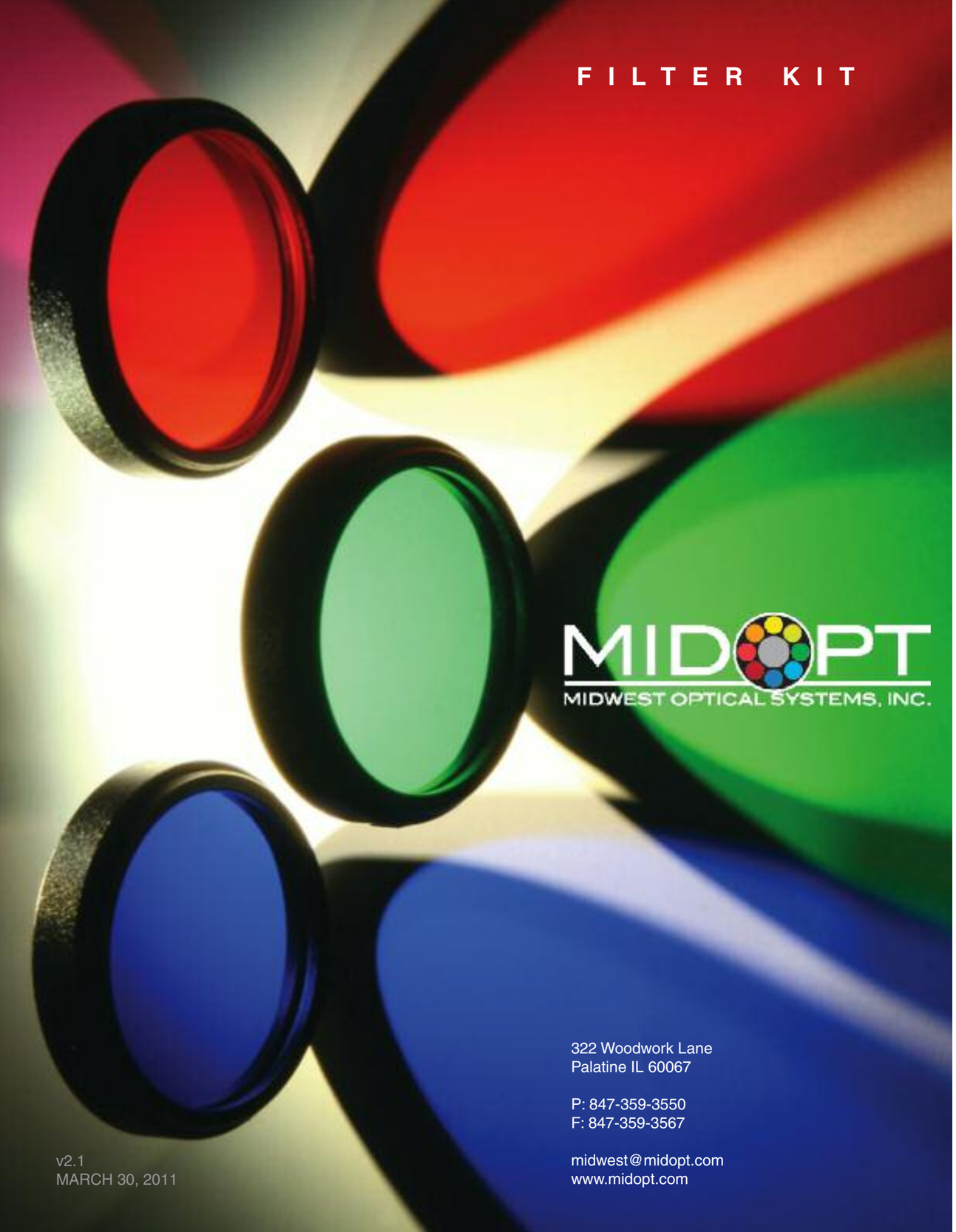

FILTER KIT

MIDOPT

MIDWEST OPTICAL SYSTEMS, INC.

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v2.1
MARCH 30, 2011

ABOUT MIDWEST OPTICAL SYSTEMS

Founded in 1988 as a manufacturer of custom precision optical components and systems, we have since been involved exclusively in the design, manufacture, import and export of vision-specific elements used by a diverse variety of industries and end users. Over time, the company has evolved and is now recognized worldwide as the premier resource for filters, lenses and accessories used in industrial imaging applications.

By combining this extensive optics background with our expertise in machine vision imaging, MidOpt continues to develop economical and solutions for industrial image processing that are simply not found elsewhere. We provide innovative new products that not only are different, they make a difference.

Today, the MidOpt filter line alone includes more than 100 types and 25 standard sizes of stock filters to cover virtually every type of lighting and/or subject matter, bandpass widths that accommodate variations in LED output and angles of incidence, and achieve greater than 90% in-band transmission. While many other companies offer filters developed for photography and scientific applications, these filters are not readily adaptable to industrial vision equipment nor do they present the best solution for many inspection-related problems.

Shortpass, longpass, bandpass, polarizing, IR and UV filters in most sizes are in stock for same-day or overnight delivery anywhere in the world.

In addition to machine vision filters and other proprietary products, we offer an extensive selection of industrial lenses from the major CCTV lens manufacturers – Fujinon, Kowa, Navitar, Pentax, etc. – as well as being the exclusive North American distributor of Goyo Optical lenses.

Our continued commitment to innovation has lead to the rotating Right Angle Attachment (left) that gives you more options for placing cameras in your system, and the multi-purpose Slip Mount that lets you add filters to lenses when (1) there are no filter threads and (2) when a filter is desired for use on a wide-angle lens.

Call on MidOpt for your custom precision optics requirements such as lenses, prisms, light pipes, lens extensions, diffusers, beamsplitters, dust covers, mirrors, reflectors, our lens and filter cleaning kit, and expert advice.

FK100 FILTER KIT CONTENTS

ARTICLES

Machine Vision Filters	An overview
Types of Filters	The 8 major types of filters produced by MidOpt for machine vision applications
Machine v/s Photographic Filters	Why photographic filters are not suitable for machine vision operations
Testing with Filters	Testing the effects of filtering and monochromatic lighting
Increase Resolution	Filters with High-Resolution and Telecentric Lenses; Chromatic Aberration
Filter Applications	UV Fluorescence, Polarizing, IR Blocking and Light Balancing Filters

FILTER NO. and TYPE	APPLICATIONS
BP324 BANDPASS	• Use with UV-sensitive sensors for UV imaging; passes UV, blocks visible and IR
BP470 BLUE BANDPASS	• Use with blue LED illumination (470nm typ.) • Use to enhance blue fluorescence resulting from UV excitation. • Highlights blue parts and darkens all others for color separation
BP525 GREEN BANDPASS	• Use with green LED illumination (520-535nm typ.). • Highlights green parts and darkens all others for color separation • Enhances green fluorescence from UV excitation; passes 505-550nm wavelengths
BP550 BANDPASS	• Blocks both UV and IR; passes only visible wavelengths
BP590 ORANGE BANDPASS	• Use with amber LED illumination (590nm typ.) • Enhances orange fluorescence from UV excitation; passes 560-620nm wavelengths • Highlights orange parts and darkens all others for color separation
BP635 LIGHT RED BANDPASS	• Use with light red LED (620-645nm typ.) or structured laser diode lighting (635nm typ.) • Highlights red parts and darkens all others for color separation
BP660 DARK RED BANDPASS	• Use with dark red illumination or structured laser diode lighting (660nm typ.) • Highlights red parts and darkens all others for color separation
BP850 INFRARED BANDPASS	• Use with IR LED illumination (850 or 880nm typ.) • Use to remove visible portion of ambient light and view unique IR spectral characteristics
PR032 LINEAR POLARIZER / ROTATING FILTER	• Use to remove glare from non-metallic objects • Use as a neutral density filter in bright ambient light conditions
LA120 LIGHT BALANCING	• Use with white LED, metal halide and xenon strobe lighting to remove strong blue component and achieve accurate color rendition
PS032 LINEAR POLARIZER SHEET 4" x 5" x .007"	• Cut to fit over light source and "cross" with PR032 mounted on camera lens for maximum benefit
STEP-UP RING 25.5-27	• Allows M27 filters to be used with M25.5 lenses
STEP-DOWN RING 30.5-27	• Allows M27 filters to be used with M30.5 lenses

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Machine Vision Filters

*MidOpt offers a complete line of mounted filters specifically designed for **industrial machine vision applications**.*

While unmounted and mounted filters have been developed for photography or other uses, they are often not easily adaptable to industrial use nor do they result in the best solutions for many of the machine vision problems typically encountered in today's factory automation systems.

More than 70 types of mounted optical filters in more than 18 common lens and camera thread sizes – all designed specifically for industrial imaging – are available for same-day shipping. Other sizes not carried in stock will typically ship within a few days. Call for help in selecting a filter that will optimize contrast and resolution and in turn maximize speed and accuracy in any application.

IMPORTANT DIFFERENCES IN MIDWEST FILTERS

- MidOpt specifically designs and manufactures filters for use with monochromatic or white LED lighting, fiber optic illumination, structured diode-generated light patterns and other lighting commonly used in machine vision applications. When matched with the correct lighting, filtering is one of the most important factors that controls the ability of an imaging system to produce acceptable results. Selecting the right filter for the job is therefore critical.
- We stock a wide variety of filter options designed to quickly and securely mount to the smaller diameter lenses used with CCD and CMOS cameras. Unlike most other filters sold as being for use with machine vision lighting, not only are MidOpt filters truly off-the-shelf and ready-to-use, the filter material is appropriately sized for each mount to provide an unrestricted field of view.
- MidOpt filter coatings are extremely durable, do not require special care or handling, and have an almost unlimited life span. Our filters are tough enough to withstand repeated cleaning, solvents, high heat, humidity and vibration without degradation.
- Because our filter materials are produced in large batch processes, manufacturing costs are kept under control, mounted filters can be priced reasonably and lead times for custom components are invariably far shorter when compared to our competition.

BENEFITS OF FILTERING FOR ELECTRONIC IMAGING

- Improves color recognition and separation of subject.
- Enhances contrast to improve viewing of desired features.
- Improves lens resolution by reducing the wavelength range being imaged.
- Can reduce the amount of light reaching the CCD, allowing wider apertures which can further reduce the depth of field for separating desired information from unwanted background noise.
- Can eliminate glare and hot spots from highly reflective surfaces.
- Protects camera lens surfaces and internal threads from dust, scratching and inhospitable environments.
- Aids greatly in reducing initial investment and replacement costs of lighting, lenses and other components used in industrial imaging systems.

ADVANTAGES OF MIDWEST MACHINE VISION FILTERS:

Broad Bandpass

Bandpass filters must take into account LED and laser diode manufacturing tolerances. Not only do LEDs emit light over a relatively broad wavelength range compared to lasers, their center wavelengths can vary by as much as +/- 10nm. Angles of incidence may also vary greatly. It is therefore important to select a bandpass range that isn't too narrow. All MidOpt bandpass filters are designed to accommodate these criteria.

Highest Possible Peak Transmission

When compared with other interference filters, transmission of MidOpt bandpass filters at the desired wavelength(s) is higher, typically 90% or greater, usually a 5% to 20% improvement over conventional epoxy-encapsulated bandpass filters.

Insensitive to Wider Angles of Incidence

Traditional bandpass interference filters are highly sensitive to the angle at which all light strikes the filter, so they usually do not perform as well at shallower angles when compared to MidOpt filters. It should be noted that some "blue shifting" (shifting toward shorter wavelengths) is still present in our designs due to a dichroic component typically used.

Greater Longevity and Environmental Stability

Wratten (gelatin) filters and interference filters made using soft, hydroscopic films must be handled with care to avoid damage. The amount of heat and humidity to which the filter is exposed drastically affect its useful life. They also are less chemically resistant and mechanically durable. MidOpt filters have high resistance to heat and exhibit permanent, consistent performance with no fading or color change during the life of the filter. They are resistant to all solvents and damage from bumping or dropping. Aside from periodic cleaning, no maintenance is required; these filters generally should never need replacement.

Threaded Mounts/Slip Mounts

MidOpt filters are offered in appropriate mounts for CCD/CMOS camera lenses with or without filter threads, and can be ordered in any size to fit your specific lens. Integrating the filter no longer presents a problem. With identical male and female threads on each screw-type mount, our filters can be threaded individually or in tandem with other filter types. Filters currently offered elsewhere are available either in very limited (unmounted) sizes or in much larger photographic lens mounts.

