REAL WORLD INTERFACES

Red, Orange, Yellow, Green, Blue and White LEDs for the TB-303 Devil Fish

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This page documents five new colours of LED for the TB-303/***Devil Fish***: Red, Orange, Yellow, Green, Blue and White. This is also relevant for the TR-606 and TR-808. Please read the notes below on the different LEDs, since the picture above cannot convey their true brightness or appearance.

There are two sets of documentation here. Firstly for users who are considering having us install new LEDs and secondly for those with a technical interest in the LEDs themselves.

Five kinds of LED are shown above. The White LEDs are not shown above, but please see the photo below. All these LEDs are diffused (milky), rather than with a clear (glass-like transparent) encapsulation. In all cases, the diffused epoxy resin of the LED is the same colour as the LED's light, though the Blue ones look pale blue-grey when not illuminated.

C and F#: **Original** LEDs	These are relatively dim, wide-angle and not particularly even in their illumination pattern. (By "illumination pattern" I means the disc of light which the LED presents when we look at it. At some viewing angles or when viewed from straight ahead, the light does not form an even disc. This could be due to the LED chip not being centred properly in the package, or because of other factors.)
C#: **Red**	These are very slightly more orange than the original LEDs – a slightly shorter wavelength, but are still pure red. Advantages include: 1. Very much brighter than the original LEDs. 2. Very wide angle – so they can be seen from any angle. 3. Even pattern of illumination within the LED, in contrast to the somewhat varied pattern of the original LEDs. 4. The non-illuminated colour is a darker red than the originals, which gives greater contrast between on and off states.

D: **Orange**
These are brighter than the original LEDs, have a wider and more even illumination pattern and are fiery *orange.*

D#: **Yellow**
Nice yellow colour. Like the Orange and Green, these are significantly brighter than the original LEDs and have a wide and even pattern of illumination. The encapsulation diffusion is a light yellow colour.

E: **Green**
This is the yellowish-green typical of most LEDs. I cannot find "pure" green (sometimes called "emerald green") LEDs which are suitable for this application. Most green LEDs are this somewhat yellowish-green colour. The diffusion is a very pale green. I am keen to obtain some "traffic-light green", blue-green LEDs, but I think it will be difficult or impossible to get them in diffused 3mm packages.

F: **Blue**
These are a beautiful blue colour. These are not ordinary "blue" LEDs as seen widely on various items of equipment. These are an unusual LED made with silicon carbide. They have a broader spectrum than the commonly available blue LEDs, with more violet and more yellow and green. The violet gives them a somewhat more steely colour than the typically rather aqua colour of ordinary blue LEDs.

The diffusion of these LEDs is minimal and faintly blue. They are not as wide a beam as the other new LEDs which have a stronger diffusion in their packaging. Like the new Red LEDs, they are bright compared to the original LEDs – but they are not excessively bright.

Here is a closeup photo of a Blue LED, showing how the minimal diffusion enables the LED chip itself to be seen.

The curve at the top of the photo is a 60 watt incandescent lamp. The LEDs are plenty bright enough to be seen in bright lighting conditions, but are not so bright as to be a problem when operating in the dark, with our irises fully open.

From March 2014, we now have a second option for Blue LEDs, which have a similar light output and spectrum, but stronger diffusion, with the diffusion having a distinctively blue colour, while the LEDs mentioned above have lighter diffusion with only a trace of blue colour in the diffusion.

Not shown in the above image are White LEDs.

White

Until mid-2010 we were unable to obtain some diffused white 3mm LEDs. Now we have some from the only manufacturer I know of which makes them: Nichia, in Japan, who are one of the pioneering companies in blue LEDs . The photo below (click it for a larger version) shows NSPW315DS LEDs in all switch positions except Run/Stop, which has a new Red LED. The NSPW315DS is specified as having a 60° beam angle. In the future we intend to get some with a slightly wider 70° angle: NSPW315BS.

Please click the image to see a larger version. Another machine, with a White LED for Run/Stop as well, is in the LEDs page: ../leds/#White_LEDs .

