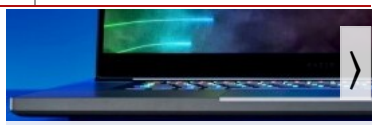

Survey: Laptop & Phone Support Satisfaction 2021


RTX 3070 unleashed: Asus Strix G15 review

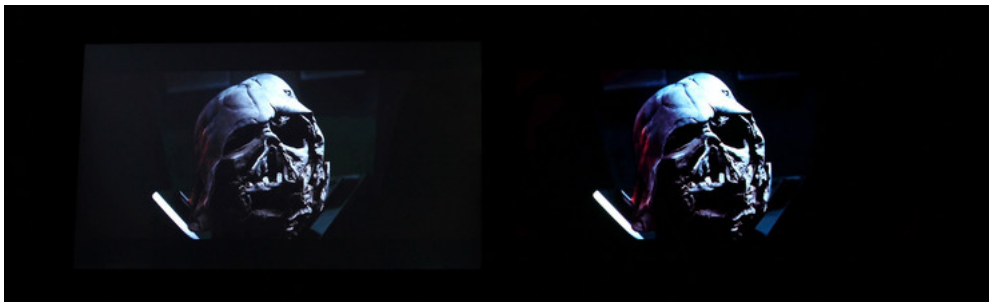

Cuts for the RTX 3070: Aorus 15G review


2021 Razer Blade Pro 17 RTX 3080 Review

Display Comparison: OLED vs. IPS on Notebooks

Welcome to the dark side. *OLED displays: undeniably one of the greatest revolutions in the realm of display technology since the first LCD monitor. They lack a backlight, display perfect black and feature vivid colors as well as incredibly low response times. For the first time, the technology has made its way into notebooks.*

Till Schönborn, ✓ Tanja Hinum (translated by Bernie Pechlaner), 07/13/2016 DE RU Laptop Touchscreen



For the original German article, see here.

The technology isn't exactly new: OLED displays are based on light-emitting organic diodes and have been used for smartphones, tablets and TVs for a few years now. So far, notebooks have been the exception, which has technical reasons as well as financial ones.

That's changing, however, as several notebook manufactures - Lenovo, Alienware, and HP among them - have announced OLED notebooks for 2016. The first candidate on our test bench is the Lenovo ThinkPad X1 Yoga, which normally ships with an IPS panel, but can be upgraded to an OLED display (same WQHD resolution of 2560 x 1440 pixels) for 300 Euro (~$330) more. If that's worth it and what advantages and disadvantages each configuration offers is the subject of our review.

Many thanks to the online shop campuspoint.de, as they have provided both ThinkPad X1 Yoga models for our review.

Why OLED?

Before we look at the individual measurements, we want to talk about OLED technology in general. While normal displays are basically filters which pass through the light emitting - from the always active - (LED) backlight for each individual pixel in a particular intensity and color, the pixels that make up an OLED display are their own source of light. There are numerous advantages to this approach:

- black areas have no remaining brightness
- the darker the display gets, the less power it consumes
- viewing angle stability is excellent
- the color gamut is very wide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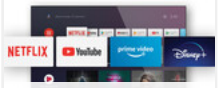
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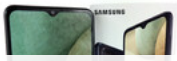
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- response time is very short
- the lack of a backlight means very slim displays

As always, there are drawbacks - in this case, there are four potential issues with OLED displays:

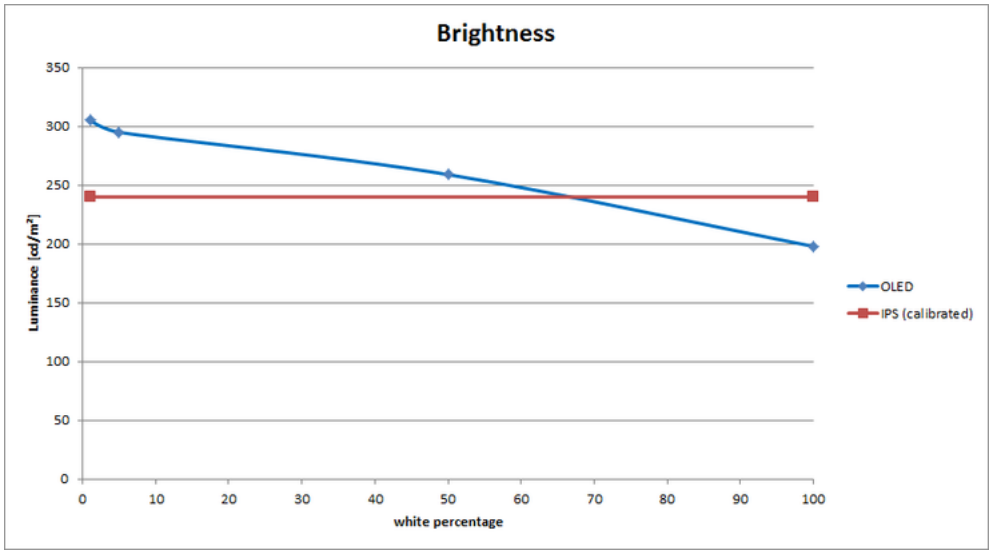
- maximum brightness is limited
- expensive to produce
- screen burn-in is possible
- aging behavior

We are going to attempt to clarify if and in what manner OLED notebook displays are affected by the above drawbacks.

