New Filters for NDVI Applications

Vision Light Tech
creating optical solutions

- **Designed for plant health surveillance**
- **Bandpass, Dual Bandpass & Triple Bandpass options**
- **Variety of mounting solutions possible**

MidOpt single, dual and triple band NDVI filters make single camera NDVI imaging possible at an affordable price. Multi Bandpass Filters used in color cameras are becoming increasingly popular in agricultural and forestry applications for process control, mapping and vegetative health monitoring.

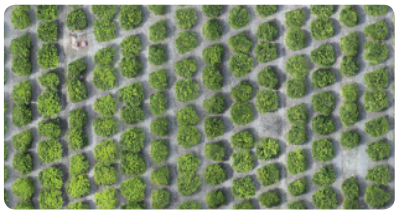
To analyze and differentiate healthy vegetation from stressed vegetation and background information, a widely used indicator known as the Normalized Difference Vegetation Index (NDVI) is applied to each image pixel. NDVI numbers are found by comparing reflectance differences in the near-infrared (NIR) and visible (VIS) spectrum using this equation:
NDVI = (NIR - VIS) / (NIR + VIS).

Traditionally, red light is used to represent activity in the visible spectrum. The logic behind this is that healthy, growing, green vegetation must produce needed energy through photosynthesis. When plants are actively photosynthesizing, they reflect or scatter near-IR light. Absorption of these wavelengths would result in overheating and tissue damage. The visible portion of the spectrum is absorbed; however, a little more green light is reflected relative to blue and particularly red light. This accounts for the greenish coloring we see in foliage.

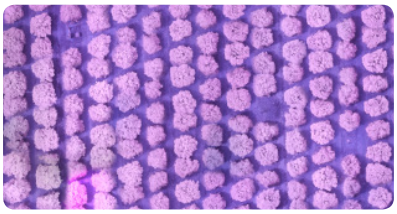
When plants are stressed or dying, photosynthesis slows down or stops. IR wavelengths are absorbed, while more visible light–particularly red light–is reflected. Also, in the case of high altitude imaging, atmospheric scattering of blue and green wavelengths has favored the use of red and near-IR light.

When using two cameras or sensors and appropriate optical filtering, getting accurate red and near-IR data is straightforward. However, to reduce the weight and cost of systems used to gather NDVI information, and with the recent proliferation of relatively inexpensive unmanned aerial vehicles (UAVs) and small, lightweight cameras (such as IR-converted digital consumer cameras), interest has grown in single camera designs using new algorithms. There has been a push to make this technology more accessible, but consumer cameras are mainly designed according to artistic tastes and typically have poor color band separation and limited dynamic range. Yet these cameras can be highly affordable, and with the help of inexpensive dual band filtering, low cost single camera NDVI (or similar) imaging is now available and the potential benefits for small-scale farmers, consumers and smaller organizations can be realized.

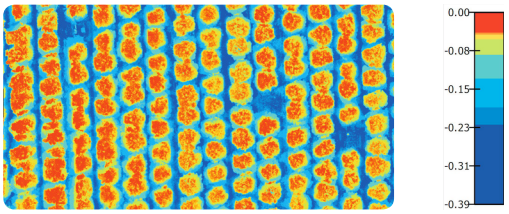
VEGETATIVE HEALTH MONITORING



Visible Light Image



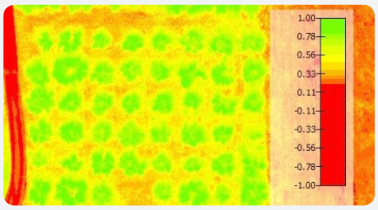
RAW NDVI Image (MidOpt DB475/850 Filter)



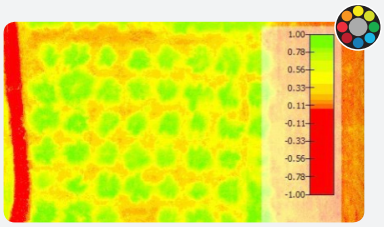
NDVI False Color Processed

COMPARISON OF CALIBRATED NDVI CAMERAS

Depending on the camera being used, in some cases performance of a single dual bandpass filter will approach that of a far more costly multi-spectral imager. In this example images are processed with Pix4DPro drone mapping software.