Precision Optical Quality

Many filter manufactures pay insufficient attention to the type of glass used or the flatness and parallelism of the filter surfaces. Filter surfaces are also often uncoated, resulting in "flare," a lack of protection from oxidation or "staining" and lower overall transmission. However, each lens surface in the lens assembly that your camera is imaging through has specific figure and centration requirements. Our view is that the same consideration should be given to the filter materials and the filter surfaces through which your camera will be imaging. Precision optical filter glasses are used in all MidOpt designs, with each surface anti-reflection coated whenever possible. The resulting image produced is therefore sharp and free of distortion.

Types of Filters

COLOR BANDPASS FILTERS

(*BP* series)

Our broad bandpass filters are ideal for LED or laser diode-based applications. Easy to use, far more rugged, thinner, less angle-sensitive, MidOpt filters have much higher transmission and are far lower in cost compared with conventional interference filters, greatly improve contrast and eliminate the need for a far more costly light shroud.

POLARIZING FILTERS

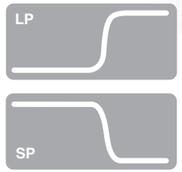
(*PR*, *PC*, *PI* and *PS* series)

Neutral gray laminated glass filters transmit visible light in only one polarization plane and are used to suppress glare from specular surfaces. Available from stock are linear, circular and infrared polarizers in most sizes. Larger sizes, along with custom laser-cut and laminated glass and plastic sheet materials are also available for polarizing all commonly used light sources.

UV FILTERS

(*LP*, *SP* and *BP* series)

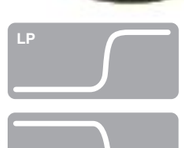
Filters are stocked for both blocking and passing select ultraviolet wavelength ranges. Blocking filters are necessary when exciting materials that fluoresce under UV light. It is important to use UV pass/visible block filters in applications that actually involve imaging at UV wavelengths.



LONGPASS AND SHORTPASS FILTERS

(*LP* and *SP* series)

Longpass filters allow longer visible and infrared wavelengths to pass while blocking shorter wavelengths. Shortpass filters have the opposite effect. Both are useful in improving contrast, resolution and separating colors in either black-and-white or color applications.



INFRARED FILTERS

(*LP*, *SP* and *BP* series)

Filters for both blocking and passing select infrared wavelength ranges. Infrared blocking filters are almost essential for color imaging while infrared pass filters should be considered mandatory for all near infrared applications.

NEUTRAL DENSITY FILTERS

(*ND* series)

Reduce luminous intensity without affecting color by using glass ND filters with neutral gray tint. Different optical densities (ODs) equate to an overall decrease in luminous transmission of visible light. Off-the-shelf varieties include 1/2 (OD=0.30), 1/4 (OD=0.60), 1/8 (OD=0.90) and 1/16 (OD=1.20) filters; many other types of custom ND filters are also available.

LENS PROTECTORS AND UV BLOCK FILTERS

(*AC*, *BP* and *LP* series)

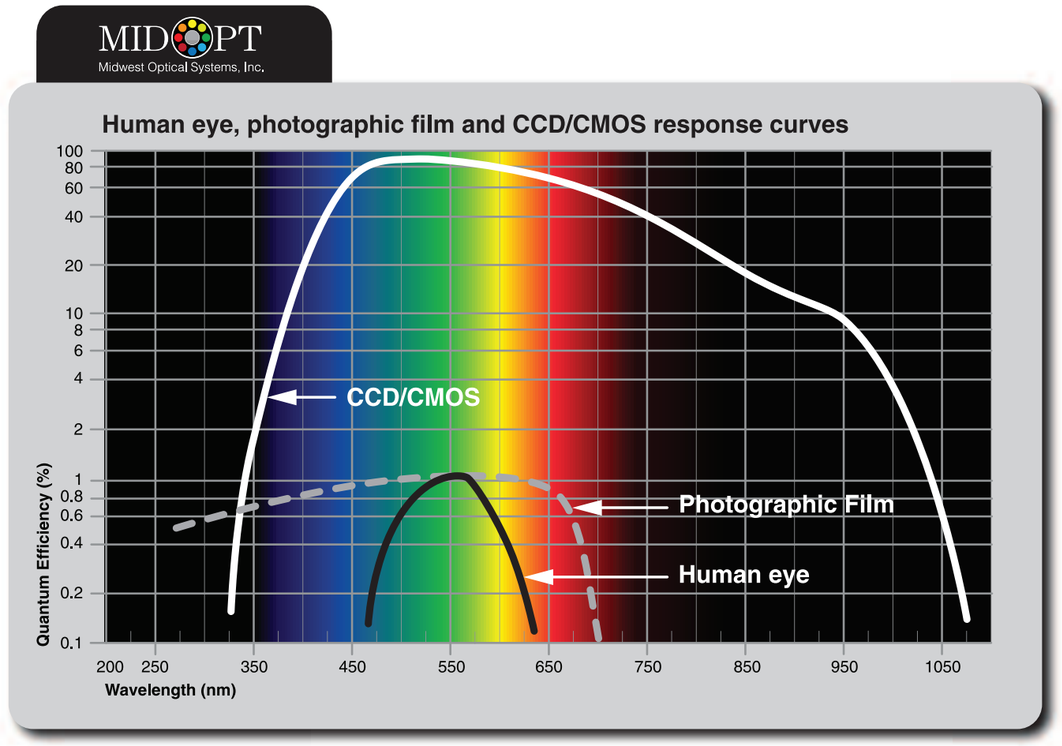
Clear, precision ground, polished and/or anti-reflection coated windows protect lenses from dust and harsh industrial environments. They transmit all visible light while blocking UV radiation. Anti-reflection/scratch-resistant coated acrylic and chemically strengthened glass versions are also kept in inventory.

COLOR CORRECTING AND LIGHT BALANCING FILTERS

(*LA*, *LB* and *FL* series)

Correct artificial lighting so colors appear more natural. LA series (amber) reduce blue shading often strongly dominate in white LED and Xenon strobe lighting. LB series (blue) reduce the red in tungsten and halogen lighting. FL series fluorescent lighting filters and other wavelength enhancing filters are available.

Machine Vision v/s Photographic Filters



WHAT IS THE DIFFERENCE BETWEEN A *PHOTOGRAPHIC FILTER* AND A *MACHINE VISION FILTER*?

When it comes to machine vision, the ideal filter should be an immediate solution that provides greater contrast, improved transmission and resolution, and long term control over the variability of ambient light.

For over 100 years, photographers have been using filters to reduce reflections, balance the color of a scene, and bring out contrast in black-and-white photos. With similar results in mind, integrators all over the world have been attempting to use photographic filters in industrial vision systems. In most cases, some improvement can be seen when using these types of filters, however the problem with photographic filters is not just in adapting their (usually) larger sizes to smaller CCTV lenses. These filters were first intended for use with film cameras, and they have not changed.

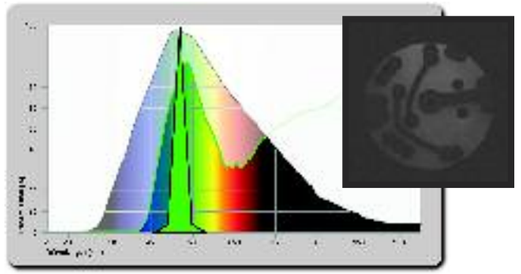
The spectral response (sensitivity) of film is from 400-700nm, i.e., the visible spectrum. Almost all CCD/CMOS cameras are sensitive in the ultraviolet (UV), visible and near-infrared (NIR) portions of the spectrum. In order to take control of lighting conditions and image quality, filters are required that take this into account and perform well over this entire range.

We have long recognized that most photographic filters are far from ideal for use in digital imaging and so designed filters specifically for most common machine vision applications.

As shown on the following pages, the improvement in contrast can be significant when a filter designed for industrial vision is used instead of a traditional photographic filter.

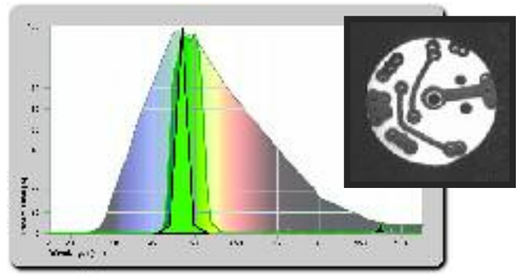
These graphs illustrate the spectral response of a typical CCD/CMOS sensor, output from common machine vision LED lighting and performance characteristics of “photographic” filters currently offered elsewhere as “Industrial Filters” vs. MidOpt’s machine vision filters.

The “industrial” filter reduces light intensity from green LED lighting by 33% or more. It also passes more of the unwanted shorter and longer wavelengths, decreasing overall contrast.



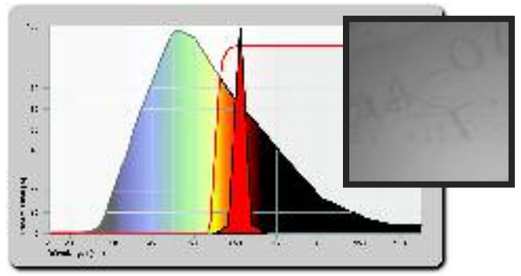
Typical CCD/CMOS camera spectral response and typical 520nm green LED illumination through an “industrial” green filter (061 green)

The **MidOpt BP525** filter blocks all unwanted wavelengths while passing 95% of the LED’s spectral output. This creates maximum contrast and control of ambient light conditions.



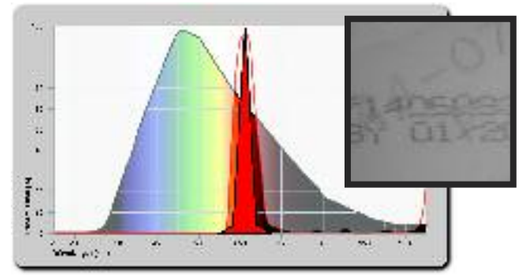
Typical CCD/CMOS camera spectral response and typical 520nm green LED illumination with Midwest Optical’s BP525 Light Green Bandpass Filter

The “industrial” filter commonly sold for MV applications only blocks the lower wavelengths. Additional unwanted longer wavelengths reaching the camera’s sensor greatly reduces contrast and overall image quality.



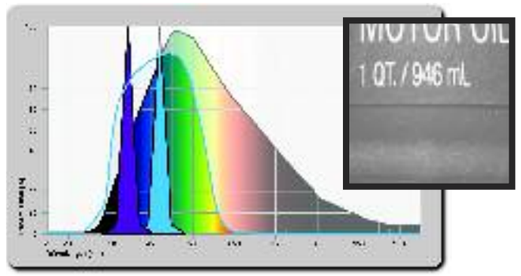
Typical CCD/CMOS camera spectral response and typical 660nm red LED illumination through an “industrial” filter (091 red)

The **MidOpt BP660** filter removes all unwanted light that might reach the camera’s sensor. This additional blocking of ambient light greatly improves overall contrast and system speed and accuracy.



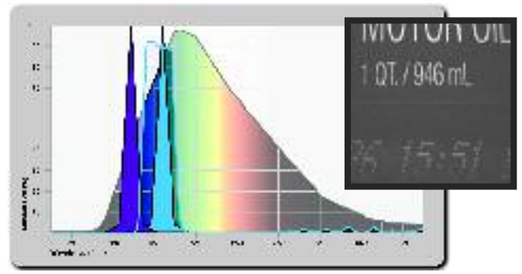
Typical CCD/CMOS camera spectral response and typical 660nm red LED illumination with Midwest Optical’s BP660 Dark Red Bandpass Filter

The “industrial” filter commonly sold for fluorescence applications doesn’t block the overpowering UV LED light source. It also passes more than just the blue wavelengths which reduces ability to detect the typically weak blue “glow” from the subject under inspection.



Typical CCD/CMOS camera spectral response and blue fluorescence emission after excitation by 395nm UV LED lighting through an “industrial” filter (081 blue)

The **MidOpt BP470** filter blocks the powerful UV light source and passes only the required blue portion of the spectrum, insuring maximum contrast when imaging any blue fluorescence.



Typical CCD/CMOS camera spectral response and blue fluorescence emission after excitation by a 395nm UV LED lighting with Midwest Optical’s BP470 Blue Bandpass Filter

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Testing with Filters

TEST THE EFFECTS OF FILTERING AND MONOCHROMATIC LIGHTING

In the machine vision industry, there is tremendous emphasis placed on lighting as a way to color the image and/or improve contrast to achieve long-term system acceptability. Countless articles are available explaining the basics of automated imaging that detail lighting, camera selection, lensing and other image-acquisition hardware and software, but few touch on the usage and importance of optical filtering.

It is of course essential to be familiar with all of the above components, and choosing the correct type of lighting is often the most critical aspect of any inspection task. Although lighting quality is now recognized as the main stumbling block to successful implementation of today's lower cost automated inspection systems, it is also obvious that in order **to achieve a system that produces fewer false accepts and false rejects**, filtering needs to be considered a major component in the equation.

