 1.11W \times 80^\circ C/W$$

where TA = +61.2°C.

The TA limits for PDIP and SO Packages in the dissipation example above are +66.7°C and +55.6°C, respectively.

Cascading Drivers

The example in Figure 3 drives 16 digits using a 3-wire μP interface. If the number of digits is not a multiple of 8, set both drivers' scan limits registers to the same number so one display will not appear brighter than the other. For example, if 12 digits are need, use 6 digits per display with both scan-limit registers set for 6 digits so that both displays have a 1/6 duty cycle per digit. If 11 digits are needed, set both scan-limit registers for 6 digits and leave one digit driver unconnected. If one display for 6 digits and the other for 5 digits, the second display will appear brighter because its duty cycle per digit will be 1/5 while the first display's will be 1/6. Refer to the *No-Op Register* section for additional information.

Serially Interfaced, 8-Digit LED Display Drivers

MAX7219/MAX7221

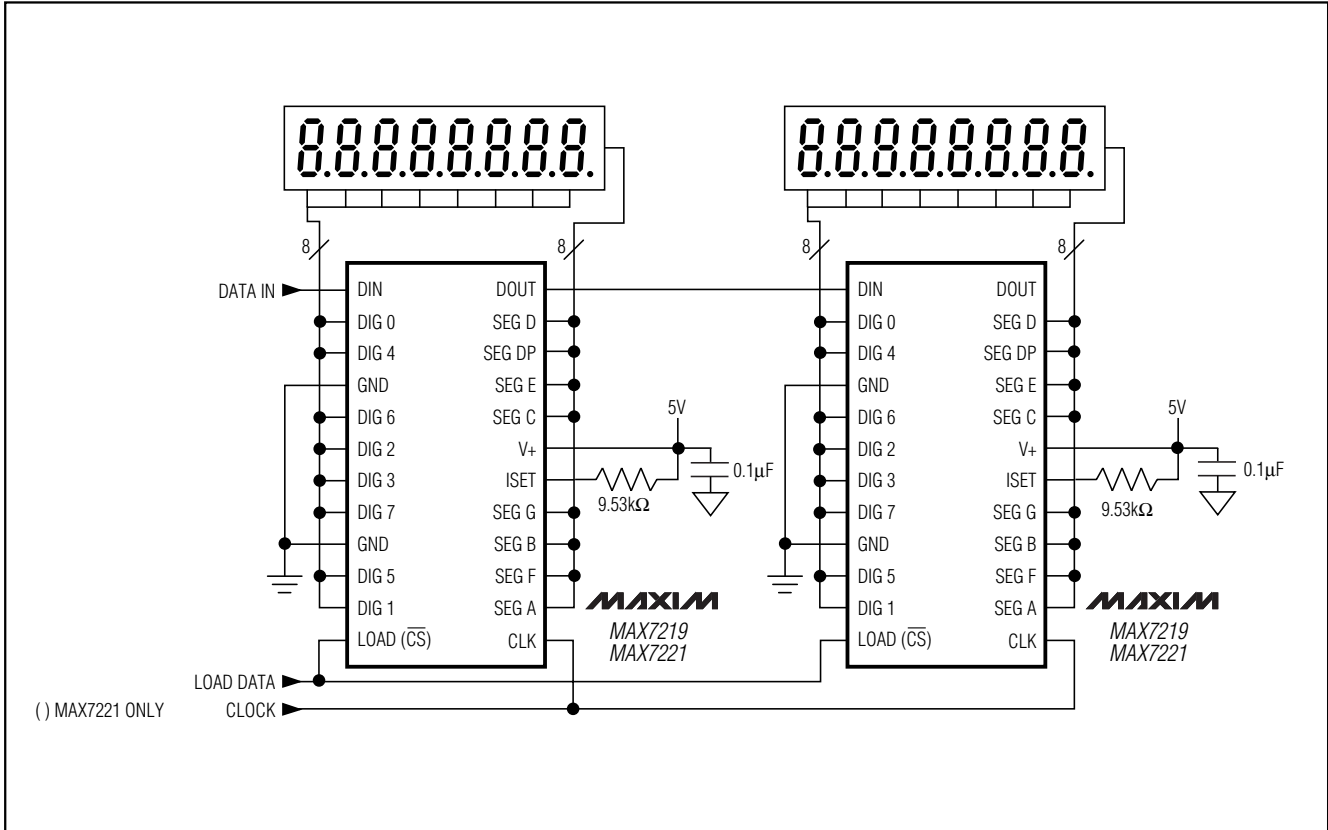


Figure 3. Cascading MAX7219/MAX7221s to Drive 16 Seven-Segment LED Digits

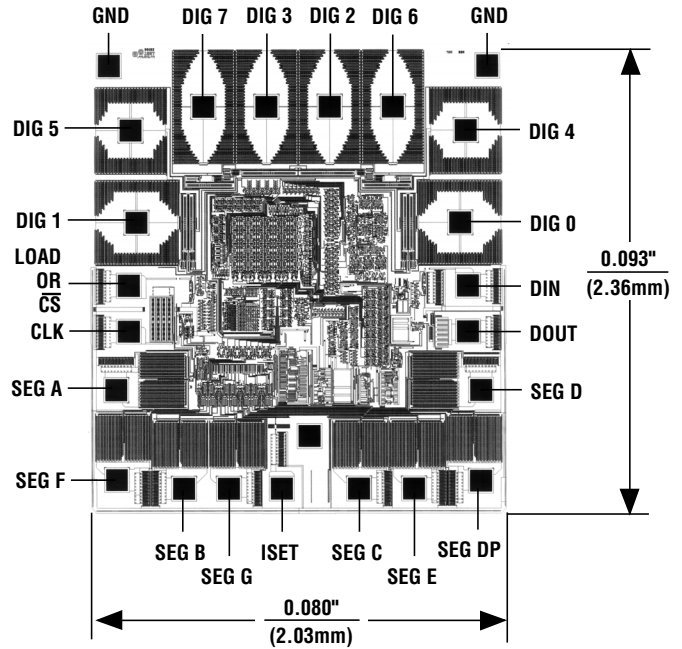
Serially Interfaced, 8-Digit LED Display Drivers

Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