Note: it is not generally possible to choose White LEDs on an individual basis for all LED positions.

White LEDs are much more efficient than the new LEDs listed above. (White LEDs are a Blue LED with yellow phosphor.) The new Red, Orange, Yellow and Blue LEDs listed above are all significantly more efficient than the original LEDs, and the extra brightness is just right, we think. Installing these new White LEDs, or ordinary Blue LEDs (not the unusual silicon carbide LEDs we use) will lead to brightnesses far in excess of what is required, and we think far in excess of what is tolerable when our eyes are adjusted to the dark.

There is a 4 x 4 scanning matrix which drives most LED positions. Consequently, when we install a set of White LEDs, we install four new, higher resistance, drive resistors to reduce the current to a value which gives a good brightness. This means we can't mix and match White LEDs with others, except as follows:

> The **Run/Stop** LED is outside the scanning matrix, so you can choose any colour LED for this. This can be a White LED if you are not using White LEDs for most switches. If you are using White LEDs for most switches, you can choose any colour for Run/Stop, including White.
>
> The same applies to the **Normal Mode**, **Pitch Mode** and **Time Mode** LEDs.
>
> When we install a white LED in one of these four positions, we alter a single resistor to make its brightness match that of the other LEDs. (Details below.)
>
> The A# LED is outside the scanning matrix too, so it could have a colour other than White if you want the main set of LEDs to be White, but this seems an unlikely choice.
>
> If you *really* want to place White LEDs in a mix and match arrangement beyond the above restrictions, we can do it, but there is extra work installing individual resistors for each White LED.

For purely functional purposes, such as making sure the LEDs are visible at wide angles in intense light, the new Red, Blue or White LEDs are ideal. The Orange, Yellow and Green LEDs are still a big improvement in brightness on the original LEDs, but the new Red, Blue and White are brighter still.

You can choose any combination of colours if you like, subject to the restrictions noted above for White LEDs. The pricing is all the same unless you want White LEDs in a mix-and match arrangement beyond these restrictions.

We generally recommend all **Blue LEDs** apart from a new **Red LED** for the Run/Stop function. This balances nicely with the three Red LEDs in the Devil Fish panel on the upper left.

Ultra-violet LEDs are available. These emit a small amount of visible violet light and a lot of invisible UV just beyond violet. For safety reasons, we do not install these.

Technical details

This is for technicians who are interested in installing LEDs in the TB-303 and other items of equipment. I do *not* recommend that this be undertaken by inexperienced people. Desoldering LEDs is non-trivial. Soldering new ones is tricky, since they need to be supported at exactly the right height and must be aligned with the front panel. The existing LED spacers don't work with all new LEDs, because the new LEDs can be narrower than the spacer's hole. In the past, I tried various approaches. The best approach was developed by my assistant in the early 2000s, Ceri Hann. He found a particular brand of cotton bud (AKA Q-Tip) called Swisspers with a suitably dimensioned tubular plastic shaft. When cut to 6.9mm or so, these make Jim Dandy spacers for the LEDs. In November 2010, the current production of Swisspers has a thicker tube wall and is not as suitable as the ones we bought a few years ago. To cut them to length, we use a plastic tube cutter from the 1960s, which is documented here: ../../../show-and-tell/plastic-tube-beads/ .

All semiconductor devices can be damaged by static electricity. It is easy to pick up 10,000 volts of static electricity walking across a floor, or sitting in a chair. The CPU of the TB-303 is unobtainable, and the risk of damaging it is significant. Good electronic technicians know these problems and take steps to avoid such damage. I am not in a position to explain how to avoid this to people who lack the required experience.

The requirements of LEDs in this application are:

1. 3mm package. (Many LEDs are 5mm, or in some other type of package.)
2. Diffused. (To disperse the light widely and evenly to ensure they are visible from all angles.)
3. Bright enough with the particular drive situation in the TB-303 to be visible, and to be significantly brighter than the original LEDs. Increasing the drive current would involve altering the drive circuitry – which would be complex and would involve drawing extra power from the internal supply Such changes may lead to interference with the audio circuitry.
4. Not too bright, as are many modern LEDs such as normal blue LEDs – unless resistor values are changed to reduce the drive current.