Before cameras were introduced to the factory floor, their use in business was primarily limited to commercial photography and scientific imaging. For professionals in these fields, employing optical filtering has typically always been the first step taken whenever necessary to bring out a desired color or manipulate contrast.

Photographers looking to darken green foliage in a black & white photograph most often cannot use a red light to illuminate a scene. They simply screw the complimentary color, a red filter, to the front of their camera lens. This blocks the green portion of the spectrum which in turn darkens the green foliage.

In scientific imaging, filters have always been used in front of a lens to bring out contrast and block unwanted ambient light; they are also used in front of the light source to help control the lighting. In these cases, the applications are often quantitative in nature and it is necessary to employ very narrow bandpass filters and/or filters with superior light blocking capabilities. Relative to traditional photographic filters, scientific filters are very expensive. Fortunately, most machine vision applications do not require this type of costly filtering; in fact, paying more in order to use filters with these characteristics can make things more difficult and the results are often detrimental to the process.

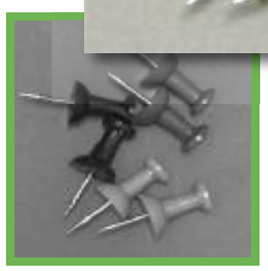
Filters designed specifically for industrial imaging are now readily available, inexpensive and play a vital roll.

FIRST CONCERNS

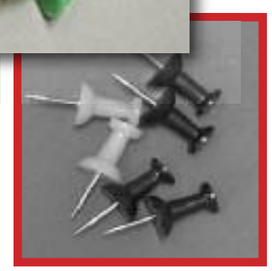
One of the first necessary concerns is the type and color of lighting to be used. In machine vision applications, LED lighting is commonly an ideal choice. Selecting the right LED lighting is all about creating optimal contrast. Unless you own a company that manufactures LED lighting, having lighting equipped with the myriad of LED wavelengths that are available is not always possible or reasonable – here is where filtering plays a central role in designing a successful system.

Instead of experimenting with different colors of LED, UV or near-IR lighting, it makes sense to simply screw a bandpass filter on the front of the camera lens to begin testing your options. Of course a sufficient amount of appropriate ambient light (sunlight, for example) is still necessary.

Ambient light ... no filter



... with BP525 Light Green Bandpass Filter



... with BP660 Dark Red Bandpass Filter

... with BP470 Blue Bandpass Filter

MidOpt's bandpass filters are designed to block all unwanted ambient light and transmit the spectral output of the LED for which they are intended to be used. The engineer/designer is able to quickly and inexpensively imitate the effect of any specific wavelength or color of LED in any application. Once the wavelength that gives optimal contrast is determined, it is possible to further narrow down the lighting options. This simple yet effective approach has saved considerable time and resources in the early stages of many designs.

TO SHROUD OR FILTER? HOW MUCH YA GOT?

Something that we have heard time and again is how the system was working great in the lab and when first installed, but after some time it just wasn't performing as well as expected. In many cases, the culprit is a change in the surrounding area that affected ambient lighting. A common and intuitive step to overcome this problem is to shield the system with some sort of shroud.

Shrouds can take up a considerable amount of space, take days or weeks to construct, limit access to the inspection equipment and product under test, and increase the overall cost of the system, often much more than necessary. Most of this can be avoided by simply using an appropriate bandpass filter to control the long-term variability of ambient light. Once again, effectiveness can be initially tested in the lab. Bandpass filtering will usually provide a decidedly simpler, more compact, and far less expensive shielding option.

WHAT CONSTITUTES A MACHINE VISION FILTER?

In photography, polarizers reduce reflections. Light balancing filters warm or cool the color of a scene. In black-and-white photography, color filters will lighten their own and similar colors while darkening the tones of complimentary colors. Neutral density filters cut overall brightness while allowing for longer exposure times and increased depth of field. With similar results in mind, integrators have attempted using photographic filters in industrial vision systems. In some cases the overall image can be improved using these types of filters.

The problem with photographic filters, however, is not just in adapting their (usually) larger sizes. They were first intended for use with film cameras, and their design has never changed. The spectral response (sensitivity) of film is from about 400-700nm - the visible spectrum. Most CCD/CMOS cameras used in industrial imaging applications are increasingly more sensitive in the ultraviolet (UV), visible and near infrared (IR) portions of the spectrum. UV and near-IR sensitivity in todays cameras often exceeds sensitivity in the visible portion of the spectrum. In order to gain control of lighting conditions, a filter is required that will take into account this entire range of sensitivity. A filter that blocks both shorter and longer irrelevant wavelengths and only passes light provided by the desired light source should be one's first consideration.

Compared to photographic filters, MidOpt's options provide much better blocking of extraneous light and feature higher transmission at required wavelengths. The additional blocking and peak transmission creates greater contrast, allowing the system to run at its full capability.

Using application-specific machine vision filters also provides greater control over ambient light, which can in turn afford vastly improved contrast for clear, high-contrast viewing of the desired features.

LONG-TERM BENEFITS

What cannot be shown in this kit or in the examples are the long-term benefits to using filters designed specifically for machine vision applications. Over time, many of the changes in system settings and ambient lighting in a factory's surrounding environment can create any number of problems that greatly impact system accuracy. These can in turn result in increased downtime and more headaches for those responsible for maintenance of these systems. From this aspect alone, **use of MidOpt filters can be thought of as a low-cost insurance policy.**

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Increase Resolution

BENEFITS OF USING FILTERS WITH HIGH RESOLUTION AND TELECENTRIC LENSES

The use of filters matched with LED or other *monochrome* lighting is important in high resolution or telecentric gaging applications.

In many machine vision applications, the lens that is used is not cheap, sometimes costing thousands of dollars. Filters, on the other hand, are relatively inexpensive and can protect these costly high resolution or telecentric lenses from accidental damage. Many of the more expensive lenses are often more susceptible to damage simply because of the large surface area of the objective lens. A filter is durable and easy to clean; however, should it get scratched or damaged, it is much easier, quicker and far less costly to replace than the front lens element. This is a particular strong case for protecting your investment and limiting potential down time.

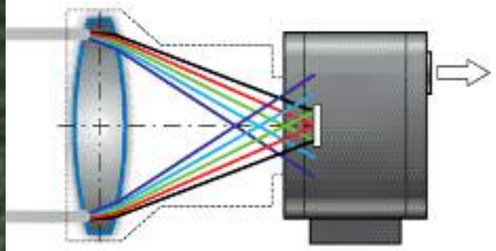
Filters that narrow the spectral range, especially when used together with monochromatic LED lighting, can also improve resolution while greatly increasing contrast by reducing the effect of chromatic aberrations.

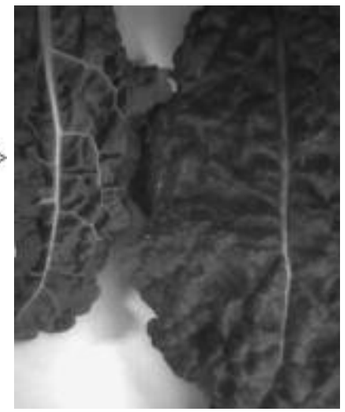
Best focus is a function of wavelength, so it is highly beneficial to limit the range of lighting on the subject you are trying to image. It can be particularly significant if there are substantial UV and/or near-infrared components to the light in the surrounding area. Generally, the faster the lens (a low 'f' number) and the wider the field of view, the greater the benefits. Improvements in off-axis resolution by as much as 20-50% are not unusual. Bandpass filters, in particular, are recommended in order to achieve this. MidOpt filters block ambient UV light, near-infrared light, and all unwanted visible wavelengths, while transmitting >90% of the desired LED wavelength range.

CHROMATIC ABERRATION

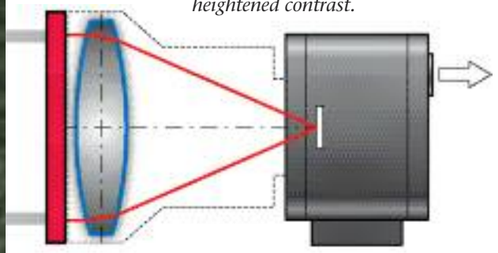
A lens focuses different colors in slightly different places because the focal length depends on an *index of refraction*. Blue light (shorter wavelength) is shorter than that of red light (longer wavelength) – this difference creates a slight blurring of the image which is often more pronounced in machine vision applications as most cameras have significant sensitivity in UV (much shorter wavelengths than blue) and IR (much longer wavelengths than red).

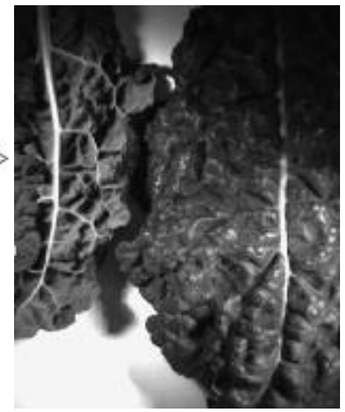
Monochrome image of kale leaves with unfiltered white light.

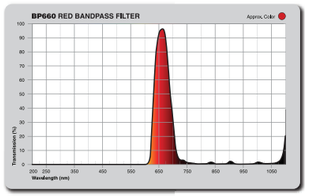




BP660 bandpass filter blocks all light except the red, typically from an LED source, creating heightened contrast.







See pages 28-29 for data on the MidOpt BP660 machine vision filter.

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Filter Applications

FILTERS FOR UV FLUORESCENCE

Many materials emit visible light when they are excited by a UV light source. Applications which require imaging these materials are becoming increasingly more common. Materials like inks, adhesives or other substances contain UV-sensitive fluorophores that are specifically added or applied by the manufacturer, while other materials including glue, starches, grease, paper, wood and some plastics may naturally contain them.

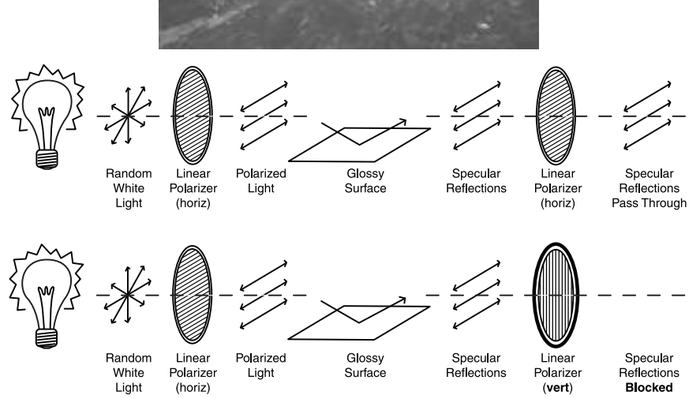
Making things difficult, the visible fluorescence is typically very weak compared to the surrounding light, particularly because of interference from the much brighter UV light source. Additionally, most cameras have significant near-UV sensitivity. Together, this means it is often very challenging for even the most sophisticated vision systems to reliably detect luminescent emissions. In order for a system to be successful in any UV application, a filter MUST be employed to brighten (or darken if against a light background) this visible emission and block all of the unwanted visible and UV light. Filtering of the UV light source itself may also be beneficial.

POLARIZING FILTERS

Light reflected from a non-metallic surface such as glass, lacquer, plastic or liquid results in a polarization of the reflected light. This polarized reflection can be the result of uncontrolled ambient light but is more often from the light source chosen for illumination, As the angle of incidence of the light and the camera relative to the subject are about the same and approach 55º to normal, a “glare” and loss of contrast becomes more pronounced.

In situations where the subject is partially obscured by the unwanted reflection, a polarizing filter can reduce or eliminate the problem. Polarizing filters can also highlight stress patterns in clear plastic or glass to determine whether the glass has been properly tempered.

Many polarizing filters consist of a plastic film – “Venetian Blind” grid – laminated between two pieces of glass. This grid is invisible to the eye and the camera’s sensor, is generally gray in color, and allows visible light to pass through in only one polarization plane. Rotating the filter makes it work as an “analyzer” to decrease highly polarized glare. Further reduction of the glare is possible by polarizing the light source. Polarizing plastic sheet material, 0.005” to 0.003” thick, can easily be cut to desired shapes and/or sizes to cover the light source.



RADIATION AND TEMPERATURE IR BLOCKING

Certain machine vision filters can be used to block the bright glow of hot metals, glass and other materials. Shortpass filters allow light up to a specific wavelength to pass through while blocking all light at higher wavelengths. This useful feature permits, for example, the viewing of hot rolled steel to see certain temperature areas while not blinding the system from the brighter, hotter areas.