MAX7221CNG	0°C to +70°C	24 Narrow Plastic DIP
MAX7221CWG	0°C to +70°C	24 Wide SO
MAX7221C/D	0°C to +70°C	Dice*
MAX7221ENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX7221EWG	-40°C to +85°C	24 Wide SO
MAX7221ERG	-40°C to +85°C	24 Narrow CERDIP

*Dice are specified at $T_A = +25^\circ\text{C}$.

Chip Topography



TRANSISTOR COUNT: 5267

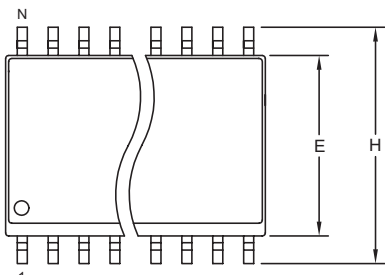
SUBSTRATE CONNECTED TO GND

Serially Interfaced, 8-Digit LED Display Drivers

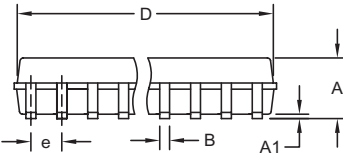
Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to www.maxim-ic.com/packages.)

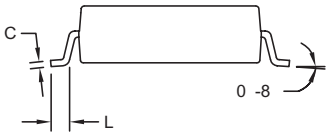
MAX7219/MAX7221



TOP VIEW



FRONT VIEW



SIDE VIEW


NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS013.
6. N = NUMBER OF PINS.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.093	0.104	2.35	2.65
A1	0.004	0.012	0.10	0.30
B	0.014	0.019	0.35	0.49
C	0.009	0.013	0.23	0.32
e	0.050		1.27	
E	0.291	0.299	7.40	7.60
H	0.394	0.419	10.00	10.65
L	0.016	0.050	0.40	1.27

VARIATIONS:

DIM	INCHES		MILLIMETERS		N	MS013
	MIN	MAX	MIN	MAX		
D	0.398	0.413	10.10	10.50	16	AA
D	0.447	0.463	11.35	11.75	18	AB
D	0.496	0.512	12.60	13.00	20	AC
D	0.598	0.614	15.20	15.60	24	AD
D	0.697	0.713	17.70	18.10	28	AE



PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, .300" SOIC

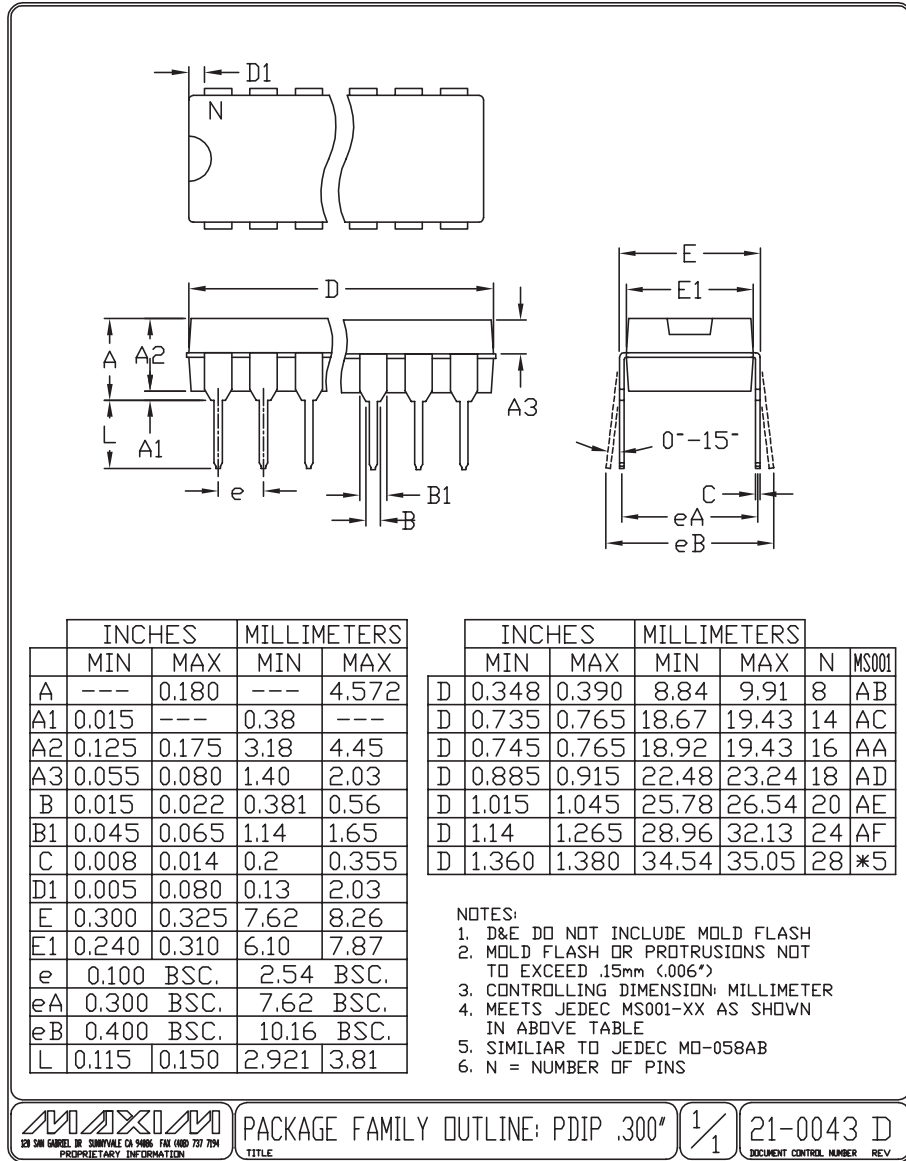
APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0042	B	1/1

SOICW EP5

Serially Interfaced, 8-Digit LED Display Drivers

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to www.maxim-ic.com/packages.)



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

16 Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 (408) 737-7600

承 认 书

SPECIFICATION

	客 户 资 料 CUSTOMER'S INFORMATION	
产品名称 LED 数码管 PRODUCTION NAME:		
产品型号: LD788BS-SS22 PRODUCTION TYPE:	机型: MODEL NO:	
规格摘要: TYPE: 红光 788 点阵管	料号: PART NO:	

日期: 2010-10-25 DATE:	承办人: ISSUEDER:
-------------------------	-------------------

客户确认 APPROVED BY	
签名 SIGN:	日期 DATE:
结论 RESULT	

确认后请回传 PLEASE RETURN BY ONE COPY

- 1 型号 PART NO LD788BS-SS22
- 2 说明 Description
发光颜色 Emitted Color 红光
外观颜色 Lens Color 黑、白两色
外形尺寸 Max Size 20.00*20.00*5.90

极限参数 Absolute Maximum Ratings ———▶ 建议使用驱动检测

参数 Parameter	单位 Symbol	极限值 Maximum Rating	单位 Unit
功耗 Power Dissipation	Pd		mW
脉冲电流 Peak Forward Current	Ifp	150	mA
直流电流 Continuous Forward Current Forward)Current	Ifm	20	mA
反向电压 Reverse Voltage	VR	5	V
工作温度 Operating Temperature Range	Topr	-40 → +85	°C
储藏温度 Storage Temperature Range	Tstg	-40 → +100	°C
静电电压 Static Voltage	Var		V

*焊接温度 Lead Sodering Temperature 260°C for 3 seconds

*当工作温度高于 25°C 时, Ifm, Ifp 和 Id 必须降低; 电流降低率是 -0.36mA/°C (直流驱动), 或 -0.86mA/°C (脉冲驱动) 功耗降低率是 -0.75mW/°C 产品的工作电流不能大于对应工作温度条件 Ifm 或 Ifp 的 60%
For operation above 25°C, The Ifm Ifp & Pd must be derated, the Current derating is -0.36mA/°C for DC drive and -0.86mA/°C for Pulse drive, the power dissipation is -0.75mW/°C. The product working current must not more than the 60% of the Ifm or Ifp according to the working temperature.

