Analysis Characteristic XPG LED Using Microcontroller Circuit Simulation

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Abstract

This work is concerned the detailed calculation of internal circuit of XPG LED and the characteristics with designing the control circuit to calculation the different brightness between XPG LED and types with lens LED diode and the point light of LED diode. The control is used method of digital circuit by increasing the duty cycle of PWM supplying voltage used the microcontroller with software development written in micro-basic language (program XPG circuit simulation) and hardware to measuring the intensity of brightness, which emitted from the LED. Using the photo resistance and this parameter read it by the microcontroller to be display it on screen. This result gives the best characteristics of XPG LED for suitable lighting.

Keywords: XPG LED Circuit, Detailed Calculation of XPG LED, Circuit Simulation.

تحليل خواص شبه الموصل الضوئي نوع XPG باستخدام دائرة المحكم الدقيق

الخلاصة

إن هذا البحث يتناول بصورة مركزة على دقة حساب الدائرة الداخلية وخواص شبه الموصل الضوئي باستخدام دائرة السيطرة لحساب شدة الانارة الضوئية و مقارنتها مع نوع شبه الموصل الضوئي(XPG)نوع ذو العدسة والنوع ذات الانبعاث النقطي وهذه الدائرة تستخدم الطريقة الرقمية وذلك بتوليد نبضات زمنية تنغيمية منتظمة لفولتية التغذية باستخدام المحكم الدقيق من خلال البرنامج المكتوب بلغة مايكرو-بيسيك (برنامج دائرة المحاكات لشبه الموصل الضوئي) والتوصيلات المربوطة والتي تتم بها قياس كثافة شدة الضوء المنبعث من شبه الموصل الضوئي وباستخدام مقاومة ضوئية ولقياس قيمة هذه المقاومة في نفس الوقت من قبل المحكم الدقيق واظهارها على العارضة المربوطة مع المحكم الدقيق ومن خـــلال ذلك ملاحظة الخواص الجيدة لهذا النوع لشبه الموصل الضوئي للاستخدامات المفضلة له في الانارة .

Notations

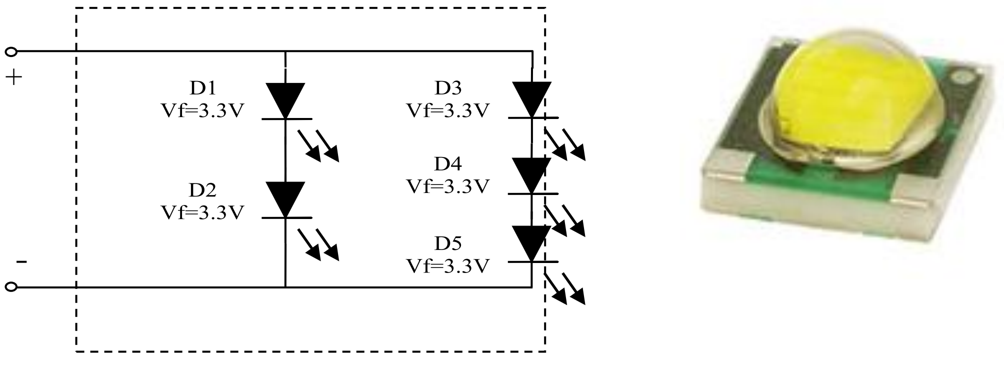
XPG XLamp Power Cree (high lumen directional light)
LED Light Emission Diode
PIC Peripheral Interface Control
PWM Pulse Width Modulation
LCD Liquid Crystal Display
lm Luminous Flux
V_D Forward Voltage Across LED
I_D Forward Current Across LED

1-Introduction

The XPG LED combines the proven lighting –class performance and reliability of XPG LED in a package with 80% smaller footprint. This smaller package extends Cree's a word-wiring LED performance in to new LED lighting applications **[1]**.
The new XPG color LEDs provide up to 69 % more flux than the existing X Lamp with an 80 % smaller footprint. The XPG reduce the space between LED die by 75% compared to the normal LEDs lamps. This type of LED more use for lighting source to view other objective by the light reflected from those objects, such as the general lighting found in most rooms or task lighting found on many desk which called illustrator LED in this type where used LED driver performs a function to ballast for discharge lamps. It is control the current following through the LED .Most LED driver is design it to provide current to a specific device or array, since LED packages and arrays are not presently standardize. It is very important that a driver is selected that is match to the specific device or array to be illustrated **[1]**.
The objective of the work which is develop the microcontroller assessment algorithm and program to digital control voltage by easy touch screen panel to increasing and decreasing the duty cycle of input voltage and reading the resistance of photo resistor to accurate measuring and see the face changing between these three types of LEDs. The XPG LEDs has many advantages is very fast achievement of full lightness, low heat loss, high-energy efficiency, long life time and very robust against mechanical vibration **[2]**.