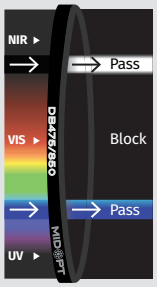
Multi Sensor Scientific-Grade Camera ($3000-$7000)



Single Sensor Consumer Camera & MidOpt DB660/850 ($200-$400)

WORKS TWICE AS HARD

MidOpt Dual Bandpass filters transmit two specific wavelength ranges while blocking unwanted light, eliminating the need for a second camera or costly filter switching mechanisms. Dual and single band filters for NDVI imaging have been created with specific vegetative reflection bands and camera spectral response in mind. Most popular plant health indices can be accommodated. Even lower cost consumer cameras can be easily converted or modified for monitoring vegetation. Dual Bandpass filters also allow use of color cameras for both day and night imaging, even in complete darkness. A broad visible passband is designed to mimic that of the camera's original IR blocking filter, while an infrared band is also provided to match popular infrared LED illuminator wavelengths. 735nm, 850nm and 940nm dual band filters are available from stock. After the color camera's internal IR blocking filter has been removed, dual or single band filters can be provided in threaded aluminum mounts, black Delrin slip-on filter mounts or in custom sizes and thicknesses for mounting between the lens and the sensor. Filters featuring anti-reflection coating for maximum transmission; hard-coated, single-substrate fabrication; and exceptional surface quality (40/20 scratch/dig or better).



New Filters for NDVI Applications

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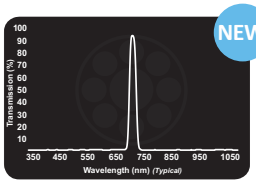
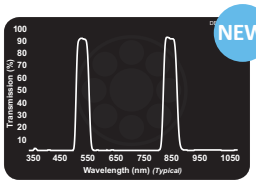
Bi725 Red Edge Bandpass Filter



Useful Range: 717-732nm
FWHM: 25nm
Peak Transmission: ≥90%
Surface Quality: 40/20

Bi725 is designed for use in certain aerial vegetative health monitoring applications. This so-called "Red Edge" filter isolates the wavelength region where the most rapid change in reflectance occurs in foliage. When plants are stressed or dying, photosynthesis slows down or stops. IR wavelengths are absorbed, while more visible light–particularly red light–is reflected. The transitional 725nm band is uniquely affected by vegetative health changes and provides information relating to chlorophyll and nitrogen status used to distinguish thriving from stressed vegetation.

DB550/850 Dual Bandpass Green + 850nm NIR



Useful Range: 535-565nm, 830-870nm
FWHM: 40nm, 50nm
Peak Transmission: ≥85%
Surface Quality: 40/20
Compatible LED: 548nm, 840nm, 850nm

The DB550/850 compliments the DB660/850 and DB475/850 filters. When modifying a single color camera by removing its IR blocking filter, incorporation of this filter in its place allows reflected near-infrared light (850nm) to be captured in the camera sensor's red channel and reflected green light (550nm) to be captured in the sensor's green channel (the blue channel is not used). Healthy vegetation will absorb (not reflect) green light and strongly reflect near-infrared light. This information can then be used to apply a false color gradient to images to better highlight the contrast between regions of healthy vegetation vs. areas with stressed, diseased or no vegetation.

There are a range of vegetation indices used by the remote sensing and precision agriculture community, and while NDVI is probably the most common, each have their advantages. Any of the indices listed below can be considered when employing a single color sensor camera that has been converted using a DB550/850 filter. Information gathered can be overlaid on vegetation maps to provide information used to make better crop management decisions.