The following information includes the type of LEDs I chose, and some alternatives I also found.

Please do not pester me for more information, or "I don't know anything about electronics but please tell me how to . . . ".

I do not supply LEDs, except as spare parts for a Devil Fish.

This page contains virtually everything I know about LEDs for this application, and part of the reason for writing it is so that *I* can refer to it in the future. Another reason is to answer people's questions so they don't have to ask me time and again. Please let me know any corrections or suggestions for improvements.

Don Klipstein's site http://members.misty.com/don/led.html is a treasure trove of information too.

Kingbright LEDs can be obtained from distributors, in Australia: http://www.tenrod.com.au/. See the Kingbright web site: http://www.kingbright.com . They package other manufacturer's chips.

The site for the LED range previously made by Hewlett Packard and then Agilent is http://www.avagotech.com .

The Blue LEDs are Kingbright, from Tenrod. The White LEDs are from Nichia directly in the USA, as noted below.The other LEDs I obtained from Farnell Electronic Components, who have branches in many countries: http://www.farnell.com/ or whatever it is they are called today . . . http://au.element14.com.

A search engine for electronic parts, returning information on where they can be purchased and for what price, is http://www.octopart.com .

Blue LEDs

For years we have been using Kingbright **L934 MBD.** They are a distinctive and beautiful LED. As noted above, these are a blue with a touch of violet, in contrast to the typical greenish blue, or aqua of commonly available blue LEDs. Their spectrum also extends into the green, yellow and orange. It is my impression that this is a far broader spectrum than that most other blue LEDs, or indeed of any colour of LED.