2- XPG LED Circuit

The circuit of the XPG LED shown in figure (1) the current split about 50/50 downs each string causing D1/D2 to burn out.



(a) (b)

Figure (1) (a) XPG LED Circuit, (b) XPG LED view

The response in the thread indicated that the circuit was not likely to be useful, with correctly pointing out that the string of three led will be very dim if lit at all. By using reasoning approach and by applying basic circuit theory ideas and general knowledge of component characteristics, they can hopefully to get a general idea of what is happening **[3]**.

As this may not involve any calculation by not getting specific or very accurate calculations, perform some more detailed calculations by using ohms law relating current and voltage for resistor. However the semiconductors equations may be more complex and they often have a choice of approaches depending on how accurate calculation want to be so by performing a purely algebraic circuit analysis which will give it some deeper insight in to the behavior of the circuit **[3]**.

The schematic supplied by XPG LED in figure (1) specific supply of 16.5v, 1A. It is not clear if this voltage source with maximum current of 1A or the current source with maximum voltage of 16.5v even the LED often driven current source **[4]**.

The LEDs are specific as having a forward voltage drop of 3.3v for each one, which would indicate 9.9v, across the three series LEDs (D3,D4,D5) and from the electric characteristics in figure (2) ,shown that a foreword voltage of 3.3v corresponds to the current of about 0.9A. Therefore, the total voltage across the two series LEDs (D1/D2) must be the same as the total voltage across D3, D4 and D5. If assuming that all the LEDs are the same characteristics, so foreword voltage for D1 and D2 be the same as that for D3,D4 and D5.By assuming a foreword voltage of 3.3v for either D1/D2 or D3 to D5 this will give a basic understanding of how the circuit will be have **[5]**. Let The D1 and D2 have foreword drop voltage of 3.3v than the total voltage across them will be 6.6v and the same way voltage appear across D3/D4/D5 if assuming these three LEDs are exactly same so the each will have 2.2v across it.

In the figure (2) shown that the current in these LEDs will be very small so the curve does not extend this far, so that easily infer a current of loss than 10mA and in fact it will probably be much smaller than this. From the figure (3) which related light output, LED current looking that a current of less than 10mA will mean LED light will be very dim and it is visible at all, thus the D1/D2 brightly lit and D3/D4/D5 off, because of a 9.9v supply delivering about 900mA, which is going through D1/D2. If the D3/D4/D5 has forward drops of 3.3v, then the total voltage across them will be 9.9v and the same voltage will appear across D1/D2. If assuming that both these LEDs are the same then each will be 4.95v (9.9/2) across it and from figure (2) shown that the voltage is not even on the graph scale and consequently the current would be enormous-the LEDs D1/D2 would destroyed **[5]**.