Brightness and Distribution

As we've mentioned briefly before, the backlight of a LCD is always set to a constant brightness (some TV dimming techniques are the exception). A white area is therefore always uniformly bright, no matter if it's the entire picture or just a small section.

OLED displays are different: since all sub-pixels have to be at their maximum intensity for the picture to be bright and white, the power draw increases significantly in that scenario. To keep the power consumption in check and to increase the life expectancy (which hinges on the temperature and the brightness), manufactures usually vary the luminance according to the display content.



The ThinkPad X1 Yoga behaves in the above manner: while the IPS panel (LG LP140QH1) shows a constant brightness of 250 cd/m², the OLED version (Samsung ATNA40JU01) fluctuates between 198 and 305 cd/m² depending on the situation. We recorded the highest value when only a small white field (< 1 % of the area) was displayed on a black background, while an entirely white background resulted in the lowest value. We measured from 240 to 260 cd/m² during word processing or web browsing. Our standardized measurement using the i1Profiler software (40 % white) resulted in a solid 277 cd/m².

We can alleviate all concerns that this adjustment is disruptive in any way: it appears that the display regulates so quickly and steplessly that even abrupt changes aren't noticeable to the human eye at all. The manner in which this happens definitely has nothing in common with the CABC-technology (Content Adaptive Brightness Control) which both the Dell Latitude 7370 and XPS 13 utilize.

OLED Display

286 cd/m²	293 cd/m²	281 cd/m²
277 cd/m²	279 cd/m²	275 cd/m²
266 cd/m²	271 cd/m²	269 cd/m²

Distribution of brightness

Samsung ATNA40JU01-0
X-Rite i1Pro 2
Maximum: 293 cd/m² Average: 277.4 cd/m²
Minimum: 7 cd/m²
Brightness Distribution: 91 %
Center on Battery: 279 cd/m²
Contrast: ∞:1 (Black: 0 cd/m²)
ΔE Color 5.15 | 0.6-29.43 Ø5.7
ΔE Greyscale 5.44 | 0.64-98 Ø5.9
100% sRGB (Argyll 3D) 98% AdobeRGB 1998 (Argyll 3D)
Gamma: 2.28

IPS Display

256 cd/m²	270 cd/m²	260 cd/m²
237 cd/m²	269 cd/m²	247 cd/m²
221 cd/m²	232 cd/m²	227 cd/m²

Distribution of brightness

X-Rite i1Pro 2
Maximum: 270 cd/m² Average: 246.6 cd/m²
Minimum: 2 cd/m²
Brightness Distribution: 82 %
Center on Battery: 268 cd/m²
Contrast: 791:1 (Black: 0.34 cd/m²)
ΔE Color 4.73 | 0.6-29.43 Ø5.7
ΔE Greyscale 5.3 | 0.64-98 Ø5.9
90.38% sRGB (Argyll 3D) 58.86% AdobeRGB 1998 (Argyll 3D)
Gamma: 2.42
ICC File (X-Rite i1Pro 2)

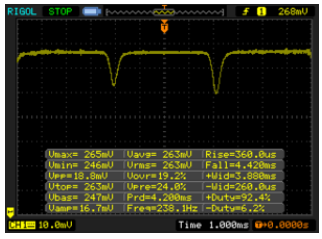
PWM and Response Times

Since the individual pixels of an OLED display never reach their theoretical maximum brightness, the luminance has to be adjusted using PWM, which in this case happens at a frequency of 240 Hz. Subjectively, we didn't notice any flickering whatsoever, but some sensitive users experience problems like headaches or nausea when working on notebooks equipped with standard LCD displays, which also use PWM.

Screen Flickering / PWM (Pulse-Width Modulation)

To dim the screen, some notebooks will simply cycle the backlight on and off in rapid succession - a method called Pulse Width Modulation (PWM) . This cycling frequency should ideally be undetectable to the human eye. If said frequency is too low, users with sensitive eyes may experience strain or headaches or even notice the flickering altogether.

Screen flickering / PWM detected	240 Hz	≤ 100 % brightness setting



The display backlight flickers at 240 Hz (Likely utilizing PWM) Flickering detected at a brightness setting of 100 % and below. There should be no flickering or PWM above this brightness setting.

The frequency of 240 Hz is relatively low, so sensitive users will likely notice flickering and experience eyestrain at the stated brightness setting and below.