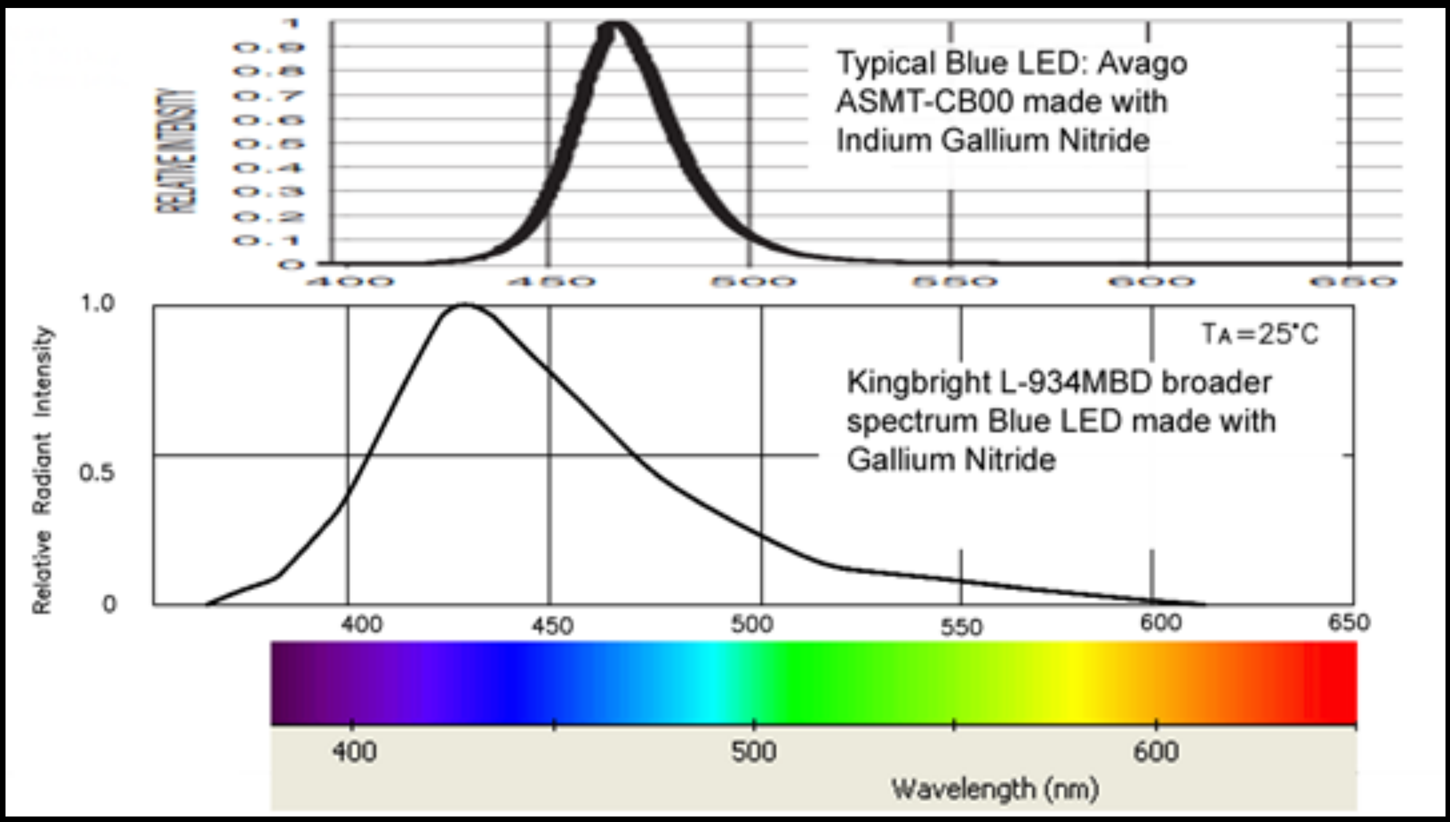
The datasheets say it is a Gallium Nitride (GaN) LED, built on a Silicon Carbide base. I can't find these LEDs at the Kingbright site. Perhaps they are still making them, but don't want to advertise it as a current product because they are unsure about the availability of die (plural of dice: LED semiconductor chips), in the future. (I understand Kingbright to not manufacture the die, but purchase them from other manufacturers, to mount them and test them to become the final LED product.) We buy these LEDs from http://www.tenrod.com.au .

Here are some datasheets I found:

http://www.rapidonline.com/netalogue/specs/55-1460e.pdf Archived here.

http://catalog.compel.ru/file/led/KGB/pdf/L-934MBD.pdf Archived here.

The first of these has the most complete spectral chart. Here is is with my annotations, and with a chart from a typical blue LED.



(Here is a larger version.)

The emissions of most blue LEDs are much narrower than this, and are usually in the 430 to 500nm range. For instance: http://ledmuseum.candlepower.us/led/specx107.htm .

I understand the spectral width of LEDs is determined by thermal motion, so I will be interested to find out why the L-934MBD has such a wide spectrum. I need a spectrophotometer and some liquid nitrogen . . . (The currently widely accepted Einstein-Debye theory of thermal motion in solids has whole atoms moving as if they were balls, but I don't believe this. Debye's mathematics is highly non-physical, since he has the whole atom vibrating at frequencies which can't propagate as acoustic waves. I think that in solids, and I guess liquids, the cores of the atoms - nuclei and inner electron shells - do not move much and probably have little thermal energy, and that most of the thermal energy and all of the movement which is important in chemistry and electronics is of the outer electron shell, almost all of it at frequencies above the limit of acoustic propagation, and up to what is generally thought of as a "quantum limit". I am hatching a theory which explains that limit without any "quantum" stuff at all. The whole of semiconductor engineering seems to depend on the outer electrons having the full thermal energy. I don't see how this is compatible with the entire atom, outer electrons and all, behaving like a solid object and having the thermal energy, since the vast majority of the energy would be in the massive nucleus.)

In the past, the quality of these LEDs was variable and I had to sort them to avoid dim and off-centre devices. Since about 2008, the quality has been improved and all devices are of a consistent brightness.

