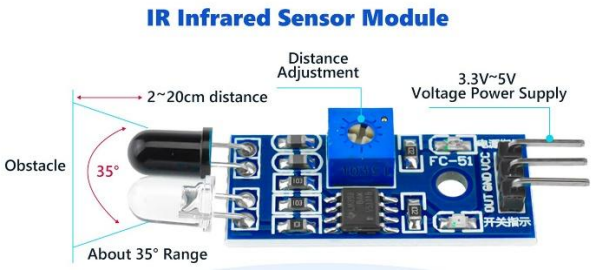
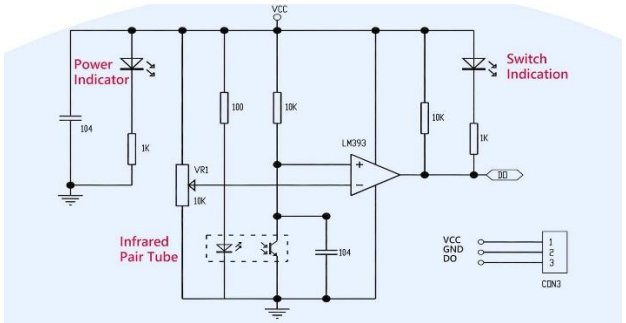
FC-51 infrared binary reflection sensor and ranges

Jørgen Bo Madsen / 24-12-2024 / MTD2A@jorgen-madsen.dk / Danish G model association

Background

The FC-51 is a simple, good and cheap binary infrared sensor that can detect objects up to 30 cm measured on bright reflective surfaces (in the case that the sensors is of good quality). In the following, a number of tests and analyses have been carried out on black semi-glossy surfaces, which is what the sensor has the most difficulty detecting. These are typically the type of surfaces found under model trains, locomotives and train carriages.





In order to use the FC-51 sensor optimally, there are three factors that must be taken into account:

1. The surface of the object that the sensor must detect (the ability to reflect infrared light).
2. Shielding the infrared receiver from disturbing ambient light.
3. The beam angle between the infrared transmitter and receiver (the mutual angle).

The above conditions have a major impact on the sensor's range. As a general rule, the sensor is most stable and least sensitive to ambient light when the sensor has a long range, but is used to detect objects at shorter distances. See the in-depth article here: Light Reflectance

Surface reflection

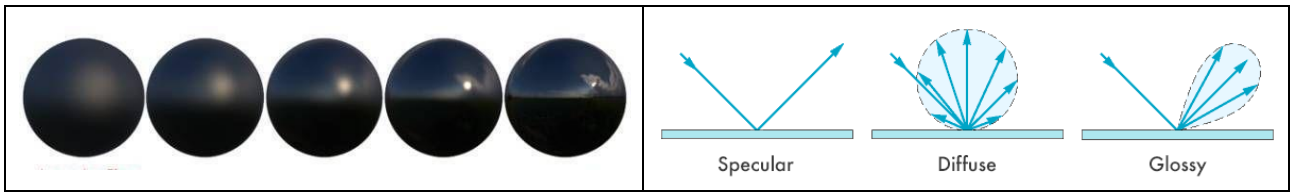
There are two conditions that affect the detector object's ability to reflect infrared light:

1. The color of the object's surface.
2. The gloss of the object's surface.

The ability of the surface to reflect Infrared light is measured in **LRV**: Light Reflectance Definition
Light surfaces have a high reflectivity and dark surfaces have a low reflectivity.

COLOR	LRV
White	70 - 90%
Ivory and Cream	55 - 71%
Light Yellow	65 - 70%
Light Buff	40 - 56%
Light Green	40 - 50%
Medium Green	15 - 30%
Orange	15 - 30%
Medium Blue	15 - 20%
Dark Blue	5 - 10%
Medium gray	15 - 30%
Red and Maroon	5 - 18%
Medium and Dark Brown	3 - 18%
Black	1 - 4%