Green Chlorophyll Index: CIg = (NIR / Green) – 1

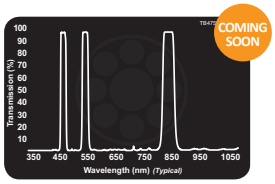
Green Difference Vegetation Index: GDVI = NIR – Green

Green Normalized Difference Vegetation Index: GNDVI = (NIR – Green) / (NIR + Green)

Green Ratio Vegetation Index: GRVI = NIR / Green

Green Soil Adjusted Vegetation Index: GSAVI = [(NIR – Green) / (NIR + Green + 0.5)] * (1 + 0.5)

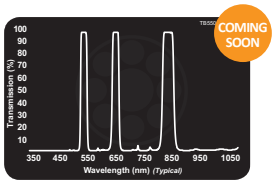
TB475/550/850 Triple Bandpass Blue+Green+850nm NIR



Useful Range: 468-483nm, 543-558nm, 835-865nm
FWHM: 20nm, 20nm, 40nm
Peak Transmission: ≥85%
Surface Quality: 40/20

The TB475/550/850 Filter, when mounted in converted consumer cameras used in aerial surveying applications, provides a more affordable, lightweight alternative vs. systems employing multiple sensors. Blue-Green-Near IR Extended Normalized Difference Vegetation Index (ENDVI) data gathered for vegetative health monitoring can be used to provide similar, but spectrally different information as compared to traditional NDVI data. Soil background, differing atmospheric conditions and various types of vegetation can all influence the reflection of visible light somewhat differently. ENDVI analysis may, at times, be able to impart more accurate or reliable information regarding plant or crop health by additional leveraging of information in the blue portion of the spectrum. The formula used is:
ENDVI = [(NIR + Green) – (2 * Blue)] / [(NIR + Green) + (2 * Blue)]

TB550/660/850 Triple Bandpass Green+Red+850nm NIR



Useful Range: 468-483nm, 543-558nm, 835-865nm
FWHM: 20nm, 20nm, 40nm
Peak Transmission: ≥85%
Surface Quality: 40/20

MidOpt tripleband filters are primarily designed for aerial agriculture mapping and surveying purposes. Green-Red-Near IR data is used for applications where Chlorophyll Vegetation Index (CVI) and other vegetative index monitoring is preferred. TB550/660/850 filters, when mounted in converted consumer cameras, can help in achieving a more affordable, lightweight alternative to systems using three or more cameras or sensors. Some of the formulas that are employed in these cases include:

Chlorophyll Vegetation Index: CVI = (NIR * Red) / (Green ^ 2)

Normalized Green: NG = Green / (NIR + Red + Green)

Normalized Near Infrared: NNIR = NIR / (NIR + Red + Green)

Normalized Red: NR = Red / (NIR + Red + Green)

Triangular Vegetation Index: TVI =0.5 * (120 * (NIR – Green) – 200 * (Red – Green))

OTHER FILTERS FOR NDVI APPLICATIONS

MOUNT & SIZE OPTIONS: In-stock, ready-to-ship Dual Bandpass Filters are available in Threaded Mounts, sizes M13.25 to M82; 25.4™ C-Mount; Slip Mounts; or Unmounted. Dual Bandpass Filters can be optically cemented behind a M12 lens if preferred, while custom shapes and sizes are also available.

APPLICATIONS: Dual Bandpass Filters are becoming increasingly popular in NDVI aerial drone inspection, allowing for single sensor imaging and reduced operation payload. Other applications include day/night surveillance, 3D point cloud imaging, and night vision.

Part #	Description	Useful Range	FWHM (nominal)	Peak Transmission
DB395/870	Dual Bandpass Absorptive VIS + NIR	VIS 375-425nm, NIR 745-970nm	110nm, 375nm	≥90%
DB475/850	Dual Bandpass Blue + 850 NIR	VIS 460-490nm, NIR 830-870nm	45nm, 55nm	≥90%
DB660/850	Dual Bandpass Red + 850 NIR	VIS 645-675nm, NIR 830-870nm	40nm, 50nm	≥90%
DB735	Dual Bandpass Visible + 735nm NIR	VIS 405-645nm, NIR 725-755nm	250nm, 50nm	≥90%
DB850	Dual Bandpass Visible + 850nm NIR	VIS 405-645nm, NIR 835-875nm	250nm, 50nm	≥90%
DB940	Dual Bandpass Visible + 940nm NIR	VIS 405-650nm, NIR 925-965nm	250nm, 60nm	≥90%

Due to continuous product improvement, specifications are subject to change without notice.