In comparison: 51 % of all tested devices do not use PWM to dim the display. If PWM was detected, an average of 9687 (minimum: 5 - maximum: 142900) Hz was measured.

The response times of an OLED panel are generally in the realm of micro-seconds, so they are much faster than their LCD-sibling and not susceptible to streaking. For that reason, the ThinkPad X1 Yoga could be a perfect gaming notebook – if it wasn't for the rather dismal performance of the integrated HD Graphics 520. The gaming rigs from MSI, Schenker and Asus would certainly benefit from the OLED-technology; so far, only Alienware Dell Alienware 13 R2: OLED Variante in den USA verfügbarhas announced a

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The Galaxy M62's new teaser. (Source: Samsung)
Samsung confirms Malaysian launch for the Galaxy M62

AMD's Radeon RX 6700 teaser confirms that the series will use Navi 22 GPUs. (Image source: AMD)
AMD schedules Radeon RX 6700 will launch on March 3, over two weeks earlier than expected; reference card design and Navi 22 GPUs confirmed

The OPPO X 2021 is teased again. (Source: YouTube)
OPPO premieres a more in-depth trailer for its slidable phone's design and function at MWC Shanghai 2021

Zeblaze Vibe 3S HD: An affordable smartwatch that is a blatant Garmin Fenix 6 Pro rip off

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model with this type of display.

Since the black/white and gray response times are so short, our measurement tools can't accurately capture them. The graphics below thus only constitute a reference point.

Display Response Times

Display response times show how fast the screen is able to change from one color to the next. Slow response times can lead to afterimages and can cause moving objects to appear blurry (ghosting). Gamers of fast-paced 3D titles should pay special attention to fast response times.

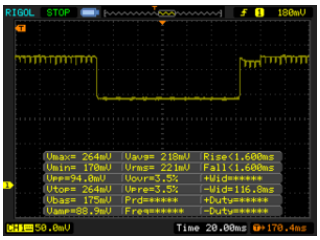
↔ Response Time Black to White

1 ms ... rise ↗ and fall ↘ combined

↗ 0.5 ms rise

↘ 0.5 ms fall

The screen shows very fast response rates in our tests and should be very well suited for fast-paced gaming.
In comparison, all tested devices range from 0.8 (minimum) to 240 (maximum) ms. » 0 % of all devices are better.
This means that the measured response time is better than the average of all tested devices (24.3 ms).



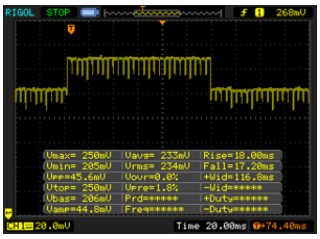
↔ Response Time 50% Grey to 80% Grey

1 ms ... rise ↗ and fall ↘ combined

↗ 0.5 ms rise

↘ 0.5 ms fall

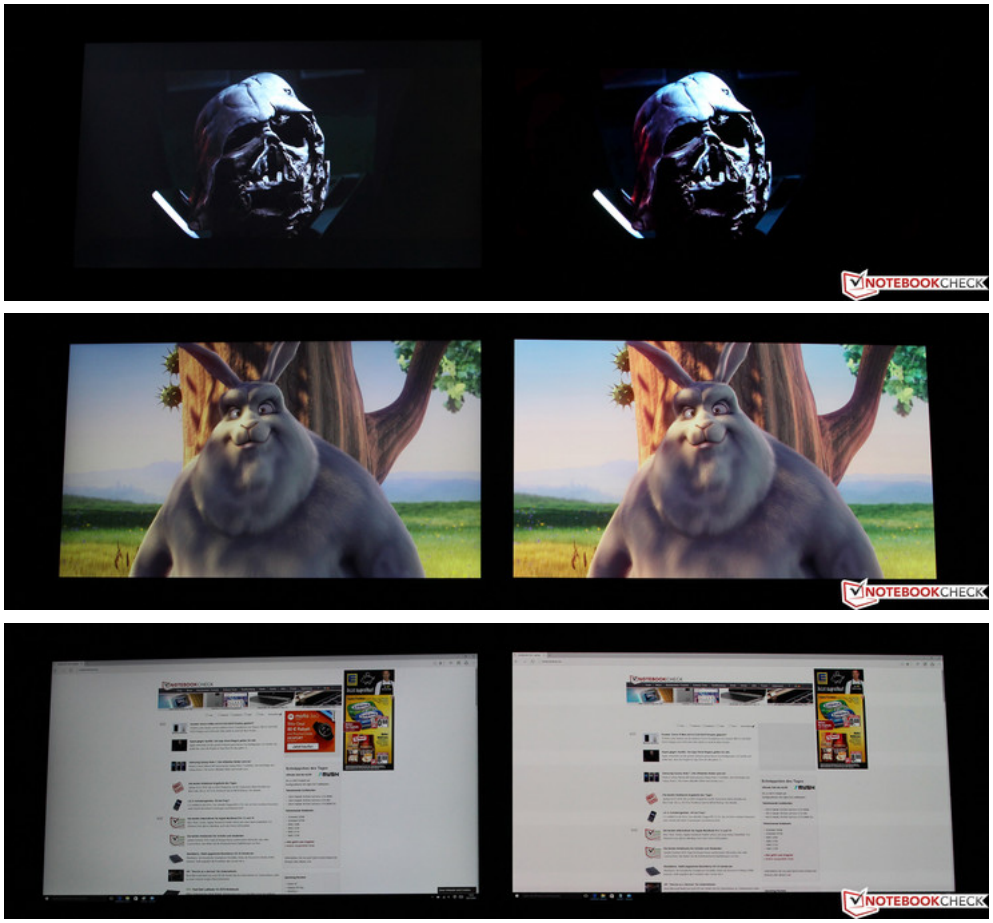
The screen shows very fast response rates in our tests and should be very well suited for fast-paced gaming.
In comparison, all tested devices range from 0.8 (minimum) to 636 (maximum) ms. » 0 % of all devices are better.
This means that the measured response time is better than the average of all tested devices (38.6 ms).