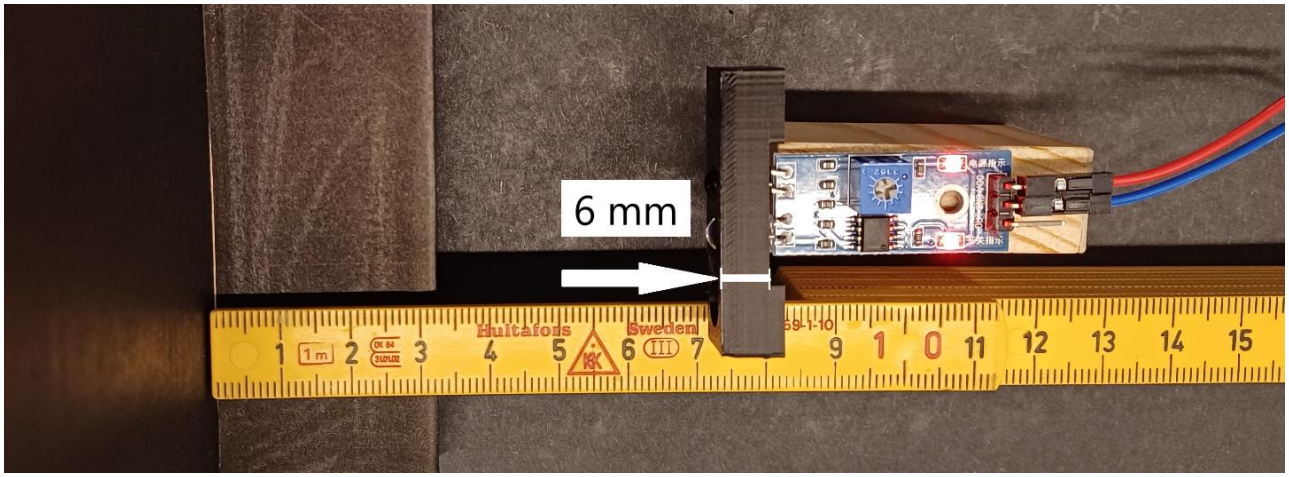
The gloss of the object also affects the ability to reflect infrared light: Specular reflection
High gloss and light surfaces reflect best, while matte black diffused surfaces are hardly reflective.



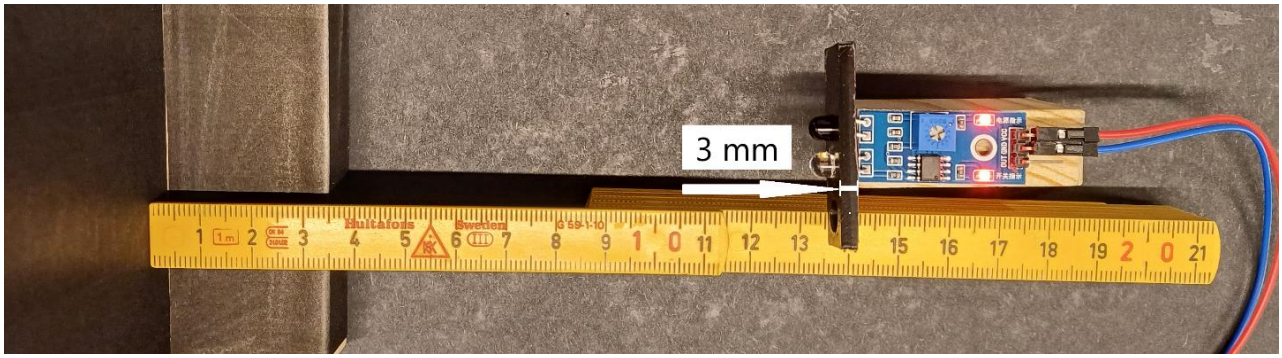
Finally, the range is affected by the size of the object. Large objects can be detected at a long distance, and small objects only at a short distance. The same applies to curved surfaces. For example, the range is reduced when using spheres and cylindrical objects.

Sensor housing

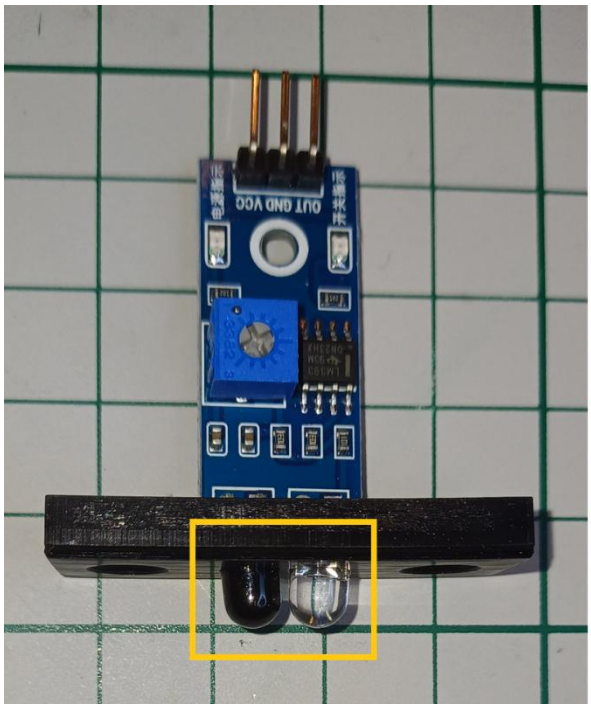
To minimize disturbing light from the surroundings, and infrared light for transmitter LEDs, it is obvious to shield the infrared receiver. But it reduces the range significantly. It is illogical. Transmitter and receiver must be able to "see each other" for optimal range.