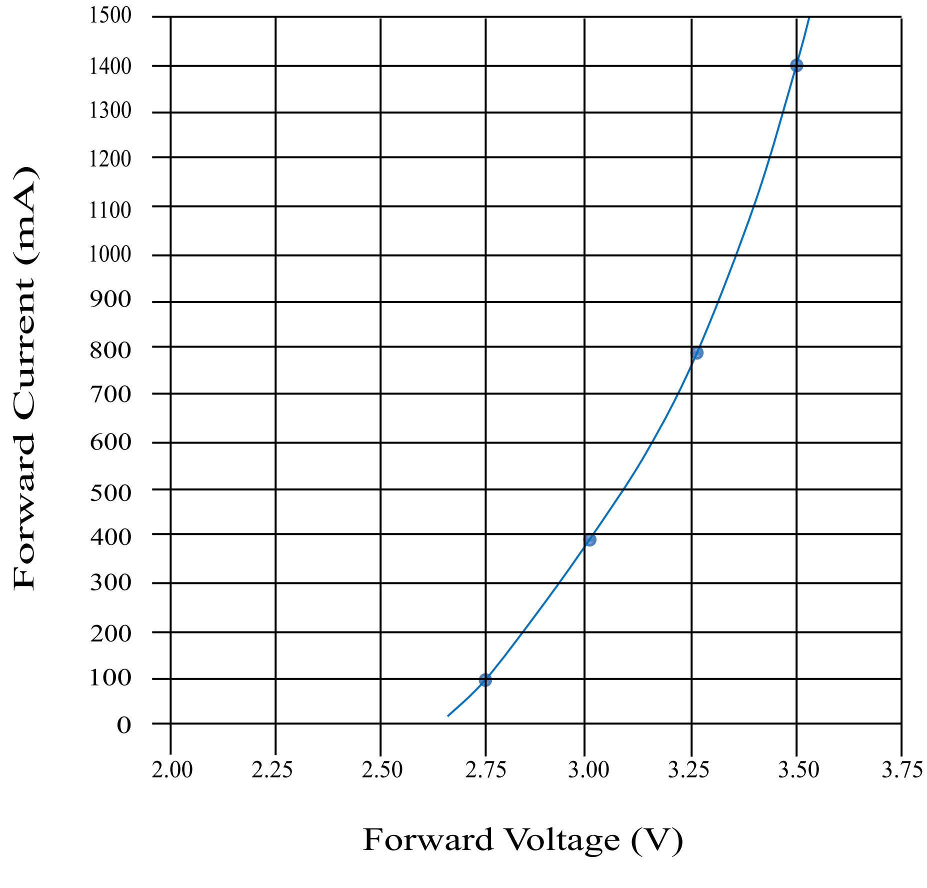


Figure (2) Electrical Characteristics of XPG LED

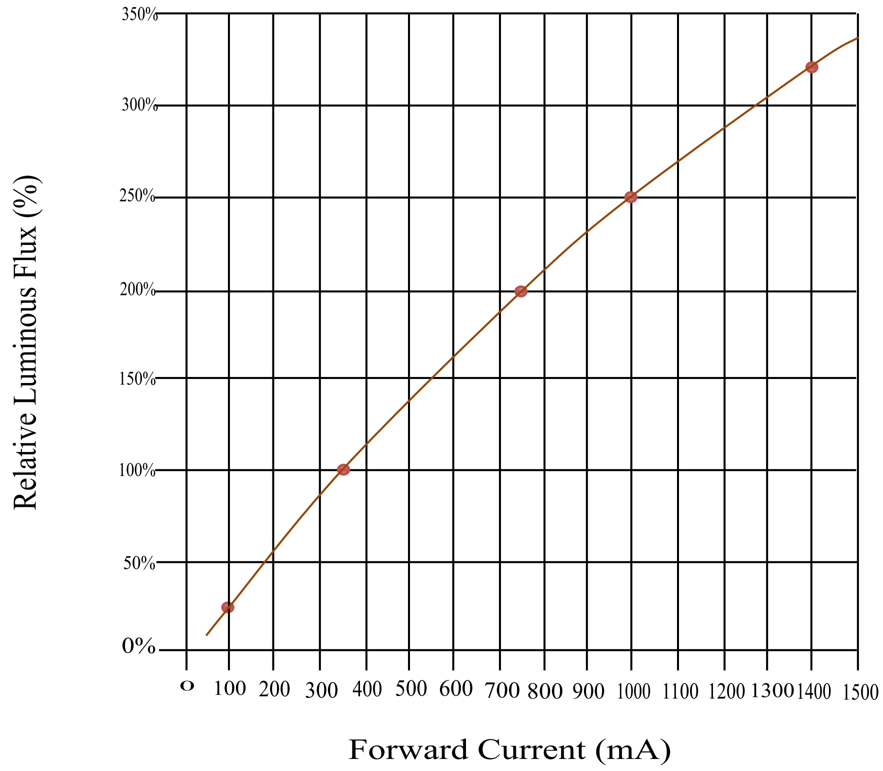


Figure (3) Luminous Flux Characteristics of XPG LED

The situation is similar to the previous case , which almost all of the total current from the supply going through D1/D2.This is the direct consequence of exponential voltage to current characteristic as see in figure (2) of all foreword biased LEDs. The fact that the voltage across each of D3, D4 and D5 will be two thirds of that across both D1/ D2 together with the exponential characteristic,

implies that the D1/D2 current will always be very much larger than the D3/D4/D5 current **[5]**.

3-Detailed Calculation of XPG Circuit

The characteristic equation for an idealized LED, relating the foreword bias current through it I_D to the voltage across it V_D is:

$$I_D = I_S\left(e^{\frac{V_D}{n}V_T} - 1\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where I_S is the saturation current, n is the ideality factor and V_T is the thermal voltage. The I_S, n are characteristics of individual LEDs, which is depend on construction and used materials. The V_T is related to temperature and basic physical constants and it is about 25 mV at room temperature but n typically between 1 and 2 for Silicon diodes ,but may be larger for LEDs .The I_S varies widely depending on the type of diodes, but is typically very small compared with usual operating current. The default value of is $1X10^{-14}$ A. **[6]**

The equation is idealize it because it does not take account of series resistance or reverse breakdown, but it is still useful in many situation. The equation can further simplified because the exponential term is very much larger than one for all but the smallest foreword voltage so therefore removing the (-1) term and rearranging the equation so the voltage across diode becomes:

$$V_D = n\, V_T \ln \; (I_D \; / \, I_S\,) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Substituting the diode equation for each diode and denoting the current through D1/D2 as I_{12} and the current through the D3/D4/D5 as I_3 , I_4 , I_5 so:

$$nV_T \ln (I_{12}/\, I_S) \; + nV_T \ln (I_{12}/\, I_S) \; = \; nV_T \ln (I_{345}/\, I_S) + nV_T \ln (I_{345}/\, I_S) \; + nV_T \ln (I_{345}/\, I_S).$$
………………….……………….. (4)