Until 2014 I didn't know any comparable device. This page: http://ledmuseum.candlepower.us/led/ledblu1.htm has spectra of some "violet-blue" Gallium Nitride LEDs. The very first spectrum looks pretty close to that of the L-934MBD. A Google search for "430nm LED" or similar may turn up some comparable devices. However, this page http://www.ledtronics.com/Products/ProductsDetails.aspx?WP=1782 which is devoted to "super blue" and "ultra blue" LEDs only has datasheets with narrow spectra.

The numbers on one of the Kingbright packages are **L-934-MBD** and **SM13 CREE744 V**. I can't find any comparable LEDs at the Cree site.

In early 2014, thanks to Josh of http://www.malekkoheavyindustry.com we discovered a Vishay 3mm diffused LED with a similar spectrum:

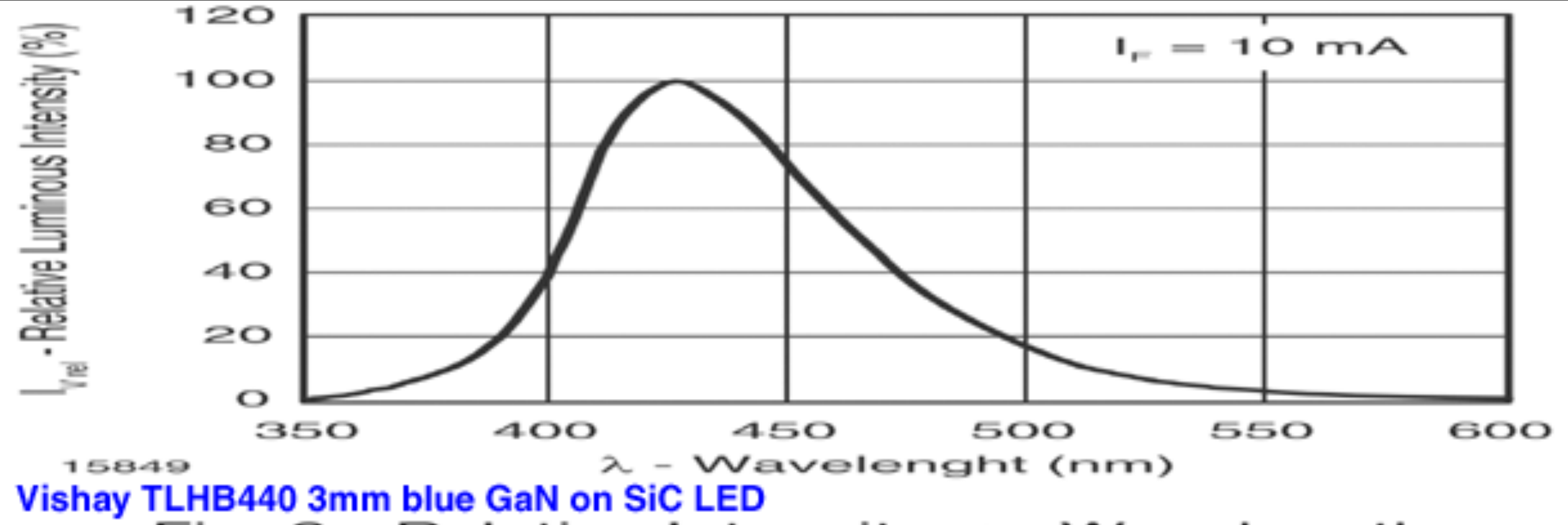


Fig. 6 – Relative Intensity vs. Wavelength

It is the **TLHB4400**, which is also GaN on SiC:

http://www.vishay.com/leds/list/product-83016/

I found a 1999 datasheet from Vishay Telefunken, with the latest datasheet being from Vishay, dated April 2013:

tlhb4400-2013-Vishay.pdf

tlhb440x-1999-Vishay-Telefunken.pdf

Other blue LEDs from Vishay are listed as having the same typical dominant wavelength of 466nm:

http://www.vishay.com/leds/blue/

The 3mm ones of these are:

Device	Vishay page	Description
TLHB4200, TLHB4201	product-83014/	Tinted, non-diffused. The TLHB4201 is brighter, with minimum 40mcd @ 20mA, but there are 7 groups of luminous intensity. 20 degree angle of half intensity.
TLHB4400	product-83016/	Tinted, diffused. Lower mcd rating than the above, but is this due to diffusion? 10 groups of luminous efficiency, spanning a 40:1 range! 30 degree angle of half intensity.
TLHB44K2M1	product-83440/	Tinted diffused. 3 groups of luminous intensity. 30 degree angle of half intensity.

All three datasheets state: "This device has been redesigned in 1998 replacing SiC by GaN technology to meet the increasing demand for high efficiency blue LEDs." They all have the same spectrum as shown above.

At the time of writing, the "search distributors" function of the Vishay site (at each of the above pages - you have to type in the part number) does not work.

Mouser has the TLHB4400 in stock The URL is too long to show here in full: http://au.mouser.com/
They are also available at [Digikey](), element14 / Newark and RS Components.

I recently installed some of these **TLHB4400** LEDs. They have a somewhat higher turn-on voltage (~3.4V compared to ~3.1V for a non-trivial light output) and the colour appears to be similar, but somewhat bluer due to the blue dye in the diffusion epoxy. The diffusion is stronger, so it is not possible to see the chip itself when the LED is illuminated. The L-934-MBD has only slightly blue diffusing epoxy, and the diffusion (cloudiness in the epoxy) is much lighter in the L-934-MBD, so the chip can be seen. Their efficiency of the TLHB4400 is low compared to most blue LEDs and appears to be identical to that of the **L-934-MBD**. Their darker blue diffusion makes for greater contrast.

I think these TLHB4400 LEDs are a good alternative to the L934 MBD which we have been using for many years. They are easier to obtain and we will keep some in stock. However, we prefer the almost uncoloured very light diffusion of the L-934-MBD leds as a match for the TB-303's anodized aluminium switch panel. Here is a photo of the **TLHB4400** LEDs:

White LEDs

Our initial batch is the 60° NSPW315DS from the [Nichia online store](): [ProdID=13]() The datasheet is at the Nichia site, but also here. Just add this text to the URL of this page: NSPW315DS-E.pdf .

There is also a 70° NSPW315BS next. [ProdID=186]() . There's no datasheet for these at the Nichia site.

Both these are described as "cool white". They are a good quality white. They are not excessively blue or violet like a lot of cheap white LEDs found in some products.

The Nichia online store only sells to people in the North and South America. Both these types of LED are available through the store only via "special order". For us, this involved a shipment direct from the Nichia factory in Japan. The Japanese tend to fuss over good packaging, and the Nichia datasheets devote several pages to the cardboard boxes they ship their LEDs in. The 100 LEDs arrived in a beautifully designed carton about the size of a shoebox, and were sent via FedEx Global Priority on our account. The FedEx shipping cost far more than the LEDs, so we suggest anyone pursuing this line of obtaining LEDs have them shipped to a US address (which is apparently inexpensive) or make special arrangements to avoid FedEx bill-shock.

Here is what we know about the status of these LEDs:

60° NSPW315DS

The online store has a datasheet and no mention of them becoming obsolete. In September 2010, there was a note: "This revision is new, and may have a long lead time." – however we experienced no such delay.

Page 23 of the catalogue
http://www.nichia.co.jp/specification/catalogue/2010_02/NICHIA_LED_Catalogue2010_2.pdf
mentions this LED.

70° NSPW315BS

The online store has no datasheet and the note: "This product will be discontinued in 2011." There's no entry for it in the above-mentioned catalogue.

Here is some information on altering the resistor values to reduce the drive current to LEDs. Please refer to the TB-303 schematics, such as from Hyperreal.org:
http://machines.hyperreal.org/manufacturers/Roland/TB-303/

The scanning matrix (all LEDs except Run/Stop, Pitch Mode, Normal Mode, Time Mode and A#) uses four current-limiting resistors:

R210, R213, R215 & R214.