Contrast and Viewing Angles

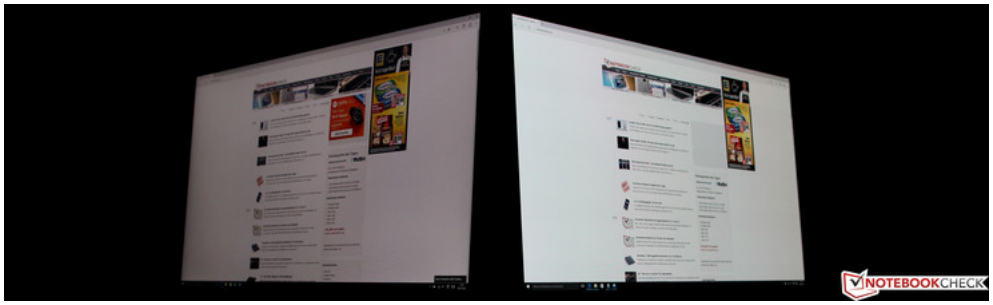
The black areas of high-end IPS panels still emit light at one one-thousandth of the backlight-luminance - so at 300 cd/m², that's still accounts for about 0.3 cd/m². OLED displays on the other hand are in an entirely different league: the manufacturer claims a contrast ratio of 2000000:1. The resulting black value 0.00015 cd/m² is too low to be measured or confirmed by the naked eye: in a completely dark room, black is simply black - and that even at maximum brightness.

What doesn't appear that exciting at first, actually has quite an impact during everyday use: in dimmer environments, an OLED display looks more saturated, more vivid and live-like than any IPS panel could. In completely dark surroundings, the difference is quite dramatic when watching movie scenes with lots of contrast: even the best IPS displays depict blacks as slightly gray, but OLED displays don't show any differences, so the black bars on top are not noticeable in a completely dark scene. The picture floats seamlessly in space and the resulting immersion is simply phenomenal. Movies like Star Trek, Interstellar or Gravity almost look better on the 14-inch Yoga then they do on an LCD TV three times the size. The following picture of a Star Wars scene unfortunately can only show that to a limited extent, as neither our camera nor normal displays are able of adequately reproducing the dynamic range an OLED display is capable of.



left: IPS, right: OLED

When looking at the display at an angle, another advantage of the OLED-technology becomes apparent. IPS panels generally have good viewing angle stability and the colors usually remain stable when viewing the display from the side - but both the brightness as well as the contrast ratio take a hit. OLED panels, on the other hand, remain as vivid as before and the brightness only decreases marginally. From about 45 degrees, an OLED display (124 cd/m^2 at 50 % white) is about twice as bright as its IPS counterpart (at 60 cd/m^2) – an advantage which not only has its benefits when watching movies, but also during regular productivity tasks.



links: IPS, rechts: OLED

Outdoor Use

Even though the most significant advantage of the OLED-technology is the perfect black value, the panels also do very well in bright daylight. Even though the maximum brightness of 240 cd/m² is nearly identical, the notebookcheck.net homepage is easier to see on an OLED display, particularly because the panel reflects less of the ambient light and therefore has a higher "real" contrast ratio. The IPS version looks more pale and not quite as clear. One advantage of Thinkpad with the LCD panel is that reflections are more diffuse - the OLED display is a highly reflective "glare-type", while the IPS version could be called "semi-matte".

Outdoor usage (left: IPS, right: OLED)

Color Reproduction

As far as the colors are concerned, "eye-catching" hits the nail on the head - such vivid colors are a rarity among IPS displays. This is not to say that the panel looks overly saturated - even at high saturation levels of 80 and 100 %, the differences are still noticeable. At times, the color gamut surpasses the very demanding AdobeRGB standard - for example for the colors red, yellow, and magenta.