Because of the all LEDs equal in characteristic so by canceling the nV_T terms and now the equation look it:

$$\ln (I_1\, I_2 \,/\, I_S) \; + \; \ln (I_1\, I_2 \,/\, I_S) \; = \; \ln (I_3\, I_4\, I_5 \,/\, I_S) + \; \ln (I_3\, I_4\, I_5 \,/\, I_S) \; + \ln (I_3\, I_4\, I_5 \,/\, I_S).$$
……………………………………………….. (5)

By given that adding algorithms is equivalent to multiplying so the equation becomes:

$$I_1\, I_2\; I_S = I_3\, I_4\, I_5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Because of the I_S is very small compared with typical foreword current so that it can conclude from this equation that I_{12} must be much larger than I_{345} .If the I_{12} is (0.5A) and the I_S is $1X10^{-14}$ A then I_{345} equal to (14µA) so in LED term this would correspond to D1/D2 shining and D3/D4/D5 being very dim **[7]**.

By removing the terms (-1) from the equation (1) and putting the current values into the approximate equation for diode voltage which n=1 and $V_T = 25mV$ gives (0.789) V and (0.526) V so first noting that value one is two thirds of the other value. As accepted for equal diodes in characteristics and second these voltages to obtain the current values using the equation (1) with term (-1) become the values are very close to (0.5) A and (14 μA), justifying our approximation **[7]**.

4-Circuit Simulation

By using the microcontroller, type PIC16F887 to design the simulation circuit which shown the block diagram in figure (4) **[8]**.

The electrical schematic circuit in figure (5) measure the intensity of light, which emitted from the XPG LED **[8]**.

The PWM power supply generated from the same circuit by the microcontroller which is controlled by the touching the box on the graphical LCD which symbolic by (+) ,to increasing the duty cycle PWM of supply voltage, and the symbolic (-) to decreasing the duty cycle supply voltage of XPG LED **[8]**.

The measuring of intensity of lighting used the photo resistor with wide range of changes of resistance and this resistance read it by the same microcontroller to displayed on same graphical LCD which shown the hardware circuit in figure (6) **[8]**.

