Biral
Visibly better

Technical Note
Forward Scatter Visibility Sensors
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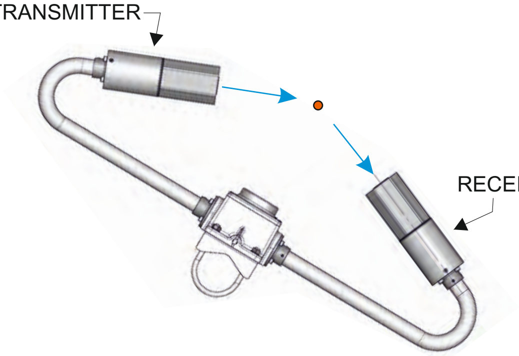
The effects of Surface Reflections and extraneous light on Forward Scatter Visibility Sensors

Forward scatter visibility sensors operate by detecting the light scattered from atmospheric particles which pass through the measurement sample volume. This volume is defined by the size, orientation and configuration of the transmitting and receiving head optics.

The transmitting and receiving heads are typically aligned such that light scattered at approximately 45º to the transmitting beam is detected and used to determine visibility. For a sensor to produce accurate results the light from the transmit optics must not reflect back into the sensor volume or receive signals due to reflections from nearby objects. If light does reflect back into the sensing volume, or directly into the receiver optics, the sensor will report a lower than expected visibility as this increased measurement signal signifies more reflective particles and therefore a lower visibility.



Most visibility sensor manufacturers angle the transmit and receive heads downwards to reduce the amount of ambient light entering the receiver and to also reduce the possibility of having blowing snow build up in the optical housings. However, by pointing the transmitter towards the ground there is a significantly increased chance of light reflecting from the ground surface back into the sensing volume. These reflections can be especially pronounced if the surface is wet, white, curved or when snow has accumulated beneath the sensor. The white, top surface of a wind turbine nacelle is an excellent example of where this issue can be seen.

Raising the sensor further above the ground can help reduce such errors but may not always be practical.

The Biral range of visibility sensors do not angle the transmit or receiver heads down as they follow the design described in the original HSS visibility sensor patents (which we now hold). In this way reflections from ground surfaces are eliminated and superior accuracy is achieved.

Ambient light levels do not affect VPF or SWS sensors due to the careful design of both the optical system and the signal processing and filtering electronics, removing the necessity to angle the heads down. The Biral sensors operate at a measurement rate of 2 KHz with proprietary signal encoding and filtering algorithms to ensure that ambient light from any local source is removed from the measurements.

The effects of Extraneous light on Biral Forward Scatter Visibility Sensors

The Biral visibility sensors have been designed to be inherently immune to light from external sources, either continuous or flashing. The immunity is derived from a number of separate, but complimentary mechanisms which are detailed in the following note.

At the optical level, a narrow bandwidth light source is projected in to the measurement volume to illuminate the fog and precipitation particles. Optics in the receiver head define a field of view to ensure that only light from the direction of the measurement volume reaches the detector. The wavelength of light used by the sensors is 850nm in the infrared region of the spectrum giving immunity from visible light. An optical band pass filter in the receiver further blocks all light outside of the source wavelength increasing the immunity.

The transmitted lighted is also modulated at a frequency of 2KHz. The receiver electronics incorporates a band pass filter such that only signals of 2KHz reach the next stage of signal processing. At this next stage, a synchronous rectifier ensures that only the 2 KHz signal in the received data derived from the transmitter is used for further processing.

When taken together these measures produce a sensor with a very high level of immunity to spurious external light sources.

Constant sources of light such as the sun, aircraft obstruction lights and general area lighting are severely attenuated by the optical narrow band pass filter and the residual constant signal cannot pass through the electrical filters or synchronous rectifier. Constant light sources therefore have no impact on the sensor performance.

Modulated or flashing light sources such as aviation warning lights or reflections from moving objects are again severely attenuated by the optical narrow band pass filter and the resultant signal will not progress through the electrical filters and synchronous rectifier unless modulated at 2KHz. As light sources are generally modulated at much lower frequencies so as to be visible to people the level of immunity to flashing lights is essentially the same as that for constant light sources.

Wind Turbine Applications – a Special Case

The Biral VPF and SWS visibility and present sensors are used on wind turbines to control both the aviation obstacle lights and for marine applications, the fog obstacle systems. For aviation obstacle light control the sensor are mounted in close proximity to the obstacle light on the nacelle and may therefore receive light reflected back from the obstacle light. Further, due to the rotation of the nacelle it can be expected that the sensors will occasionally align directly with obstacle lights on adjacent turbines.

For this special and important application Biral has undertaken a series of real-world tests to understand any effects this unique situation may have on its visibility sensors.

Reflected Illumination Tests

The reflected illumination tests were designed to determine if the operation of the Biral sensors would be influenced by reflected light emitted directly by the obstacle light. The reflected light could potentially cause changes in the atmospheric extinction coefficient (EXCO) as measured by the sensor or it might cause reports of false particles and hence false precipitation. These controlled tests were undertaken in a small enclosed space such that the amount of light reflected into the sensor optics would be much greater than will be seen in a typical, (or even a poor) installation. These tests were designed to represent a worst case scenario.

Neither the SWS nor VPF sensors showed any significant change in Total EXCO during these tests. It can be concluded that the in-built optical and electronic filtering (as described in this Note) of these sensors results in their visibility measuring capabilities being unaffected by high levels of reflected light from the obstacle light.

Neither the SWS nor VPF sensors reported any false particles during these tests. It can be concluded that the present weather identification and measurement capabilities are equally unaffected by high levels of reflected light from the obstacle light. These tests have shown the SWS and VPF sensors to be immune to white, red and infrared light reflections.

Direct Illumination Testing

The direct illumination tests were designed to determine if the SWS or VPF sensors' operation would be influenced by light shining directly into the receiver optics. These tests are intended to simulate the condition where a sensor mounted on a nacelle rotates such that it points directly at the obstacle light on an adjacent wind turbine or other structure. Tests were carried out to a minimum separation distance of 47m which is designed to be less than would be encountered in any wind turbine installation.

Neither the SWS nor VPF sensors showed any significant change in Total EXCO during these tests. It can be concluded that the in-built optical and electronic filtering of these sensors results in their visibility measuring capabilities being unaffected by direct illumination from the obstacle light at distances greater than 50m.

Neither the SWS nor VPF sensors reported any false particles during the tests. It can be concluded that the present weather identification and measurement capabilities are equally unaffected by direct illumination from obstacle lights at distances greater than 50m. These tests have shown the SWS and VPF sensors to be immune to white, red and infrared light from direct illumination from obstacle lights at distances greater than 50m.

It should be noted that the atmospheric extinction coefficient measured by the sensors at the time of the test was very low. Therefore there was very little reduction in the intensity of the light reaching the sensors due to scattering losses. This low atmospheric extinction coefficient represents a worst case condition for causing interference and hence the most appropriate condition for carrying out these tests.