LIGHT BALANCING FILTERS

Light Balancing Filters are primarily used in color applications and are designed to warm or cool the color balance of a scene. MidOpt’s **LB080** and **LB120** filters are bluish in appearance and are used to raise the “color temperature,” thus reducing unnatural red tones produced by high-pressure sodium lamps and some halogen lighting. **LA080** and **LA120** filters are amber colored and used to correct high color temperatures from xenon, metal halide and white LED lighting which tends to be blue in appearance. LA120 filters in particular are recommended for suppressing the strong blue “spike” found with standard white LEDs and represent the most cost-effective method available for correcting this problem. The names for the above filters derive from the *mired shift value* to be anticipated in each case.

Pinkish **FL550** filters are used to eliminate the harsh greenish hue that results when using fluorescent lighting. They absorb light in the middle of the visible spectrum where most color cameras have their strongest response, resulting in a more true-to-life color rendition.

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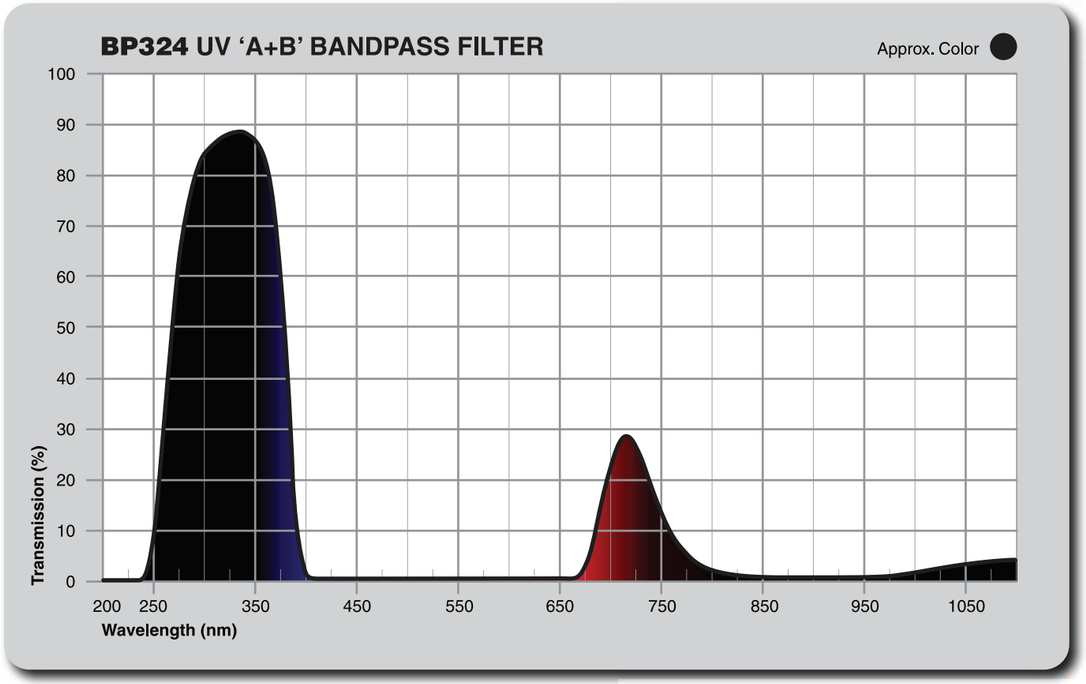
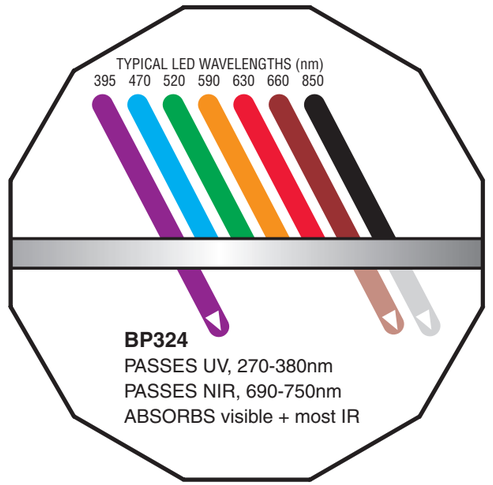


BP324 Data Points (typical)

WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	3.78	800	2.10	500	0.00
1090	3.78	790	3.02	490	0.00
1080	3.75	780	4.39	480	0.01
1070	3.54	770	6.48	470	0.01
1060	3.29	760	9.44	460	0.00
1050	3.11	750	13.39	450	0.00
1040	2.80	740	18.40	440	0.00
1030	2.40	730	23.91	430	0.00
1020	2.07	720	28.08	420	0.00
1010	1.73	710	27.35	410	0.01
1000	1.47	700	21.88	400	1.08
990	1.16	690	14.15	390	12.73
980	0.88	680	5.46	380	46.70
970	0.74	670	1.01	370	72.89
960	0.66	660	0.07	360	83.40
950	0.61	650	0.00	350	87.02
940	0.54	640	0.01	340	88.32
930	0.52	630	0.00	330	88.32
920	0.59	620	0.00	320	87.68
910	0.60	610	0.00	310	86.28
900	0.42	600	0.00	300	83.97
890	0.42	590	0.00	290	79.00
880	0.45	580	0.00	280	69.22
870	0.44	570	0.01	270	52.40
860	0.54	560	0.01	260	29.71
850	0.57	550	0.00	250	7.53
840	0.70	540	0.02	240	0.18
830	0.88	530	0.00	230	0.00
820	1.13	520	0.00	220	0.00
810	1.52	510	0.00	210	0.04



BP324

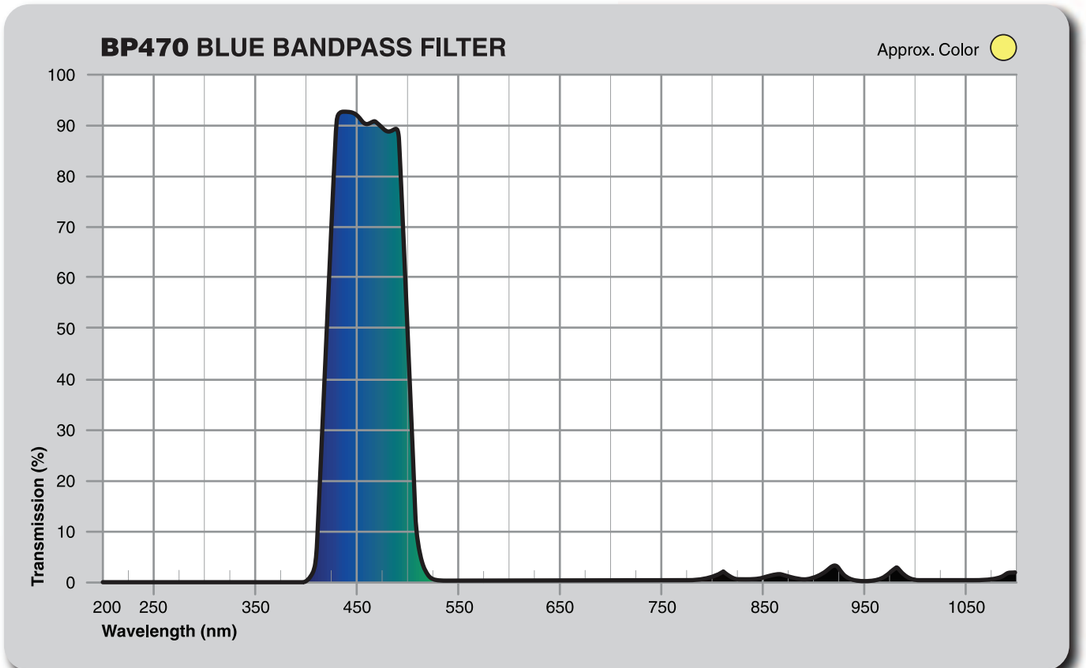
BP324 filters have broad spectral bandwidth in the ultraviolet while effectively blocking visible and infrared light. These filters are particularly useful in true UV imaging applications where blocking of longer wavelengths is essential and the camera employed is often designed to be particularly sensitive in the ultraviolet. Both the UV-A and UV-B portions of the ultraviolet spectrum are passed, while the UV-C portion is blocked. Aside from mounted versions that are placed in front of the camera lens, different configurations can also be supplied for mounting in front of ultraviolet LED light sources for blocking visible and near infrared output.

For other types of higher wattage, high-heat UV light sources, we recommend our BP365 filter.

NOTE:
UV-A: 320-380nm
UV-B: 280-320nm
UV-C: <280nm

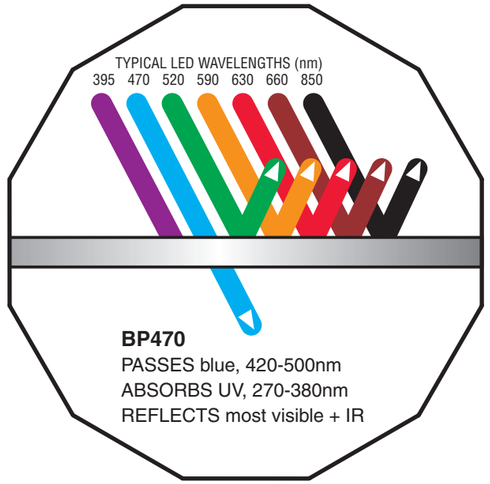
Camera, no filter... repair is unseen

BP324 Machine Vision Filter shows a mismatch in the clear coat.



BP470 Data Points (typical)

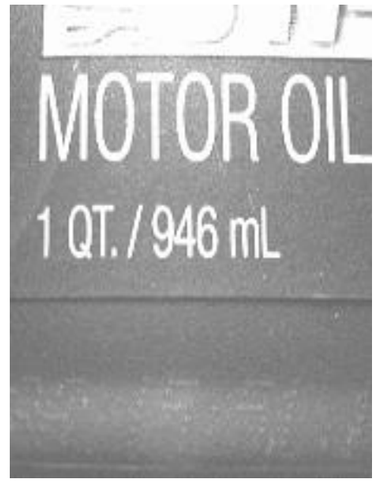
WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	1.61	800	0.98	500	47.75
1090	1.44	790	0.23	490	89.01
1080	0.76	780	0.22	480	88.66
1070	0.37	770	0.29	470	90.52
1060	0.20	760	0.40	460	90.09
1050	0.13	750	0.13	450	92.03
1040	0.11	740	0.05	440	92.61
1030	0.10	730	0.02	430	91.87
1020	0.11	720	0.04	420	50.00
1010	0.16	710	0.08	410	3.65
1000	0.30	700	0.03	400	0.00
990	0.98	690	0.00	390	0.00
980	2.55	680	0.00	380	0.00
970	0.85	670	0.00	370	0.00
960	0.40	660	0.07	360	0.00
950	0.32	650	0.01	350	0.00
940	0.42	640	0.00	340	0.00
930	0.96	630	0.00	330	0.00
920	3.35	620	0.03	320	0.00
910	1.65	610	0.15	310	0.00
900	0.65	600	0.05	300	0.00
890	0.51	590	0.07	290	0.00
880	0.67	580	0.09	280	0.00
870	1.23	570	0.06	270	0.00
860	1.42	560	0.08	260	0.00
850	0.78	550	0.10	250	0.00
840	0.58	540	0.20	240	0.00
830	0.65	530	0.44	230	0.00
820	1.07	520	1.09	220	0.00
810	1.97	510	9.28	210	0.00



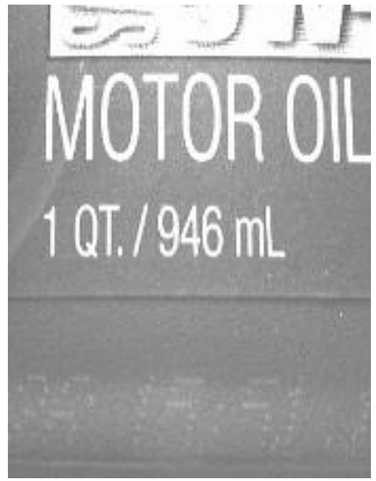
BP470

BP470 filters are recommended for use in most blue LED (~470nm) and many UV-excited blue fluorescence (430-500nm) imaging applications. Important for both applications is the breadth of the bandwidth. In the case of blue LEDs, variation in center wavelengths and angles of incidence can easily be accommodated. For typically weak blue fluorescence applications, it is important to be able to detect as much of the blue emission as possible while effectively blocking all of the UV light. Since 90% of all industrial UV fluorescence applications involve imaging a blue-colored "glow," it can be summarized that most applications involving a UV light REQUIRE the use of a BP470 filter. Without a filter of this type, it is nearly impossible to successfully image the desired feature.