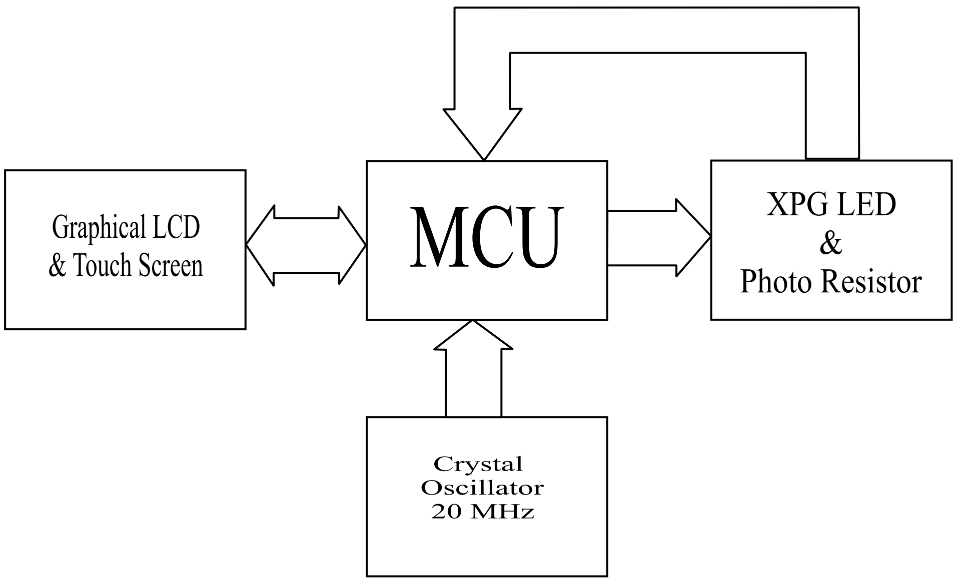


Figure (4) Block diagram of circuit simulation

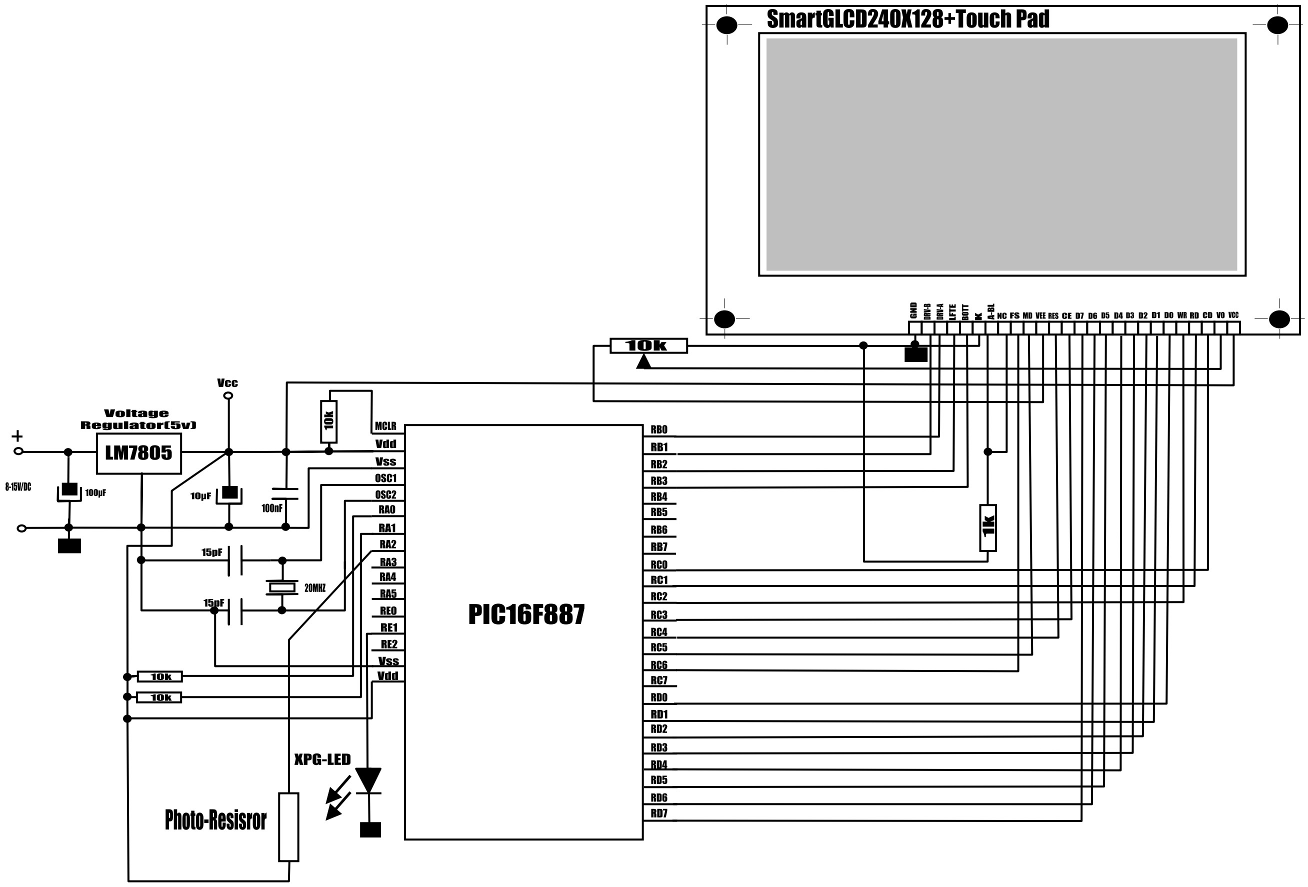


Figure (5) Electrical schematic circuit simulation

The program was written with the micro-basic language and compiled to the HEX-file then loaded to microcontroller which shown in appendix to generate the duty cycle of pulse width modulation. Then converting this system to decimal number, which is display it on the graphical LCD meaning the input voltage and by reading the value of photo resistor then display it on the same LCD, which represent approximately the intensity of lighting **[9]**.