Outstanding coverage of the color spaces

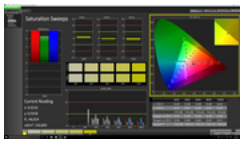
The higher saturation would be an issue while working in the smaller sRGB color space, so Lenovo supplies different color profiles, which can be selected via right-clicking on the desktop. In addition to the default option ("Native"), there is another one called "Standard" (roughly corresponding with the sRGB color space) and "Photo Pro" (approximately equivalent to the AdobeRGB color space). Although the color temperature is a little too low in either case, the presets certainly produce respectable results, as the average DeltaE-deviations of 3.1 (ColorChecker sRGB) respectively 3.8 (ColorChecker AdobeRGB) clearly show.

Unfortunately we weren't able to improve the results via a calibration. The profiles we created during our attempts all exhibited a bluish cast and lightening of darker areas - likely a software issue, since the panel should lend itself to a calibration quite nicely thanks to the outstanding color gamut.

OLED display (profile "Standard", vs. sRGB)


Graylevels


Colors

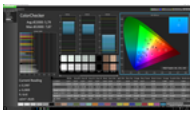

Saturation


Primary/secondary colors

OLED display (profile "Photo Pro", vs. AdobeRGB)


Graylevels


ColorChecker


ColorChecker, 45 degrees from above


Saturation


Primary/secondary colors

IPS display (as shipped, vs. sRGB)


Graylevels (uncalibrated)


ColorChecker (uncalibrated)


Saturation (uncalibrated)


Primary/secondary colors (uncalibrated)

IPS display (calibrated, vs. sRGB)


Graylevels (calibrated)


ColorChecker (calibrated)


ColorChecker, (calibrated), 45 degrees from above


Saturation (calibrated)


Primary/secondary colors (calibrated)

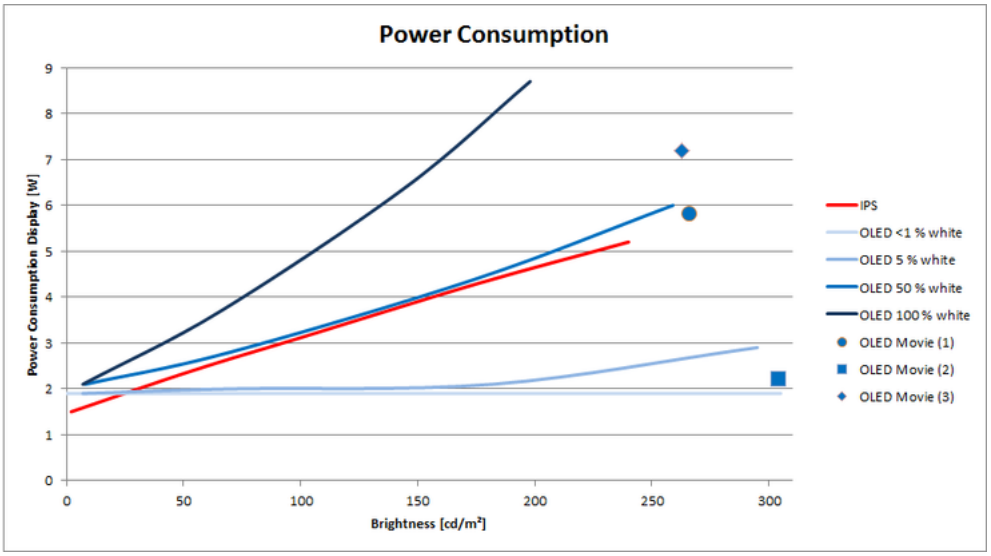
Power Consumption and Efficiency

To determine the power consumption and efficiency of both the IPS and OLED displays, we recorded the differences between an active and inactive display for various usage scenario for each of the notebooks.

The IPS panel shows a nearly linear correlation between power consumption and brightness. At 2 cd/m² we showed a consumption of about 1.5 watts, at 150 cd/m² about 3.9 watts and at 240 cd/m² about 5.2 watts. As we mentioned before, this is independent of the display content.

For the OLED display we measured a slightly higher minimum consumption of 1.9 watts, which fluctuated according to brightness as well as the content. As long as the percentage of white areas is minimal, even raising the display brightness to 300 cd/m² doesn't really affect the power requirements, while a completely white background at 198 cd/m² resulted in a healthy power draw of 8.7 watts.

During browsing and word processing tasks, 50 to 70 % white on average is realistic in our opinion. Taking into account that the OLED display consumes about as much as the IPS display only at 45 % and below, the user consequently can expect a shorter battery life. Watching movies can result in the opposite: depending on the situation - take a look at the scene "Movie (2)" from Star Wars below - the OLED display can actually be the more efficient and should be at least equal to the IPS display.