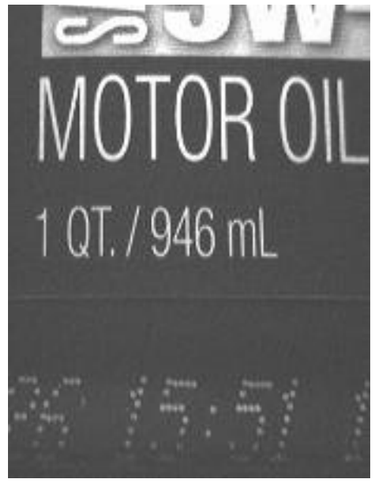
We recommend the BP470 Blue Bandpass Filter over any other filter because of its broad yet more compact peak (T>90%), superior blocking of shorter UV and longer IR wavelengths, and steeper cut on and cut off slopes. All of this results in far brighter, higher contrast images when using the BP470 filter compared to other filters that are available.



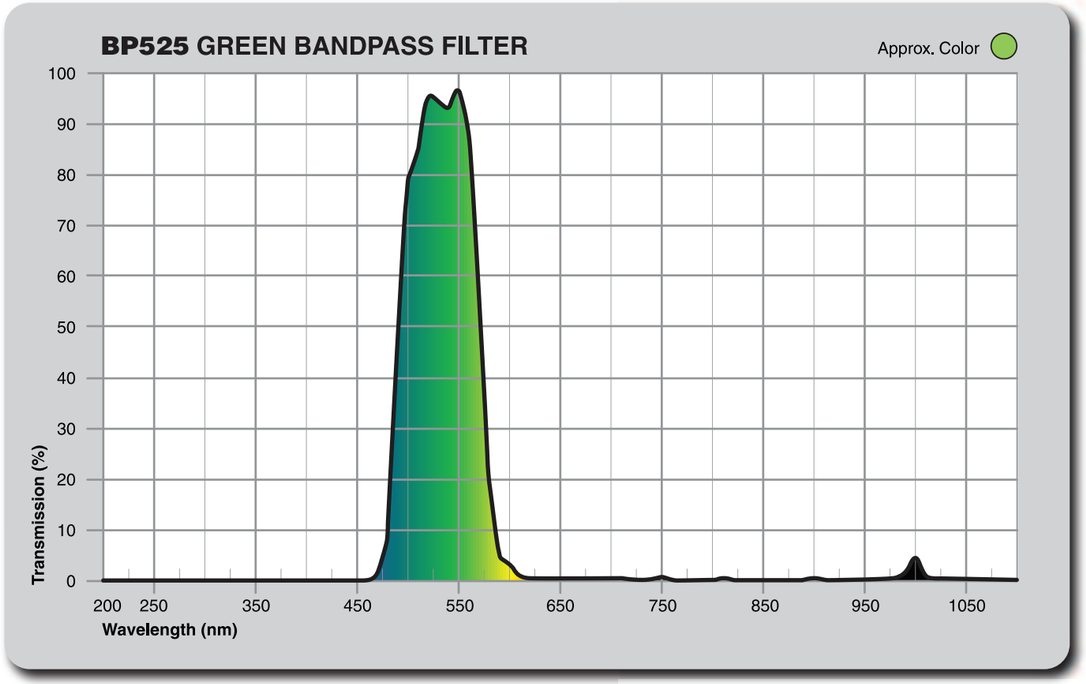
Camera, no filter, batch code is unseen.



Photographic filter does not see fluorescence.



BP470 filter provides machine vision contrast.



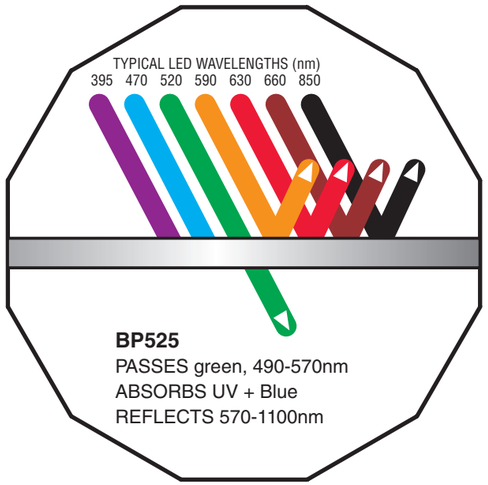
BP525 Data Points (typical)

WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	0.07	800	0.02	500	78.03
1090	0.06	790	0.01	490	49.21
1080	0.07	780	0.00	480	10.49
1070	0.11	770	0.00	470	1.32
1060	0.11	760	0.04	460	0.23
1050	0.11	750	0.52	450	0.07
1040	0.21	740	0.20	440	0.04
1030	0.38	730	0.06	430	0.02
1020	0.45	720	0.08	420	0.01
1010	0.98	710	0.10	410	0.00
1000	4.42	700	0.07	400	0.00
990	1.53	690	0.06	390	0.00
980	0.49	680	0.07	380	0.00
970	0.21	670	0.11	370	0.00
960	0.11	660	0.11	360	0.00
950	0.06	650	0.11	350	0.00
940	0.00	640	0.21	340	0.00
930	0.03	630	0.38	330	0.00
920	0.00	620	0.45	320	0.00
910	0.05	610	0.98	310	0.00
900	0.09	600	3.04	300	0.00
890	0.03	590	5.36	290	0.00
880	0.02	580	20.92	280	0.00
870	0.01	570	60.72	270	0.00
860	0.01	560	87.67	260	0.00
850	0.01	550	96.41	250	0.00
840	0.00	540	93.27	240	0.00
830	0.01	530	94.29	230	0.00
820	0.06	520	95.28	220	0.00
810	0.17	510	85.37	210	0.00

Camera, no filter.

Photographic filter mutes the whole image.

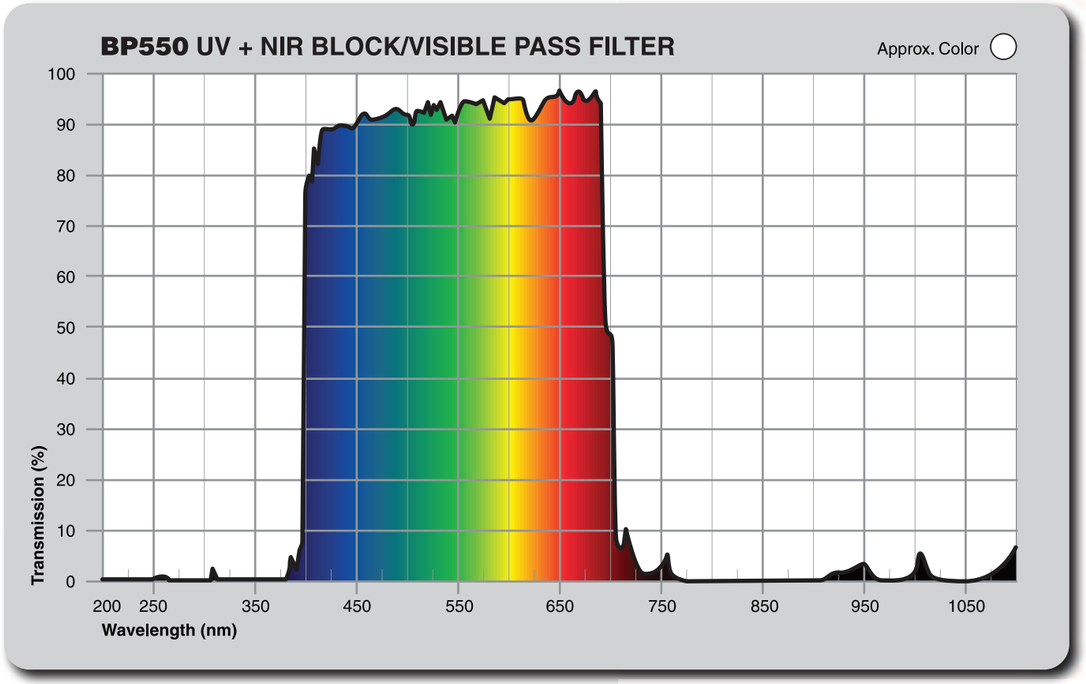
BP525 filter creates contrast.



BP525

The BP525 filter has been designed for use in almost all green LED or laser diode applications. They also have wide application in UV fluorescence imaging of various commonly used stains and plastic materials.

MidOpt strongly recommends our BP525 Light Green Bandpass filter over all other widely offered green bandpass filters because of its broader range, higher peak transmission, superior blocking of UV and IR wavelengths, and less sensitivity to angle of incidence changes. Compared to any other “green” filter, the BP525 nearly always results in significantly brighter and higher contrast images.



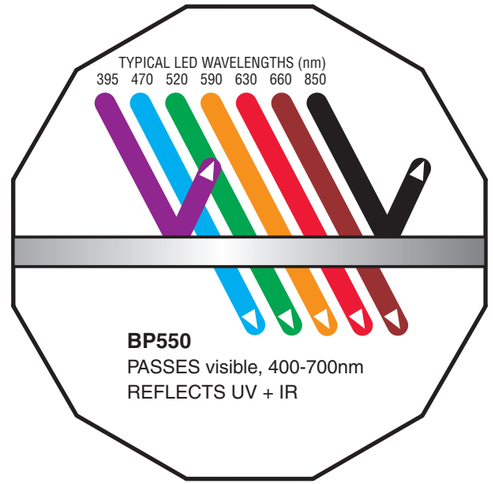
BP550 Data Points (typical)

WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	5.00	800	0.00	500	93.66
1090	4.00	790	0.00	490	91.79
1080	0.70	780	0.00	480	90.57
1070	0.50	770	0.00	470	90.63
1060	0.00	760	0.08	460	91.14
1050	0.00	750	0.02	450	90.49
1040	0.00	740	0.62	440	90.48
1030	0.00	730	1.77	430	90.72
1020	0.87	720	9.47	420	89.41
1010	4.30	710	7.56	410	86.03
1000	1.10	700	48.09	400	79.66
990	0.00	690	94.15	390	5.05
980	0.00	680	95.07	380	1.55
970	0.00	670	93.85	370	0.00
960	0.00	660	95.05	360	0.00
950	2.30	650	94.51	350	0.00
940	1.80	640	92.31	340	0.00
930	1.40	630	92.30	330	0.00
920	0.00	620	94.21	320	1.95
910	0.00	610	95.02	310	0.00
900	0.00	600	94.38	300	0.00
890	0.00	590	91.58	290	0.00
880	0.00	580	92.92	280	0.00
870	0.04	570	94.57	270	0.00
860	0.00	560	90.64	260	0.00
850	0.00	550	92.60	250	0.00
840	0.00	540	94.87	240	0.00
830	0.00	530	93.94	230	0.00
820	0.00	520	93.72	220	0.00
810	0.00	510	93.08	210	0.00

BP550

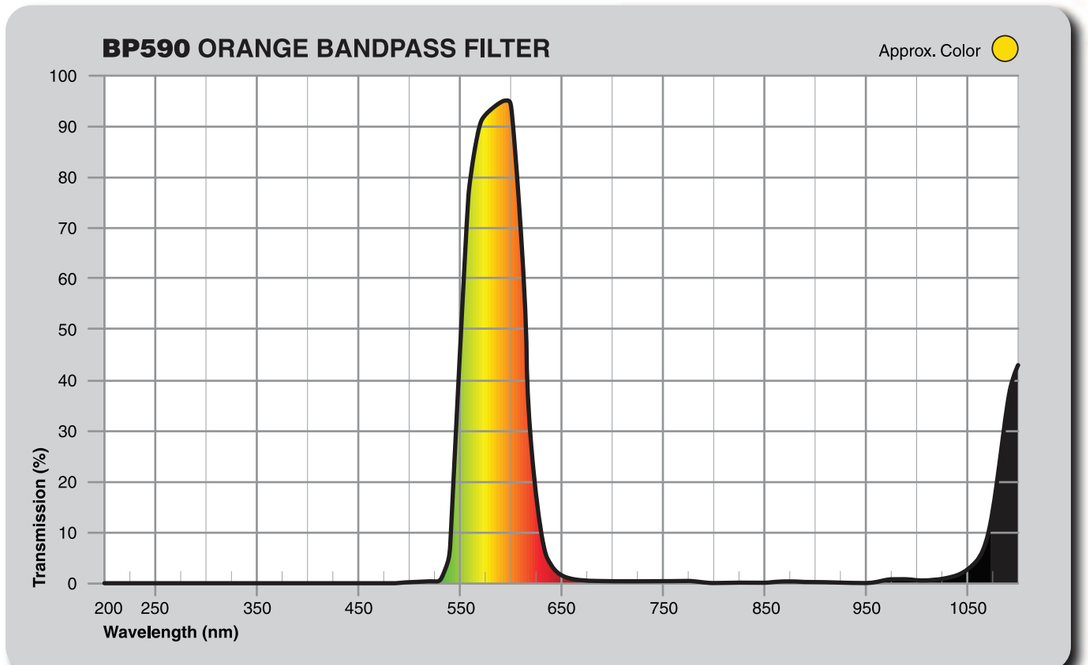
The BP550 filter is designed for use in full-color, white light applications where either infrared (heat) and ultraviolet light – or both – may be present. Because of the design's steep cut-off of these undesired wavelengths, the BP550 filter effectively passes all visible light without "discoloring" the image. While color rendition is greatly improved, this filter also serves as a dust cover, protecting lens surfaces and internal threads.