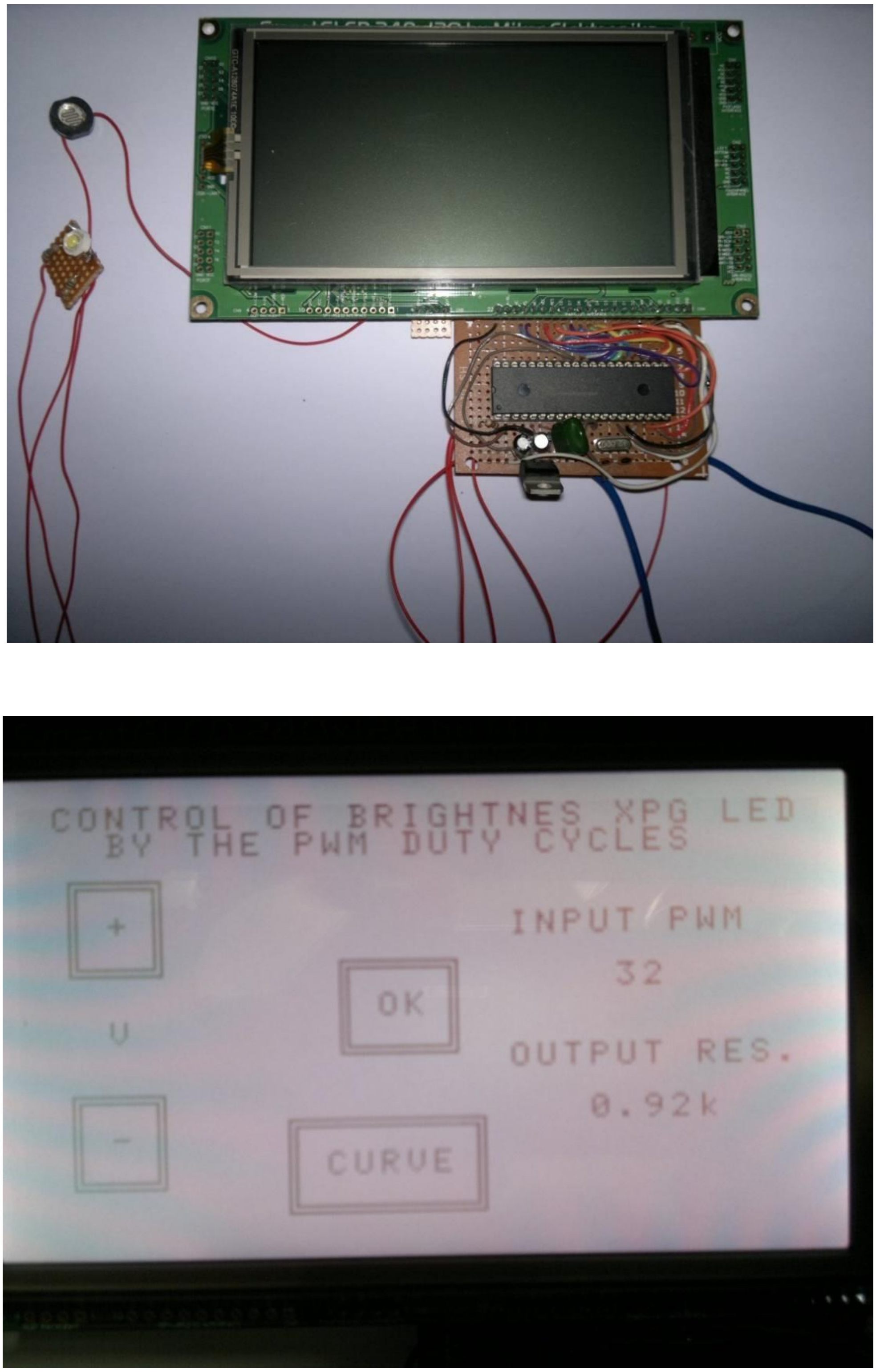
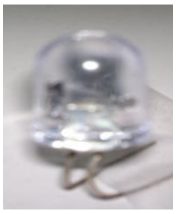


Figure (6) The Hardware of circuit simulation with LCD monitor

The circuit shown in figure (6) is used to measure the intensity of light between the three types of LEDs in figure (7) (XPG, normal LED and light point LED). T figure (8) shown the lighting Characteristics of these three types, and table (1) show the different result between them by variation the PWM gives less resistor that equal to high light intensity type XPG LED.

(a)



(b)

(c)