For the NSPW315DS White LEDs, I changed these resistors to 2.7k. (I have modified Technology Transplant replacement front panels, with ordinary, highly efficient, Blue LEDs so they are not too bright. I chose 680 ohms for these.)

The four other LEDs have individual drive circuits with a 680 ohm resistor:

Run/Stop: R204.
Pitch Mode: R206.
Normal Mode: R208.
A#: R220
Time Mode: R225

For the NSPW315DS White LEDs, I changed these to 12k. This is about 4 times the value of the 2.7k resistors I chose for matrix circuit, which makes sense since the matrix LEDs must be driven with about 4 x the current since they are on only 1/4 of the time. (For the Technology Transplant replacement front panels, with ordinary, highly efficient, Blue LEDs, I chose 4.7k, though perhaps 3.3k or 3.9k should be considered.)

New Red LEDs

There are probably dozens of sufficiently bright, but not highly efficient, 3mm diffused LEDs. I chose HP's LED: **HLMP-1700**. Farnell part number 1003207.

Orange LEDs

I chose Vishay **TLH04400** . Farnell part number 1045462. Other contenders were:

- LED Technology L08R3000F1. (Farnell 1208849.)
- HP HLMP-K401. (Farnell 1003389.)

Yellow LEDs

I chose Multicomp's **L-934 LYD**. This part number is very similar to a Kingbright part number. Farnell part number 1142515. Other contenders were:

- HLMP 1719 – seems to be identical.
- HLMP 1401. Very similar, but the diffusion is more orange.
- Siemens / Infineon LY3366-PS. A very bright diffused yellow LED which is perhaps fractionally redder than the above. I judged this to be too bright for the TB-303, but it is a beautiful LED.

Green LEDs

I chose Multicomp **L-934 LGD**. Farnell part number 1142509. This is the typical 565 nm colour of most "green" LEDs, which I consider to be a yellowish green. Other contenders were:

- Vishay TLH64405. Very similar, with darker diffusion (which is think is better, for greater contrast) but the flange was a little slim and they tended to go straight through the TB-303 front panel holes.
- There are some "Emerald Green" LEDs from Hewlett Packard, such as the 558nm HLMPK600. This is undiffused 3mm, and is barely bright enough. If there is a diffused version, I predict it would not be bright enough. This "emerald green" is halfway between the standard "yellowish-green" of most green LEDs and what I think is a "pure-green", as described below.
- Kingbright make a 3mm diffused "pure-green" LED (L-934PGD) with a peak intensity wavelength of 555 nm. Unfortunately it is too dim.
- I have a sample of a *beautiful* pure-green LED from Toyoda Gosei http://www.toyoda-gosei.com/led/ : the E1L51-3G. This is a bright green LED and its peak wavelength is 520 to 530 nm, which is is a touch shorter (bluer) than the L-934PGD. It is seriously bright! *If* it was available in 3mm diffused, and if the electronics were modified to reduce the drive current, this would make a really beautiful pure green LED. In 2010, this LED does not seem to be available.

Update history

- 2000 March 22: Page established.
- 2003 April 24: Mentioned UV LEDs and the Red Run/Stop.
- 2010 January 3: Updated description from "deep blue" to an attempt to describe the somewhat broader blue, with more violet, nature of the Blue LEDs compared to the most widely used Blue LEDs.
- 2010 April 29: Updated links and Farnell stock numbers.
- 2010 September 20: Added information about White LEDs, changing resistor value and the cutter we use for making LED spacers.
- 2010 November 28: Moved the information about the plastic tube cutter to the Show-and-Tell department.
- 2011 July 27: Added more discussion of the spectrum of the L-934MBD and a chart comparing its spectrum to that of an ordinary blue LED.
- 2014 January 28: Added mention of Vishay TLHB4400.
- 2014 March 5: Added photo of the Vishay TLHB4400 LEDs installed.

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