The substrate material used in the BP550 is Borofloat, a low expansion glass similar to Pyrex. Our latest version of this filter features extended infrared rejection out to ~1750nm, resulting in significantly more heat removal in many applications when compared to standard commercial "hot mirrors." The second surface is anti-reflection coated for improved transmission and elimination of glare and ghost images.



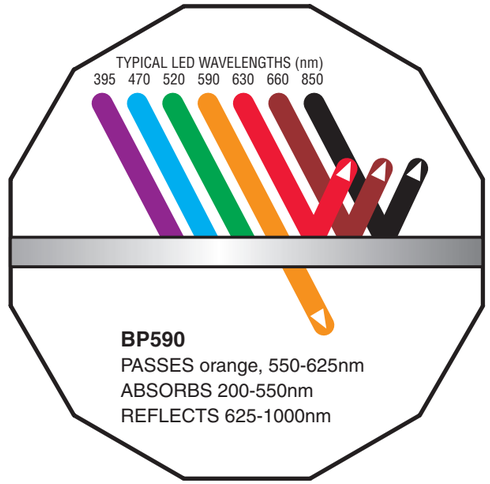
No filtering of the UV and IR.

BP550 permits only the visible wavelengths.



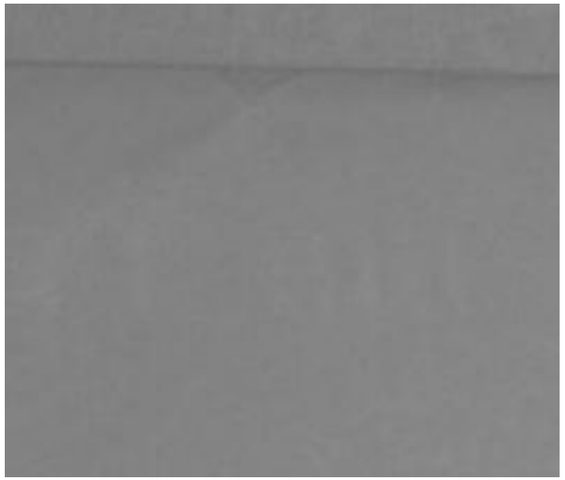
BP590

BP590 filters are recommended for use in systems that make use of amber or orange LED lighting. These filters are also widely used in fluorescence imaging applications, particularly with certain inks, ethidium bromide, Qdot 605 and other similar stains. As with all MidOpt bandpass filters, peak transmission is greater than 90%. Blocking of shorter AND longer wavelengths averages >99% when used in applications utilizing any sensor that has a typical silicon response. This is particularly important in situations where infrared light may be present; orange long-pass filters have traditionally been recommended for these applications, but they offer no such IR blocking.

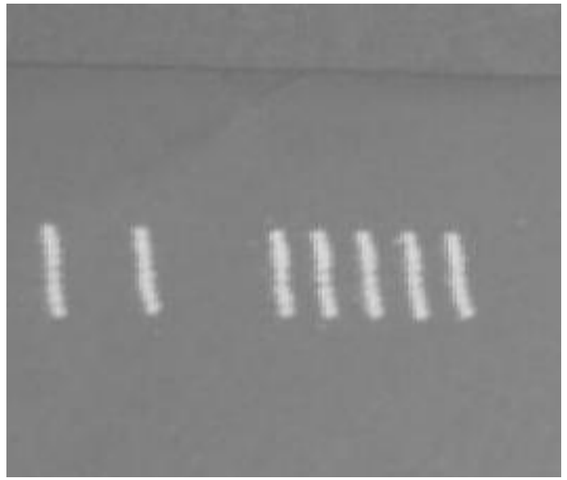


BP590 Data Points (typical)

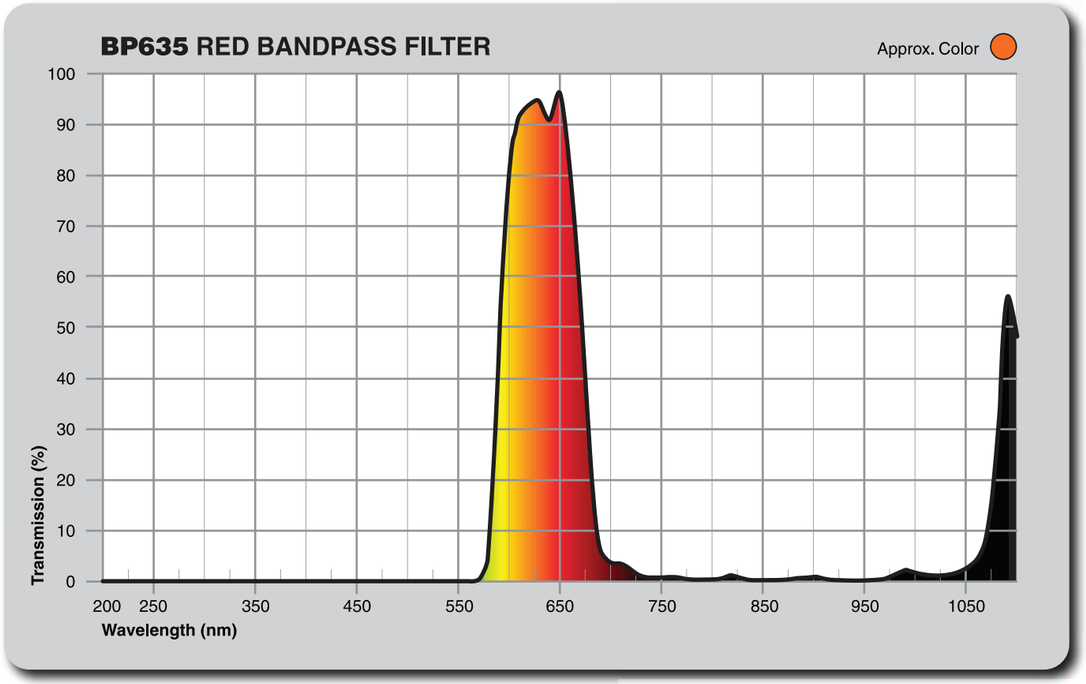
WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	43.49	800	0.02	500	0.08
1090	35.87	790	0.07	490	0.01
1080	20.78	780	0.21	480	0.00
1070	9.66	770	0.29	470	0.00
1060	4.79	760	0.12	460	0.00
1050	2.75	750	0.10	450	0.00
1040	1.58	740	0.15	440	0.00
1030	1.06	730	0.22	430	0.00
1020	0.83	720	0.20	420	0.00
1010	0.71	710	0.14	410	0.00
1000	0.63	700	0.17	400	0.00
990	0.83	690	0.25	390	0.00
980	0.87	680	0.45	380	0.00
970	0.71	670	0.65	370	0.00
960	0.31	660	0.87	360	0.00
950	0.04	650	1.54	350	0.02
940	0.00	640	3.60	340	0.02
930	0.00	630	9.64	330	0.00
920	0.00	620	27.07	320	0.01
910	0.07	610	68.94	310	0.00
900	0.00	600	94.63	300	0.00
890	0.00	590	94.76	290	0.00
880	0.20	580	93.14	280	0.00
870	0.33	570	90.32	270	0.00
860	0.08	560	78.91	260	0.00
850	0.02	550	46.55	250	0.00
840	0.01	540	6.45	240	0.00
830	0.00	530	0.51	230	0.00
820	0.00	520	0.25	220	0.00
810	0.02	510	0.18	210	0.03



Postal bar code under UV light, no filter.



BP590 Machine Vision Filter creates enhanced contrast.

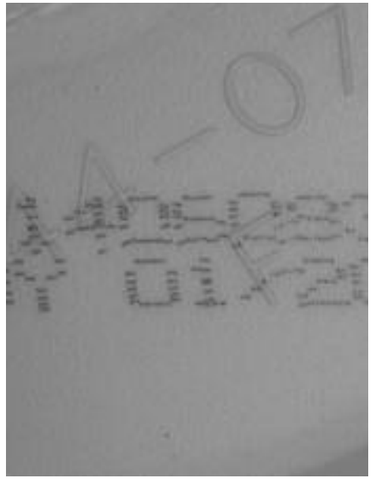


BP635 Data Points (typical)

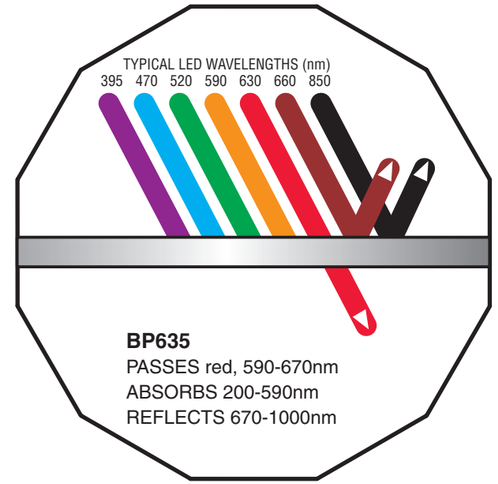
WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	48.62	800	0.44	500	0.00
1090	55.46	790	0.37	490	0.00
1080	25.35	780	0.41	480	0.00
1070	8.89	770	0.70	470	0.00
1060	4.22	760	0.92	460	0.00
1050	2.58	750	0.75	450	0.00
1040	1.64	740	0.71	440	0.00
1030	1.28	730	1.09	430	0.00
1020	1.14	720	2.38	420	0.00
1010	1.25	710	3.62	410	0.00
1000	1.74	700	3.63	400	0.00
990	2.24	690	6.59	390	0.01
980	1.37	680	21.42	380	0.00
970	0.61	670	55.70	370	0.00
960	0.28	660	79.46	360	0.00
950	0.23	650	96.10	350	0.00
940	0.16	640	90.63	340	0.02
930	0.25	630	94.58	330	0.00
920	0.31	620	93.73	320	0.01
910	0.79	610	91.58	310	0.00
900	0.91	600	80.91	300	0.00
890	0.57	590	45.04	290	0.00
880	0.53	580	6.04	280	0.00
870	0.24	570	0.19	270	0.00
860	0.19	560	0.00	260	0.00
850	0.21	550	0.01	250	0.00
840	0.33	540	0.01	240	0.00
830	0.63	530	0.00	230	0.00
820	1.16	520	0.00	220	0.01
810	0.78	510	0.00	210	0.03

Coffee can date/batch code, no filter.

Photographic filter does not improve much.



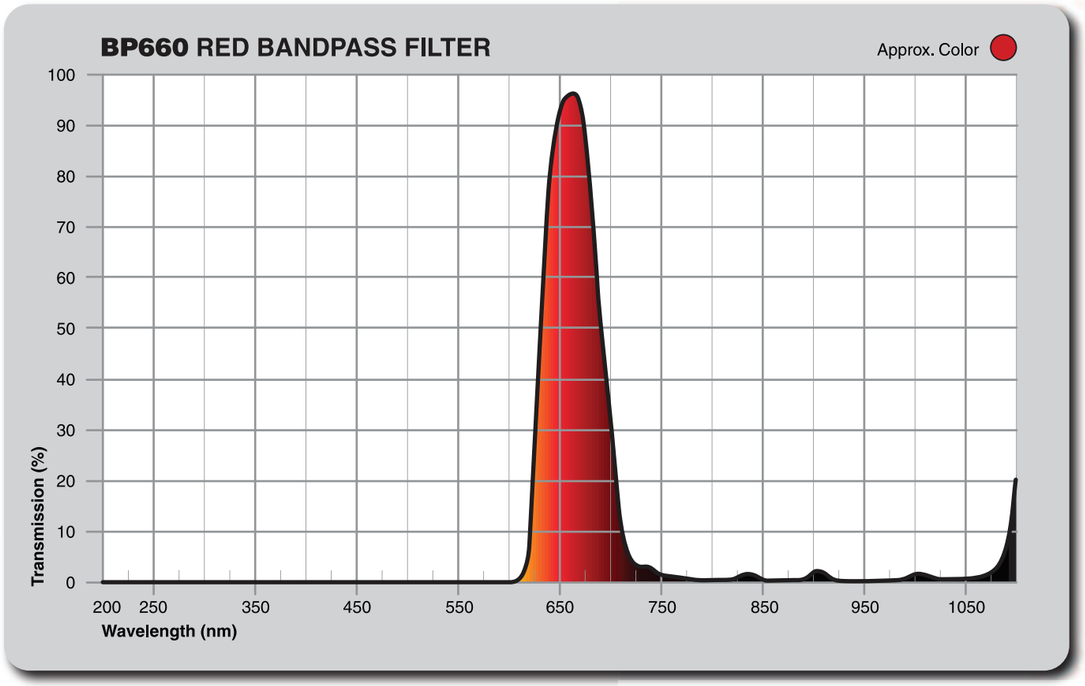
PB635 creates the needed contrast.