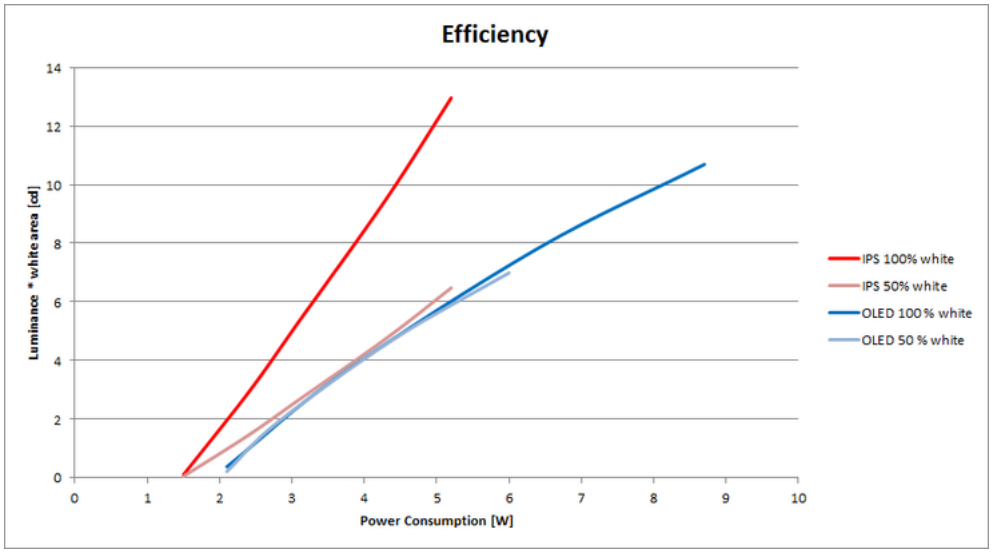
Movie (1)

Movie (2)

Movie (3)

If we only take the areas into consideration which are actually lit and determine the "candelas per watt" for both technologies, it becomes clear that the OLED display operates at a near-constant efficiency. The LCD panel is a lot more efficient when only white is displayed, but it gives up the advantage as the number of dark pixels increases.

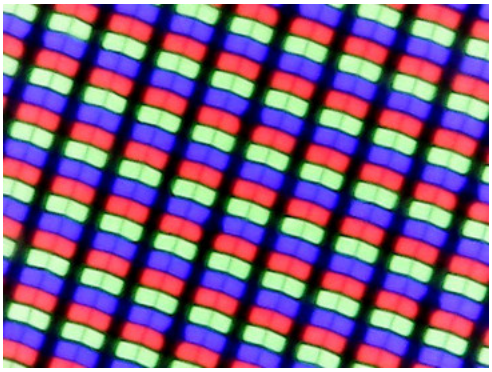
Is the OLED panel truly less efficient when displaying only white? Not necessarily: "luminance" describes light emittance in a certain direction - during our tests, normally at a right angle to the display. Since an OLED panel has outstanding viewing angle stability and emits more light in other directions than an IPS display would, the luminous flux is actually quite a bit higher - and the overall efficiency better than the measurements indicate.



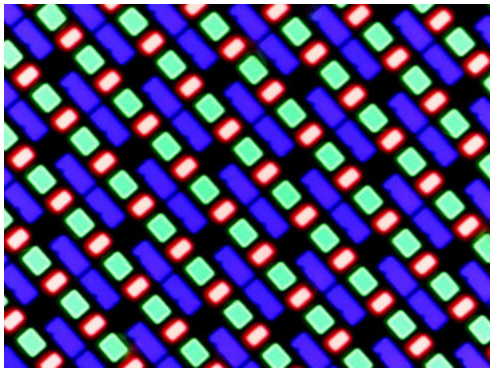
Burn-in and Aging

Static elements - for example the task bar or various menu bars - are quite common when operating a Windows computer, so burn-in and memory effects could potentially be an issue. During our review period (spanning several days) we did not encounter any apparent afterglow as a result of contrast-rich display contents. We can only hope that the display will remain unaffected even after years of usage at high brightness levels.

Another potential issue typical for OLED displays is the aging of the pixels, which happens at a different rate for each color (red, green, and blue). Samsung and other manufactures aim to prevent that by using different subpixel sizes, so the load matches the aging process. Commonly, the rather delicate blue subpixels are the largest ones, which can clearly be seen in the microscope image below. What can't be prevented is the steady decrease of the brightness over the life span of the display, which for current OLED TVs is around 30 to 50 % in 20000 usage hours. For our Thinkpad this means that intensive use (8 hours per day) could potentially result in a display that's only half as bright after 7 years time.