Figure (7) a.XPG LED, b. LED with lens, c. Light Point LED

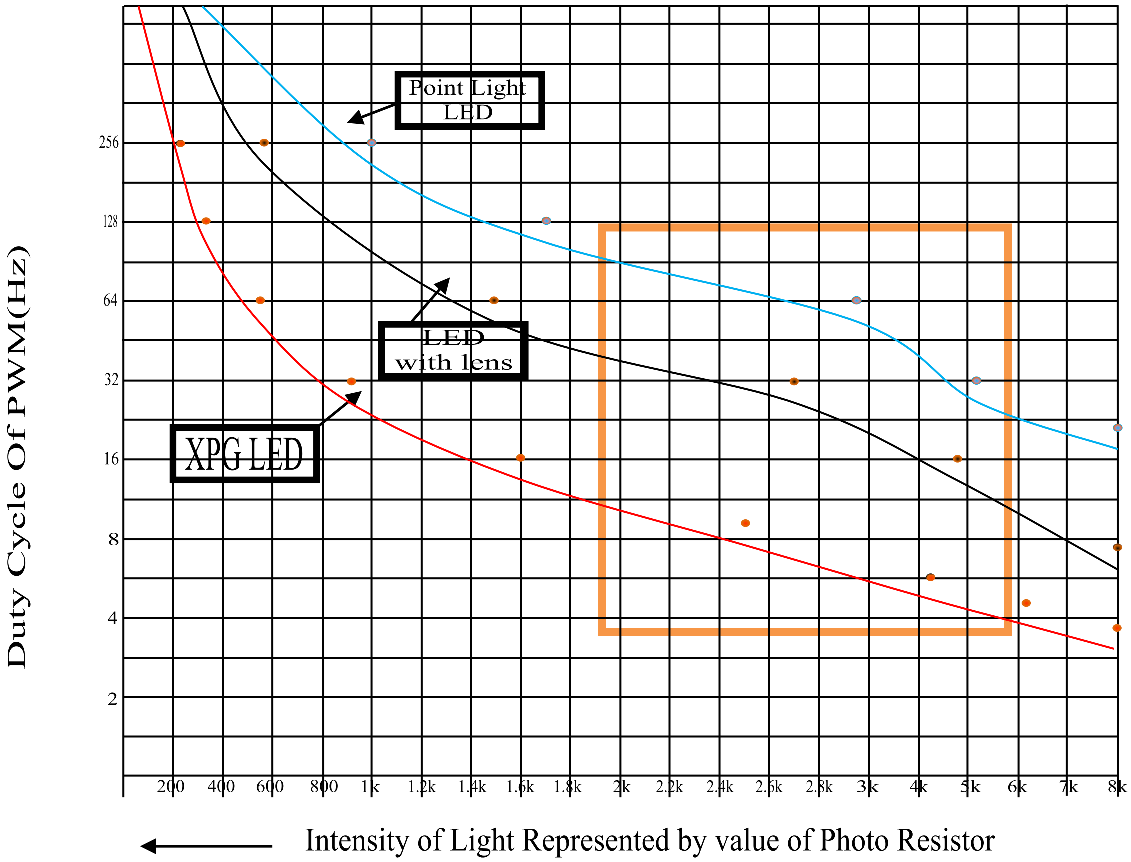


Figure (7) Lighting Characteristics of XPG, LED with lens & point light LED

Table (1) The result of characteristics of three types LED

Type \ PWM(Hz)	4	8	16	32	64	128	256
XPG LED Light intensity Represent by Photo Resistance(kΩ)	7.26	2.73	1.6	0.92	0.57	0.37	0.25
LED with lens Light intensity Represent by Photo Resistance(kΩ)	20	7.75	4.85	2.72	1.52	0.96	0.76
Point Light LED Light intensity Represent by Photo Resistance(kΩ)	41.11	16.32	9.21	5.22	2.95	1.71	1.1

Conclusions

To be confirming the equation because of developed earlier that the two side of equation **(**6) are out by about factor of ten, and these values include the cube of forward current, which is exponentially dependent on circuit voltage to give the XPG LED best characteristics. So the one of advantage of this way they can perform very easy that 1W LED with illustration power of 100 lm is able to replace a halogen lighting system. This discrepancy is not a problem due to the fact that the circuit simulated using the microcontroller is more accurate and hence complex than the one used method of calculation to generate duty cycle PWM using hardware, software to programming of microcontroller.

References

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[8]Seung Hwan, Basic on LED and LED control, lighting system, ,(2009),page(198),
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Appendix:

<u>Notation:</u>
This programs must follow with library files of module smart graphical liquid crystal display 240X128.

```
program XPG_Circuit_Simulation
include __Lib_T6963C_Consts
' T6963C module connections
dim T6963C_dataPort as byte at PORTD          ' DATA port
dim T6963C_ctrlwr as sbit at RC2_bit          ' WR write signal
dim T6963C_ctrlrd as sbit at RC1_bit          ' RD read signal
dim T6963C_ctrlcd as sbit at RC0_bit          ' CD command/data signal
```

```
dim T6963C_ctrlrst as sbit at RC4_bit              ' RST reset signal
dim T6963C_ctrlwr_Direction as sbit at TRISC2_bit     ' WR write signal
direction
dim T6963C_ctrlrd_Direction as sbit at TRISC1_bit   ' RD read signal direction
dim T6963C_ctrlcd_Direction as sbit at TRISC0_bit   ' CD command/data signal
direction
dim T6963C_ctrlrst_Direction as sbit at TRISC4_bit  ' RST reset signal direction
' Signals not used by library, they are set in main sub function
dim T6963C_ctrlce as sbit at RC3_bit               ' CE signal
dim T6963C_ctrlfs as sbit at RC6_bit               ' FS signal
dim T6963C_ctrlmd as sbit at RC5_bit                ' MD signal
dim T6963C_ctrlce_Direction as sbit at TRISC3_bit   ' CE signal direction
dim T6963C_ctrlfs_Direction as sbit at TRISC6_bit   ' FS signal direction
dim T6963C_ctrlmd_Direction as sbit at TRISC5_bit   ' MD signal direction
' End T6963C module connections
dim   panel as byte         ' current panel
         i as word        ' general purpose register
      curs as byte        ' cursor visibility
     cposx,
     cposy as word          ' cursor x-y position
     txtcols as byte       ' number of text coloms
     txt, txt1 as string[29]
     txt3 as string[6]
     txt4,txt5 as string[1]
     txt6,txt7 as string[10]
     txt8,txt9 as string[11]
     txt10 , txt11 as char[1]
 dim  rr as byte
dim ss as longint
dim ii as word
rr=0
 dim x_coord,y_coord,
x_coord240,y_coord128 as longint
dim p_duty , o_duty as byte
sub function Get x() as word
PORTB.0=1
```

```
PORTB .1=0
Delay_ms(5)
Result =ADC_read(0)
end sub
sub function Get y() as word
PORTB.2=0
PORTB.3=1
Delay_ms(5)
Result =ADC_read(1)
end sub
main:
  txt1 = " BY THE PWM DUTY CYCLES "
  txt  = "CONTROL OF BRIGHTNES XPG LED"
  txt3 = "V"
  txt4 = "+"
  txt5 = "-"
  txt6 = "OK"
  txt7 = "INPUT  PWM"
  txt8 = "OUTPUT RES."
  txt9 = "CURVE"
  txt10= "."
  txt11= "k"
  ANSEL  = 0x07          ' Configure AN2 pin as analog
  TRISA  = 0xFF          ' PORTA is input
  ANSELH = 0
  C1ON_bit = 0               ' Disable comparators
  C2ON_bit = 0
  TRISB0_bit = 0             ' Set RB0 as output
  TRISB1_bit = 0             ' Set RB1 as output
  TRISB2_bit = 0             ' Set RB2 as output
  TRISB3_bit = 0             ' Set RB3 as output
  TRISB4_bit = 1             ' Set RB4 as input
  T6963C_ctrlce_Direction = 0
  T6963C_ctrlce = 0           ' Enable T6963C
  T6963C_ctrlfs_Direction = 0
  T6963C_ctrlfs = 0           ' Font Select 8x8
```

```
 T6963C_ctrlmd_Direction = 0
 T6963C_ctrlmd = 0             ' Column number select
 panel = 0
 i = 0
 curs = 0
 cposx = 0
 cposy = 0
 ' Initialize T6369C
 T6963C_init(240, 128, 8)
'  * Enable both graphics and text display at the same time
 T6963C_graphics(1)
 T6963C_text(1)
'  * Text messages
 T6963C_write_text(txt, 1, 0, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt1, 2, 1, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt3, 3, 8, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt4, 3, 4, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt5, 3, 12, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt6, 13, 7, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt7, 18, 4, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt8, 18, 9, T6963C_ROM_MODE_XOR)
 T6963C_write_text(txt9, 11, 13, T6963C_ROM_MODE_XOR)
'  * Cursor
 T6963C_cursor_height(8)       ' 8 pixel height
 T6963C_set_cursor(0, 0)       ' Move cursor to top left
 T6963C_cursor(0)              ' Cursor off
'  * Draw rectangles
 T6963C_rectangle(15, 22, 42, 50, T6963C_BLACK)
 T6963C_rectangle(17, 24, 40, 48, T6963C_WHITE)
 T6963C_rectangle(15, 86, 42, 114, T6963C_WHITE)
 T6963C_rectangle(17, 88, 40, 112, T6963C_WHITE)
 T6963C_rectangle(95, 46, 130, 74, T6963C_WHITE)
 T6963C_rectangle(97, 48, 128, 72, T6963C_WHITE)
 T6963C_rectangle(79, 94, 138, 122, T6963C_WHITE)
 T6963C_rectangle(81, 96, 136, 120, T6963C_WHITE)
PORTA=255
```

```
TRISA=255
PORTE=0
TRISE=0
PWM1_lnit(5000)
p_duty =0
o_duty =0
PWM1_start()
  WHILE TRUE
 X_coord=GetX()
 Y_coord=GetY()
 X_coord240=(x_coord *240)/1024
 Y_coord128=128-((y_coord *128)/1024)
 if((X_coord240>=17) and (X_coord240<=40) and (Y_coord128>=24) and
(Y_coord128<=48)) then
  if o_duty and (POTRA,0,1,1) then
p_duty = p_duty +1
if (PORTA,0,1,1) then
o_duty = 255
end if
end if
  end if
  if((X_coord240>=17) and (X_coord240<=40) and (Y_coord128>=88) and
(Y_coord128<=112)) then
  if o_duty and (POTRA,1,1,1) then
p_duty = p_duty -1
if (PORTA,1,1,1) then
o_duty = 255
end if
end if
end if
if o_duty < > p_duty then
PWM1_set_duty (p_duty)
o_duty = p_duty
PORTE = o_duty
end if
ss=ADC_read(3)*1000
```

```
ii=(ss/185.9)
T6963C_write_text(ii div 100 mod 10+48, 20, 9, T6963C_ROM_MODE_XOR)
T6963C_write_text(txt10, 21, 9, T6963C_ROM_MODE_XOR)
T6963C_write_text(ii div 10 mod 10+48, 22, 9, T6963C_ROM_MODE_XOR)
T6963C_write_text(ii mod 10+48, 23, 9, T6963C_ROM_MODE_XOR)
T6963C_write_text(txt11, 24, 9, T6963C_ROM_MODE_XOR)
 Delay_ms(200)
 wend
end.
```