BP635

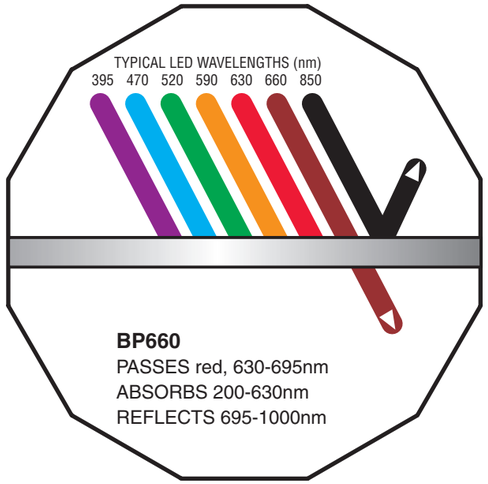
Color longpass filters have long been recommended for use with monochrome cameras to increase contrast and resolution. These filters block UV and shorter visible wavelengths, and pass longer wavelengths of light. Except in those few cases where an IR blocking or other shortpass filter is incorporated into the camera or sensor, MidOpt will often recommend the use of a broad color bandpass filter (whose design incorporates these longpass filters) over a color longpass filter alone. Next to the BP660 filter, the BP635 is our second most popular filter type.

BP635 filters are recommended for use with 615-645nm LED and laser diode lighting. Because of its broad bandwidth and high peak transmission, the BP635 works very well for all lighting applications in this range.



BP660 Data Points (typical)

WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	20.80	800	0.33	500	0.00
1090	6.72	790	0.49	490	0.00
1080	2.76	780	0.65	480	0.00
1070	1.45	770	0.93	470	0.00
1060	0.85	760	1.12	460	0.00
1050	0.67	750	1.49	450	0.00
1040	0.62	740	2.86	440	0.00
1030	0.65	730	3.13	430	0.00
1020	0.89	720	4.49	420	0.00
1010	1.48	710	11.80	410	0.00
1000	1.65	700	33.02	400	0.00
990	0.66	690	52.29	390	0.00
980	0.32	680	78.07	380	0.00
970	0.17	670	94.81	370	0.00
960	0.15	660	96.25	360	0.00
950	0.15	650	92.78	350	0.00
940	0.17	640	78.79	340	0.00
930	0.22	630	44.78	330	0.00
920	0.44	620	6.15	320	0.00
910	1.95	610	0.38	310	0.00
900	2.12	600	0.07	300	0.00
890	0.62	590	0.03	290	0.00
880	0.34	580	0.00	280	0.00
870	0.27	570	0.00	270	0.00
860	0.33	560	0.00	260	0.00
850	0.62	550	0.00	250	0.00
840	1.51	540	0.00	240	0.00
830	1.50	530	0.00	230	0.00
820	0.64	520	0.00	220	0.00
810	0.37	510	0.00	210	0.00

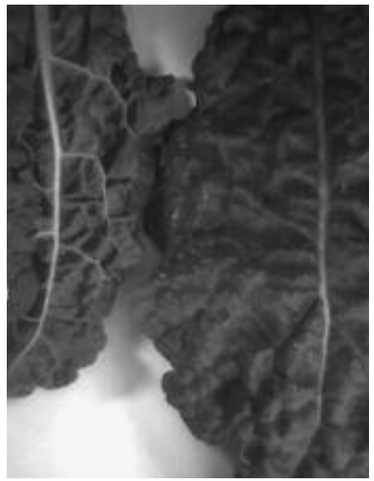


BP660

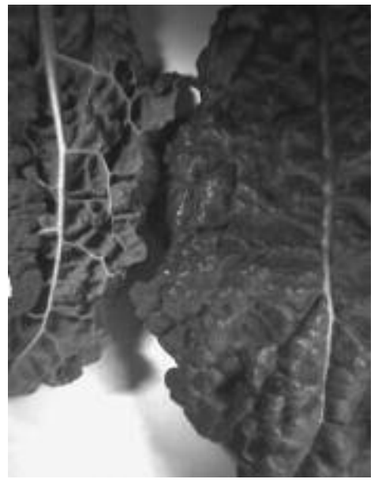
The BP660 is recommended for use with 660-680nm LED and laser diode lighting. Because of the ample bandwidth and excellent in-band transmission, it works very well for all camera-related applications in this range.

Color longpass filters, sometimes refered to as “sharp cut” filters, are often suggested by others for use in creating increased contrast and resolution. Longpass filters will block UV and shorter visible wavelengths but they still pass all the longer wavelengths, too.

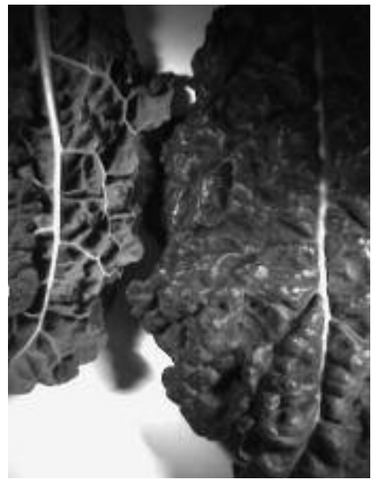
Except in a few cases where an IR-blocking or other shortpass filter is incorporated into the camera or sensor, MidOpt will recommend one of our broad color bandpass filters (such as BP660) over these color longpass filters alone. The results in a majority of cases are more consistent and far greater long-term contrast in most inspection applications. Currently, we provide more BP660 filters than any other filter in our line.



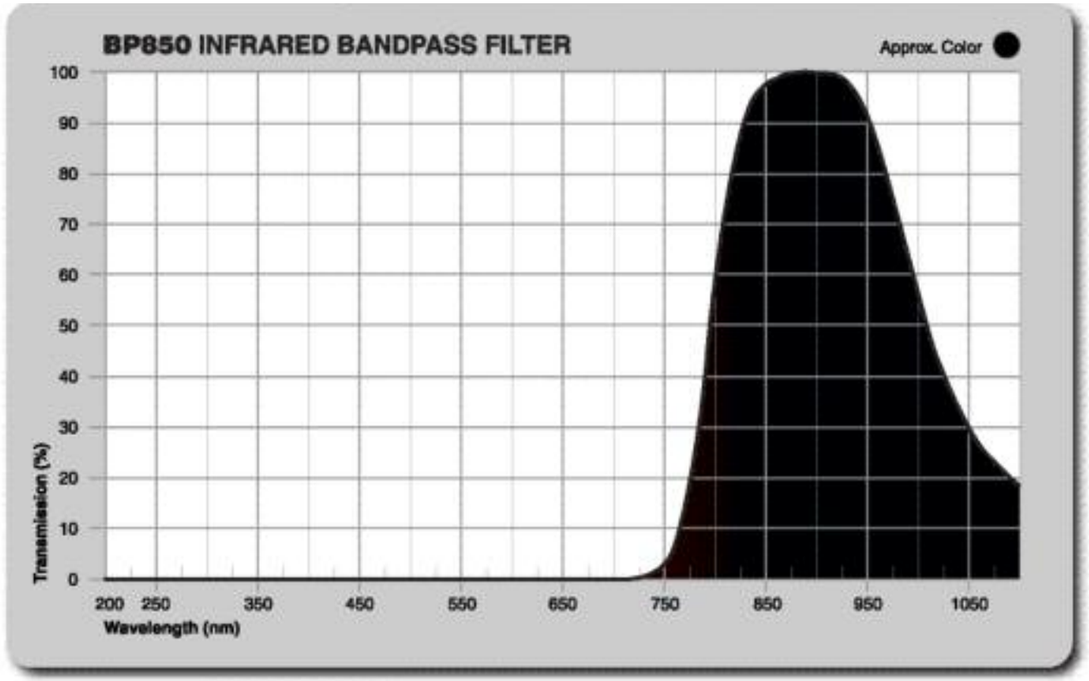
Unfiltered image of kale (spinach).



Photographic filter brings out a little tone.



Contrast is enhanced with our BP660 filter.



BP850 Data Points (typical)

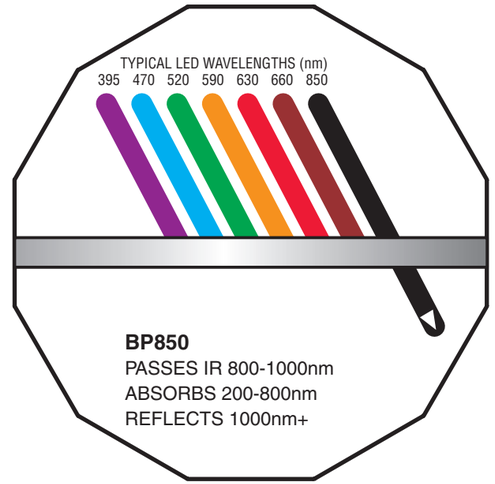
WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	18.52	800	57.66	500	0.00
1090	20.08	790	40.40	490	0.00
1080	21.89	780	24.82	480	0.00
1070	24.05	770	13.24	470	0.00
1060	26.69	760	6.43	460	0.00
1050	29.86	750	2.94	450	0.00
1040	33.67	740	1.36	440	0.00
1030	38.23	730	0.66	430	0.00
1020	43.57	720	0.35	420	0.00
1010	49.66	710	0.20	410	0.00
1000	56.47	700	0.12	400	0.00
990	63.93	690	0.08	390	0.00
980	71.76	680	0.05	380	0.00
970	79.39	670	0.03	370	0.00
960	86.16	660	0.00	360	0.00
950	91.73	650	0.00	350	0.00
940	95.60	640	0.00	340	0.00
930	98.09	630	0.00	330	0.00
920	99.39	620	0.00	320	0.00
910	99.55	610	0.00	310	0.00
900	99.76	600	0.00	300	0.00
890	99.95	590	0.00	290	0.00
880	99.76	580	0.00	280	0.00
870	99.51	570	0.00	270	0.00
860	98.49	560	0.00	260	0.00
850	97.71	550	0.00	250	0.00
840	95.47	540	0.00	240	0.00
830	91.21	530	0.00	230	0.00
820	83.94	520	0.00	220	0.00
810	72.74	510	0.00	210	0.00

BP850

The use of a filter is almost mandatory for IR applications in order to significantly improve and maximize contrast. MidOpt normally recommends the use of our BP850 filter in the majority of these situations. When LED lighting is chosen for illumination purposes – in well over 90% of all inspection applications this ends up being 850nm (or 880nm) LED lighting – we often suggest our BP850 filter as it offers very high peak transmission (typically >99%) and the coatings are very dense, hard and environmentally stable.

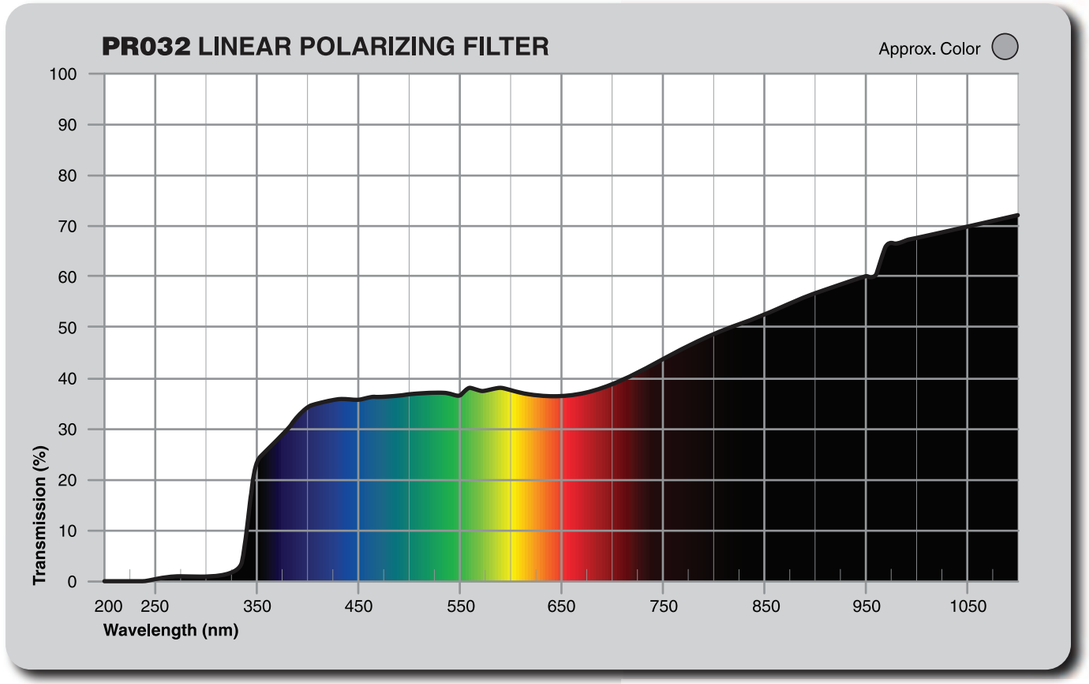
Since ANY camera's sensitivity drops quickly beyond 880nm, there is normally little necessity or appreciable benefit to block these longer wavelengths; essentially, the camera sensor is taking care of this all by itself. Infrared narrow bandpass filters that are offered by competitors will generally have lower peak transmission compared to the BP850 and, given the lower sensitivity of all cameras in the near-infrared, improved transmission is of far greater benefit than additional out-of-band blocking.