Subpixel-arry IPS



Subpixel-arry OLED

Verdict

Notebooks displays based on OLED-technology are a significant leap forward in quality: while TN and IPS displays differ in their contrast ratio by a factor of two to five, an OLED display can outperform other LCD panels by a factor

of one thousand - and offers a perfect black value as a result. Combined with an extensive color gamut, the picture quality is now at levels not seen before.

Lenovo ThinkPad X1 Yoga, courtesy of: campuspoint.de

The advantages of OLED displays don't end here: thanks to the extremely fast response times, the technology seems to be ideally suited for powerful gaming notebooks and professional graphics workstations, since the additional costs (when viewed as an increase in percent) come less into play. The small disadvantage in power consumption we observed when comparing the OLED-version of the ThinkPad X1 business notebook to the IPS is much less noticeable when the screen content is predominantly dark and/or colorful. We shouldn't forget either that the higher power draw is a direct result of the much better viewing angle stability.

We can't really comment on the long-term durability yet. If we take the particulars of comparable TV displays and transfer them onto the Yoga, it shouldn't be too much of an issue down the line - also keeping in mind that Lenovo picked a high-end ThinkPad model with a longer warranty as their trailblazer for the technology.

At the end, it's likely going to be the additional cost which might prevent the breakthrough of OLED displays for a few more years. Once the the price difference drops to around 100 Euro (~$110) though, there is no real argument to be made for traditional LCDs - especially in the upper and high-end segment.

14 comments

post your questions, comments or corrections here
read whole topic in the forum / answer

#14 **Jas0nF46** 3 years 10 months 28 days ago
Is the red glow on the side of Vader's helmet from the camera autofocus or in the image itself?
» read whole comment

#13 **Udo** 4 years 1 months 9 hours ago
Well, from the photos in the article it is clear that glossy screen sucked in outdoor. I have no clue what the author are talking about, saying OLED performs better at outdoor, as his photo show the opposite.

Also OLED isn't capable to change the fact that glossy screens are causing an eye strain (there're peer-reviewed researches), and are generally bad for eyes.

The colors... I think better colors are bad excuse to make screen glossy. I'm talking specifically about OLED, though. Glossy screen would suck at colors too if being compared to the screen with same parameters but the anti-glare coating.
» read whole comment

#12 **Jörn** 4 years 1 months 4 days ago
Hi there, I am thinking about X1 Yoga and wonder if IPS might be more versatile than OLED? OLED seems to be not much brighter than IPS, but IPS is less glossy, so IPS should be more comfortable in bright surroundings. Is this assumption correct? Does anyone have the ability to compare IPS to OLED on X1 Yoga? For text/photo/desk/travel use?
Thanks!
» read whole comment

#11 **alexgrayes** 4 years 1 months 21 days ago
Agressive ~200Hz PWM even on next generation display. Very impressive, Lenovo.
» read whole comment

#10 **markchodotcom** 4 years 6 months 26 days ago
Hi Tristen, unfortunately I've had the laptop mostly plugged in so it's limited testing for myself, too, but I would expect in the range of 5 hours? I'm in browser windows and Office windows a lot of the

time, so a lot of white screens which would increase power usage.

By the way, have you ever tried the Intel Extreme Tuning Utility? I tried it on my Dell XPS 13 because I was having some heat related issues when I was playing games for longer periods of time. I undervolted about 0.1 mV on the graphics package and the processor and it seems to have fixed the problem. I'd imagine you'd get slightly more battery life out of the system this way, too.

» read whole comment

#9 **Tristen** 4 years 6 months 27 days ago

Mark, good to hear about the screen issues. How are you finding the battery on the X1 Yoga? I have only been able to do limited testing. One day it lasted 4 hours with a little bit of Pandora playing and screen very bright. Another day it looked like I could tease it to 7-8 hours.

» read whole comment

#8 **markchodotcom** 4 years 6 months 27 days ago

Thanks to the author for writing this great and thorough review! Notebookcheck.net is an incredible reference for anyone who is picky about their hardware.

Tristen: I also had the same experience as you, going from a Surface Book to a Dell XPS 13 and now to the X1 Yoga with OLED screen. It's funny, I reached many of the same conclusions you did regarding the Surface Book. I too loved the screen and speakers. I wrote a bit about it on my website under the tech section (www.markcho.com)

The Surface Book screen is fantastic, up until the OLED, probably the best 13" screen I've used. However, I think the X1 Yoga's OLED screen beats it. I don't have issues of it being dim or having a tinge, except at very extreme viewing angles. It does sound like you have a defective part ... ?

I would love to see the next generation of the X1 Yoga with an OLED 3200x1800 screen and an Iris video part. One can dream!

» read whole comment

#7 **Tristen** 4 years 6 months 29 days ago

I've had an X1 Yoga OLED laptop for a couple of weeks now, using it side by side with a Microsoft Book. For movies, the OLED is clearly better, for word processing, browsers, etc, it is worse. The X1 OLED screen is dim, and almost sepia like compared to the Book screen. The OLED viewing angle is not better (as suggested in the article), at a very slight angle the greenish tinge appears quickly and the screen dims (for word processing at least). My experience is so much different from the claims in the article, I wonder if my unit is defective?

