Flasher Board Design Calculations

November 11, 2002 N. Kitamura

LED = Nichiha NSHU550

$c := 299792458 \cdot \frac{m}{sec}$ $h := 6.6260755 \cdot 10^{-34} \cdot joule \cdot sec$ $e := 1.60217733 \cdot 10^{-19} \cdot coul$

$nm := 10^{-9} \cdot m$ $eV := \frac{e}{coul} \cdot joule$ $ns := 10^{-9} \cdot sec$

$\lambda mean := 375 \cdot nm$ $\Delta\lambda := 12 \cdot nm$ $\nu mean := \frac{c}{\lambda mean}$

$\nu mean = 799.447 \times 10^{12} Hz$

(800 THz)

$Emean := \frac{h \cdot c}{\lambda mean}$ $\delta E := \frac{-h \cdot c \cdot \Delta\lambda}{\lambda mean^2}$

$Emean = 529.719 \times 10^{-21} J$ $\delta E = -16.951 \times 10^{-21} J$

The peak frequency (energy) is a Lorenzian

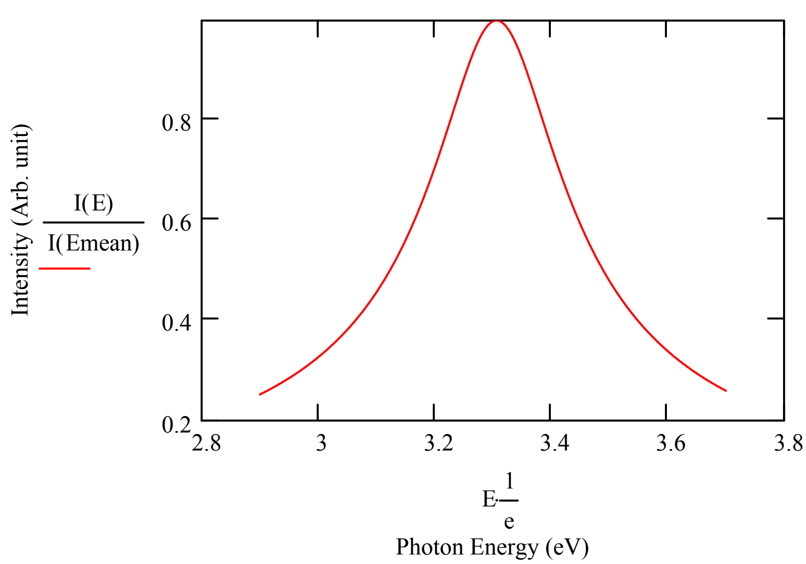
$\frac{Emean}{e} = 3.306 V$

$A := 1$

$\frac{\delta E}{e} = -0.106 V$

$$I(E) := \frac{A}{\sqrt{(E - Emean)^2 + \delta E^2}}$$

$E := 2.9 \cdot eV, 2.901 \cdot eV .. 3.7 \cdot eV$



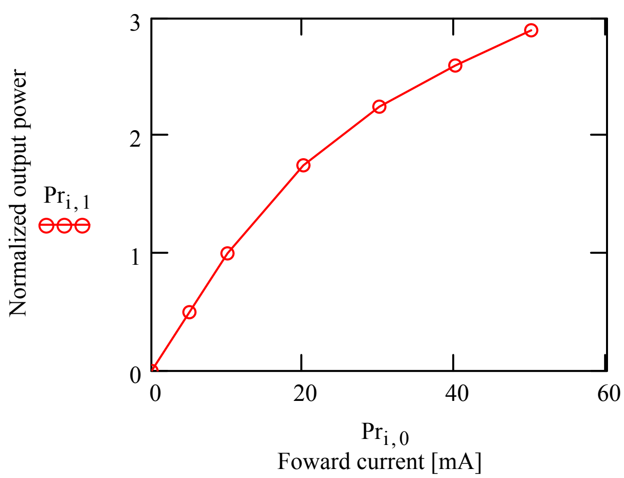
Optical output for IF=10 mA is Po = ~700uW at 25 degC (Rank 2 devices)

Normailzed output power as a function of forward current [mA], read off of the datasheet is as follows (Ta = 25 degC):

$i := 0..6$

$$Pr := \begin{pmatrix} 0 & 0 \\ 5 & 0.5 \\ 10 & 1.0 \\ 20 & 1.75 \\ 30 & 2.25 \\ 40 & 2.6 \\ 50 & 2.9 \end{pmatrix}$$

$If := Pr^{\langle 0 \rangle}$



Datasheet states that the nominal output power Po for the forward current of 10mA is

$Prank1 := 500 \cdot 10^{-6} \cdot watt$ $Prank2 := 700 \cdot 10^{-6} \cdot watt$ $Prank3 := 1000 \cdot 10^{-6} \cdot watt$

Replot the output power vs mA for various grades ("Ranks") of the LED:

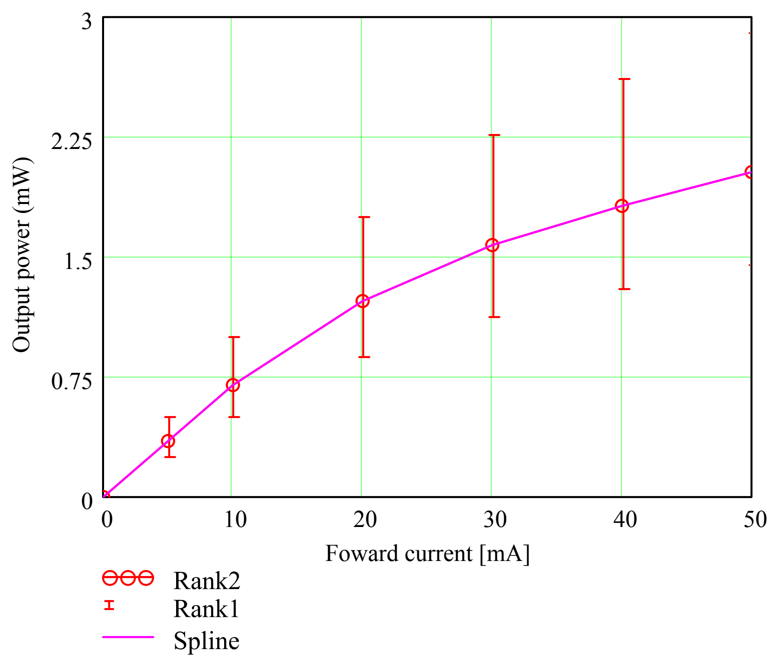
$Pp1 := Pr^{\langle 1 \rangle} \cdot Prank1$ $Pp2 := Pr^{\langle 1 \rangle} \cdot Prank2$ $Pp3 := Pr^{\langle 1 \rangle} \cdot Prank3$

$$If = \begin{pmatrix} 0.000 \\ 5.000 \\ 10.000 \\ 20.000 \\ 30.000 \\ 40.000 \\ 50.000 \end{pmatrix} \qquad Pp2 = \begin{pmatrix} 0.000 \\ 350.000 \times 10^{-6} \\ 700.000 \times 10^{-6} \\ 0.001 \\ 0.002 \\ 0.002 \\ 0.002 \end{pmatrix} W$$

$vs := lspline(If, Pp2)$

	0
0	0.000
1	3.000
2	0.000
3	0.000
4	$776.712 \cdot 10^{-9}$
5	$-3.107 \cdot 10^{-6}$
6	$-1.568 \cdot 10^{-6}$
7	$-1.122 \cdot 10^{-6}$
8	$-244.521 \cdot 10^{-9}$
9	0.000

vs = (table above) W



Rank1, Rank2, Rank3 (25 degC)

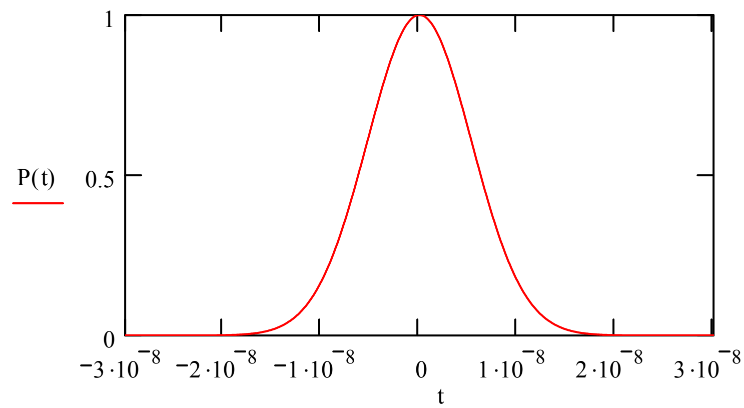
The voltage corresponding to the forward current of 10mA is about 3.5V. Thus, the efficiency at 10mA is approximately:

$$\frac{0.75 \cdot 10^{-3}}{10 \cdot 10^{-3} \cdot 3.5} = 0.021$$

The next question is what should be the peak current setting in order to produce so-many photons per pulse. Assume that the pulse has a gaussian temporal profile.

$$\Delta t := 15 \cdot ns \qquad t := -30 \cdot ns, -29.9 \cdot ns .. 30 \cdot ns$$

$$P(t) := Ppeak \cdot \exp\left[\frac{-4t^2}{(\Delta t)^2}\right] \qquad Ppeak := 1 \cdot watt$$



The area under the curve (total energy) is

$$Epulse := \sqrt{\pi} \cdot Ppeak \cdot \frac{\Delta t}{2}$$

Let the number of photons to be produced per pulse be $\quad Npulse := 5 \cdot 10^9$

$$Ppeak := Npulse \cdot \frac{2 \cdot h \cdot \nu mean}{\sqrt{\pi} \cdot \Delta t} \qquad Ppeak = 0.199\,W$$

The rated absolute maximum pulse forward current is

$$Ifmax := 50 \cdot mA$$

Applying the cubic spline function obtained from the datasheet, the maximum optical power corresponding to the peak forward current is:

$$interp(vs, If, Pp2, 50) = 0.002\,W$$

So, we are about a factor of 100 short!!!