光电特性 Optical-Electrical Characteristic ———▶ 建议使用驱动检测

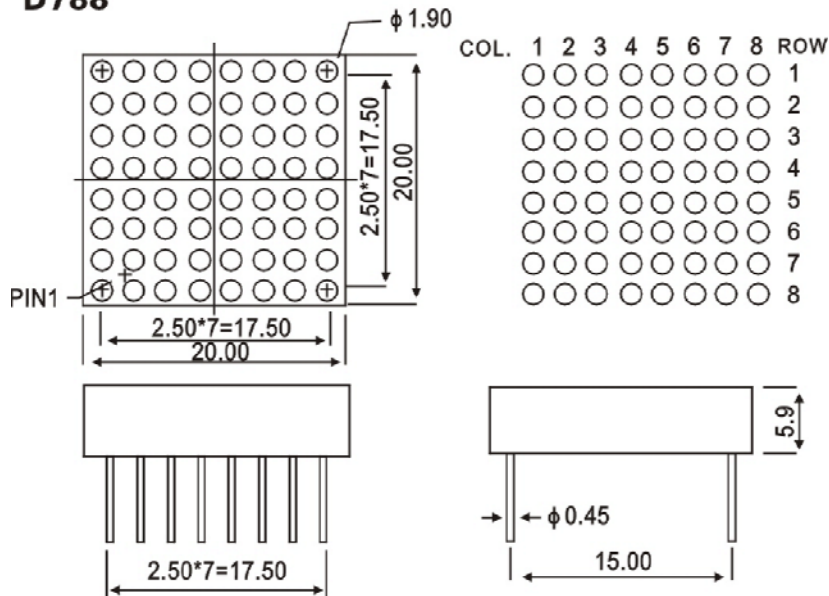
参数 Parameter	测试条件 Test CONDITING	单位 Symbol	Min	Type	Max	单位 Unit
发光强度 Luminous Intensity	IF=10mA	Iv	21.8	25.9	28.4	Mcd
正向电压 Forward Voltage	IF=10mA	VF	-	2.01	-	V
反向电流 REVERSE Current	VR = 5V	IR	-	20		uA
波长 Peak Wavelength	IF=10mA	155.7	630.8	631.7	634.3	nm
带宽 Spectral Bandwidth	IF=10mA	△λ	-	40	-	nm
查看角度 View Angle	IF=10mA	2θ 1/2	-		-	Deg.

3.结构尺寸 Mechanical Outline :

(未注尺寸公差 Unspecified Tolerances is: X±0.2

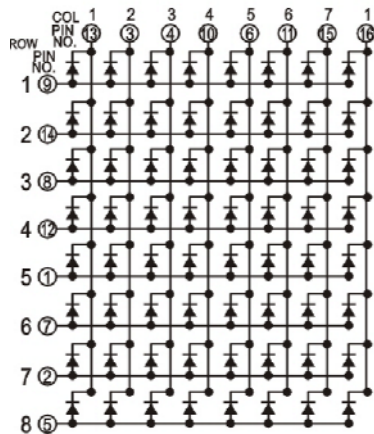
发光颜色 红色
COLOR

D788



. 电路图 Circuit Diagram :

PCB:FJ788A/B



5. 保存和焊接条件 Storage & Soldering Condions :

- Store with care. Storing the units in bad condition will cause the reflector sheet and decrease it' s adhesive power. Storage the products under the condition :temperature ($25^{\circ}\text{C} \pm 10^{\circ}\text{C}$) and humidity ($65^{\circ}\text{C CRH} \pm 20^{\circ}\text{C CRH}$) our recommendation.
- The Soldering Temperature is $260 \pm 5^{\circ}\text{C}$ and Soldering Time should be less than 3 sec, and soldering iron power should be less than 30W.
- The soldering point should be farther than 1.6mm from body.

注意保存, 保存条件不好时, 会降低膜片与反射壳 导光板 的粘附力
推荐保存条件为 温度 $25^{\circ}\text{C} \pm 10^{\circ}\text{C}$
湿度 $65^{\circ}\text{C CRH} \pm 20^{\circ}\text{C CRH}$

焊接温度 $260^{\circ}\text{C} \pm 5^{\circ}\text{C}$, 焊接时间小于 3 秒, 烙铁功率小于 30W

焊接点应离产品实体大于 1.6mm