This presents a quandary. The Lenovo keyboard is superior (and easily replaceable if needed), trackpad click buttons are nice, and Thinkpad durability is great. The battery in the Book screen makes balance a little awkward but not a deal breaker. While movies look better on the X1 OLED, movies on the Book are not bad, and the X1 speakers are not great, more worse than the screen is better. The Book has the best laptop speakers I have heard, I think they are phenomenal and I don't feel a need to use external speakers most of the time. (So the X1 Yoga has great visuals but bad sound, and the Book has good visuals and great sound.) The Book has more screen real estate, which is far better for word processing, but irrelevant for movies. Battery life on the Book is great (but not for the disconnected tablet). I'm not sure about battery life yet on the X1 Yoga, so far, based on the task bar meter, it does not look good. I'll try to report back on the battery, but at this point it looks like 4-7 hours only with WiFi on. Those darn page up/down buttons on the Book are killing me, so maybe I need to work on a paradigm shift to end my reliance on those keys?

I also have an X1 Tablet. The Surface Pro 4 was not nearly as good, and the benefits of higher processor power were not at all worth the trade offs for me. If I had to only pick one device, it would be the X1 Tablet. I have lived with it only traveling and I love it. (My view of the Surface Pro 4 is partly biased because the two I had never had stable display drivers. I had this problem with the Book, but it may have been finally fixed as of late July 2016.)

Thank you for writing your X1 Yoga reviews, they are excellent and helpful.

» read whole comment

#6 **Joe** 4 years 7 months 10 days ago

> Is the effect of PVM causing headache and nausea a proved phenomenon or could it be just a nocebo effect?

Definitely not a placebo effect. Here are some resources for you:

http://lrt.sagepub.com/content/45/1/124.refs

http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.211.7871

http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/documents/2014-09-29_workshop/comments/Professor_Arnold_J_Watkins_Comments_2014-11-25_TN-74074.pdf

http://m.lrt.sagepub.com/content/early/2015/10/19/1477153515612526.abstract?rss=1

» read whole comment

#5 **Adrian** 4 years 7 months 10 days ago

So far the issue seems to be that Lenovo only allows OLED upgrade on high-end i7 models from QHD, so you cannot get the cheapest i5 FHD config but spend the money on the OLED upgrade - so you will end up with a very expensive laptop in the end...

For those of us just wanting an anti-glare panel and not a glossy tablet - the normal Carbon X1 may not get the OLED option at all. Pity...

» read whole comment

#4 **Till Schönborn** 4 years 7 months 11 days ago

Fixed these translation errors, thanks! :)

» read whole comment

#3 **Stas** 4 years 7 months 11 days ago

*same QQHD **solution** of 2560 x 1440 pixels?*

Come on guys, you can do much better than that.

Als erstes in unser Testlabor hat es nun das Lenovo ThinkPad X1 Yoga geschafft, bei dem sich das herkömmliche IPS-Panel für glatt 300 Euro Aufpreis durch ein OLED-Display mit identischer WQHD-Auflösung (2.560 x 1.440 Pixel) ersetzen lässt

For the first time, the Lenovo ThinkPad X1 Yoga has made it into our test lab, whose conventional IPS display can be replaced with an OLED display with an identical WQHD resolution (2.560 x 1.440 Pixels) for a sizable 300 euro premium.

» read whole comment

#2 **Joel** 4 years 7 months 11 days ago

> the manufacturer claims a contrast ratio of 20000:1. The resulting black value 0.00015 cd/m² is too low to be measured or confirmed by the naked eye

Shouldn't that be 0.015 cd/m^2? (300/20000 = 0.015)

» read whole comment

#1 **Joel** 4 years 7 months 11 days ago

Is the effect of PVM causing headache and nausea a proved phenomenon or could it be just a nocebo effect?

» read whole comment

read all 14 comments / answer

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> Notebook / Laptop Reviews and News > Reviews > Display Comparison: OLED vs. IPS on Notebooks

Till Schönborn, 2016-07-13 (Update: 2018-05-15)

Editor of the original article: **Till Schönborn** - Managing Editor Business

Translator: **Bernhard Pechlaner** - Review Editor

Ended up in the IT sector in the 90s more or less accidentally and have remained in the industry (as a sysadmin) ever since. Always been interested in laptops - first purchase was - if memory serves correctly - a Toshiba Satellite T2115CS with DX4-75 processor, 4 MB of RAM and 350 MB hard disk drive (and Windows 3.1). To this day, laptops appeal to me - much to the chagrin of my wife, who doesn't seem understand why we need 5-10 of them at any given time ;-).