MidOpt filters are supplied with coated surfaces to improve transmission and inhibit staining, a problem common to most infrared filter glasses, particularly unprotected, polished surfaces. This problem manifests itself over time as a cloudy, white film that etches into the glass surface. Over time, staining can greatly reduce both transmission and resolution, and cannot simply be wiped away. Factors determining the time required and severity of staining include the year-round heat, humidity and air quality of the surrounding area. In most environments, these coatings are a necessity.



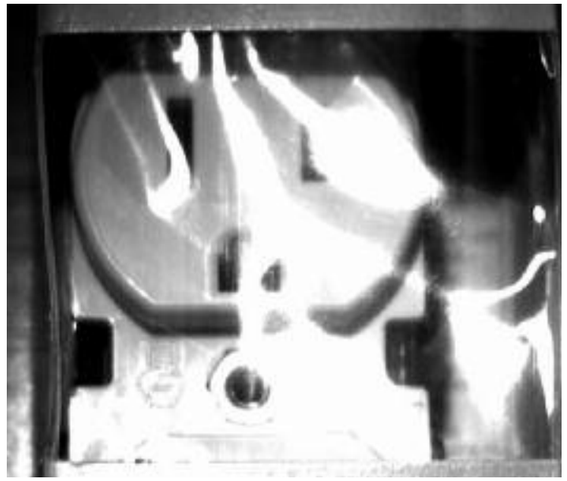
Camera, no filter, ambient light.

BP850 separates the outer shipping label from the product labels.

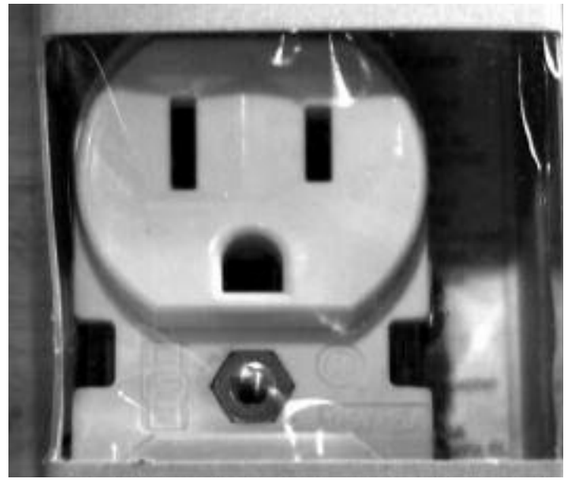


PR032 Data Points (typical)

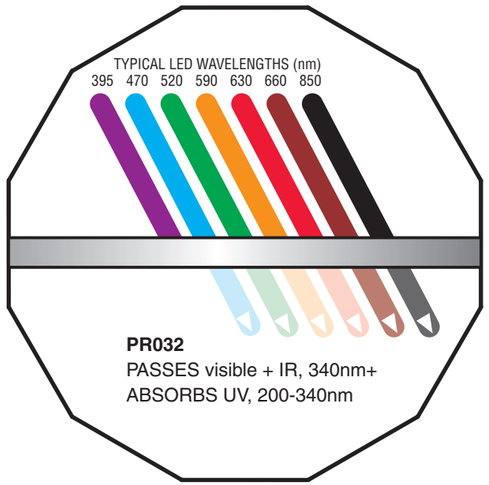
WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	72.05	800	48.80	500	36.92
1090	71.66	790	47.87	490	36.72
1080	71.19	780	46.91	480	36.53
1070	70.78	770	45.89	470	36.40
1060	70.24	760	44.83	460	36.29
1050	69.80	750	43.77	450	35.82
1040	69.33	740	42.68	440	35.80
1030	68.97	730	41.64	430	35.77
1020	68.51	720	40.60	420	35.53
1010	68.02	710	39.69	410	35.12
1000	67.55	700	38.82	400	34.27
990	67.09	690	38.08	390	32.46
980	66.68	680	37.48	380	29.79
970	66.12	670	36.99	370	27.70
960	60.54	660	36.65	360	25.73
950	60.03	650	36.48	350	23.98
940	59.46	640	36.52	340	18.32
930	58.81	630	36.69	330	11.05
920	58.09	620	36.83	320	3.17
910	57.37	610	37.14	310	0.99
900	56.75	600	37.69	300	0.04
890	56.02	590	38.12	290	0.00
880	55.20	580	37.90	280	0.00
870	54.34	570	37.55	270	0.00
860	53.51	560	38.16	260	0.00
850	52.63	550	36.83	250	0.00
840	51.78	540	36.95	240	0.00
830	51.05	530	37.17	230	0.00
820	50.32	520	37.19	220	0.00
810	49.66	510	37.08	210	0.00



Camera, no filter, ambient light.



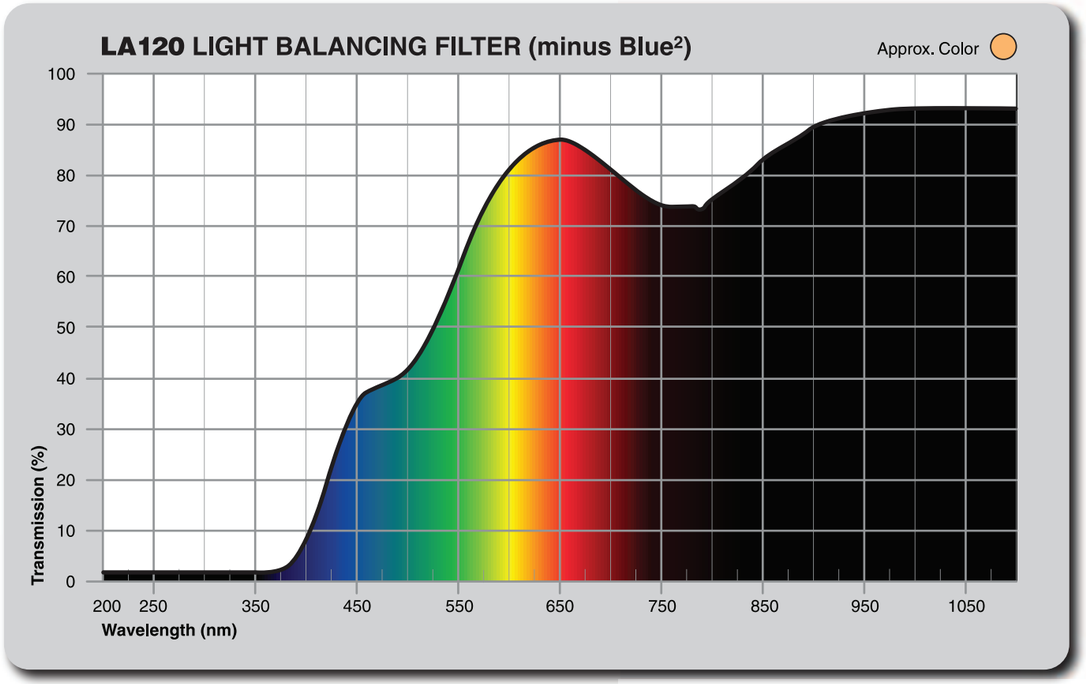
Correctly aligned polarizing filter eliminates the reflections.



PR032

A linear polarizer in a rotating mount offers maximum flexibility and ease of use. Once the filter is threaded onto the lens, the upper portion of the mount rotates freely. This facilitates determining the point where reduction of glare or the contrast in stress patterns in glass or plastic materials is maximized. However because the mount rotates freely, it is also possible for vibration or other inadvertent interference to cause the filter to move from this position and adversely effect the system's performance. For this reason, all mounted MidOpt polarizers come with a locking thumbscrew to insure that jarring or accidental movement during cleaning does not result in a change to the filter's position.

For lenses that do not have filter threads, MidOpt offers linear polarizers both in *Slip Mounts* (fits over the outside of the front end of a lens) and *Quick Mounts* (fits the inside of the front of a lens). In both cases, the mount and filter can easily be positioned on the lens so a rotating mount is not required.



LA120 Data Points (typical)

WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)	WAVELENGTH (nm)	TRANSMISSION (%)
1100	93.17	800	75.44	500	41.56
1090	93.16	790	73.42	490	39.97
1080	93.19	780	73.79	480	38.96
1070	93.10	770	73.69	470	38.25
1060	93.18	760	73.69	460	37.13
1050	93.19	750	74.23	450	34.99
1040	93.12	740	75.06	440	31.30
1030	93.14	730	76.15	430	25.86
1020	93.09	720	77.63	420	19.29
1010	93.02	710	79.29	410	12.78
1000	93.00	700	80.98	400	7.69
990	92.98	690	82.79	390	4.45
980	92.86	680	84.26	380	2.73
970	92.62	670	85.52	370	1.96
960	92.46	660	86.34	360	1.73
950	92.18	650	86.84	350	1.79
940	91.84	640	86.70	340	1.79
930	91.43	630	86.20	330	1.37
920	90.89	620	85.05	320	0.76
910	90.10	610	83.29	310	0.28
900	89.34	600	80.99	300	0.04
890	88.25	590	77.97	290	0.00
880	87.18	580	74.64	280	0.00
870	86.03	570	70.54	270	0.00
860	84.26	560	66.11	260	0.00
850	82.79	550	61.13	250	0.00
840	81.12	540	56.26	240	0.00
830	79.40	530	51.47	230	0.00
820	77.89	520	47.31	220	0.00
810	76.58	510	43.97	210	0.00

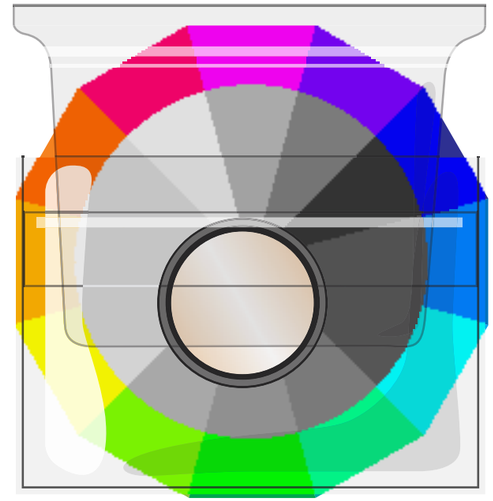
Midwest Optical Systems, Inc. 847-359-3550 www.midopt.com

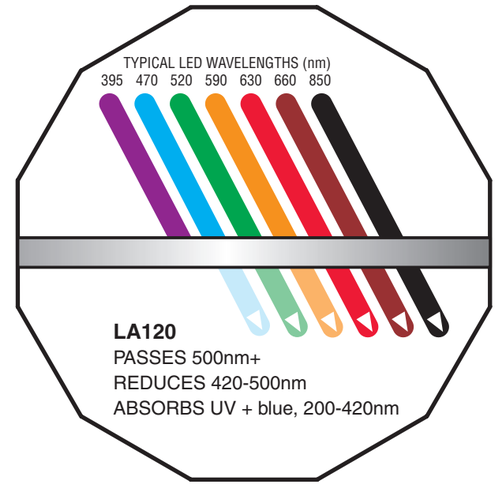
LA120

After considerable testing, we found these filters ideal for use with white LED lighting when accurate color rendering is desired. White LEDs typically have a strong *blue spike* that creates a strong overall bluish cast on the subject being illuminated. Not only can this be disconcerting, poor color rendition may result in difficulties in some color inspection applications.

While there currently are *warm white* LED options available, they are significantly more expensive as they have significantly lower output and a shorter lifetime, and often a slight bluish tint remains. Using only an LA120 filter over the camera lens with standard, less expensive white LEDs works just as well and is a far more cost effective alternative.

These benefits can also be seen when using an LA120 filter on subjects illuminated with metal halide and mercury lighting.





Camera, no filter, metal halide illumination.

LA120 warms the light for a more pleasing color.