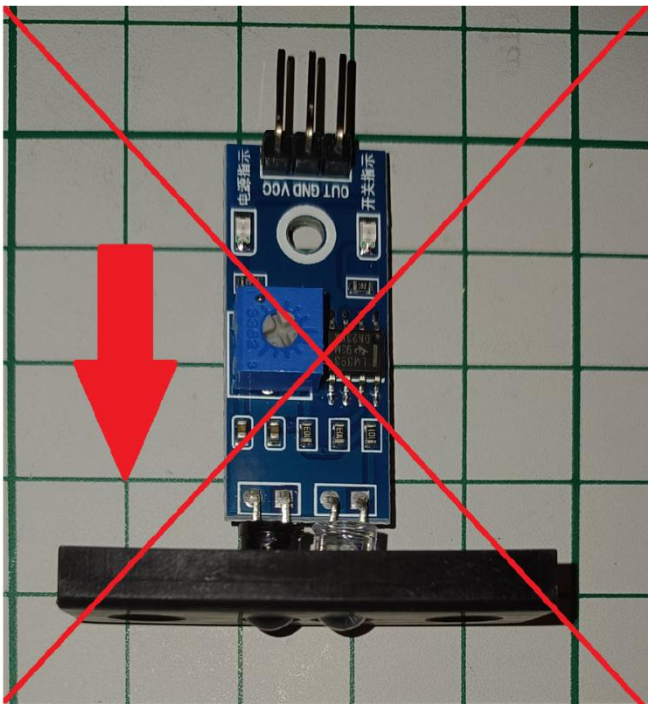


By reducing the thickness of the sensor holder from 6 to 3 mm, the range is doubled.



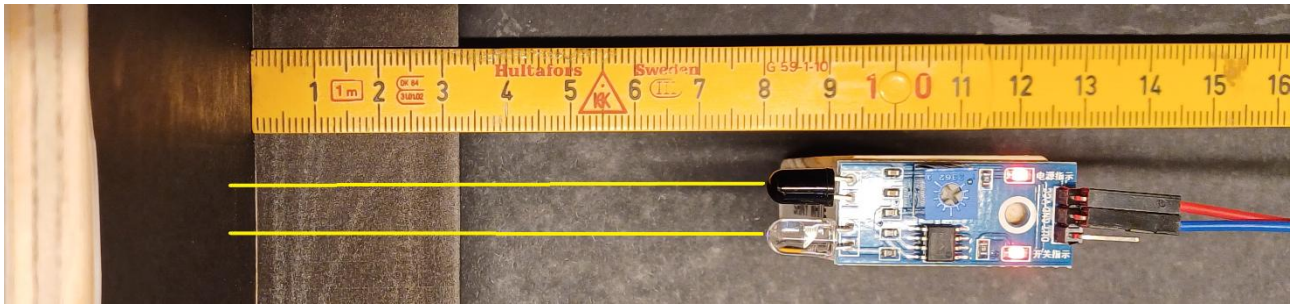
The location of the sensor holder on the infrared transmitter and receiver is also of great importance. The optimal placement of the sensor holder is by soldering the terminals to the infrared transmitter and receiver, as shown in the picture below. If the sensor holder is placed opposite direction the solder terminals, the range is reduced to about half!



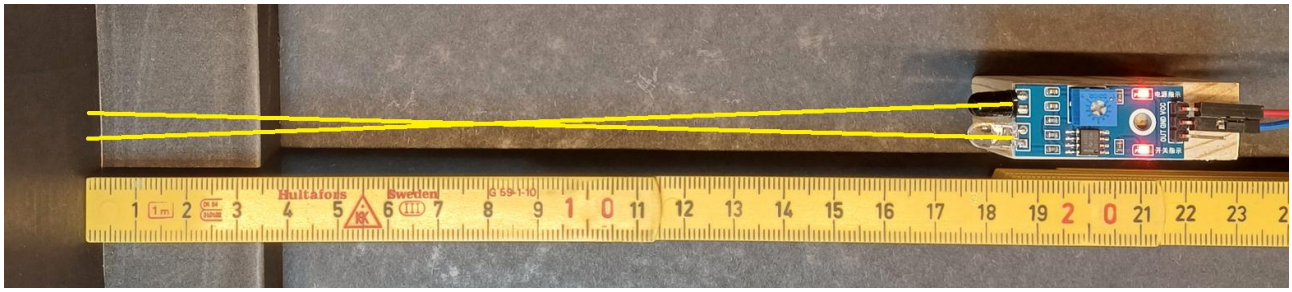


Mutual beam angle

The angle between transmitter and receiver is crucial. The longer the reflection distance, the greater the importance of the angle.



The optimal angle is 6° at 14 cm reach.



Disturbing ambient light

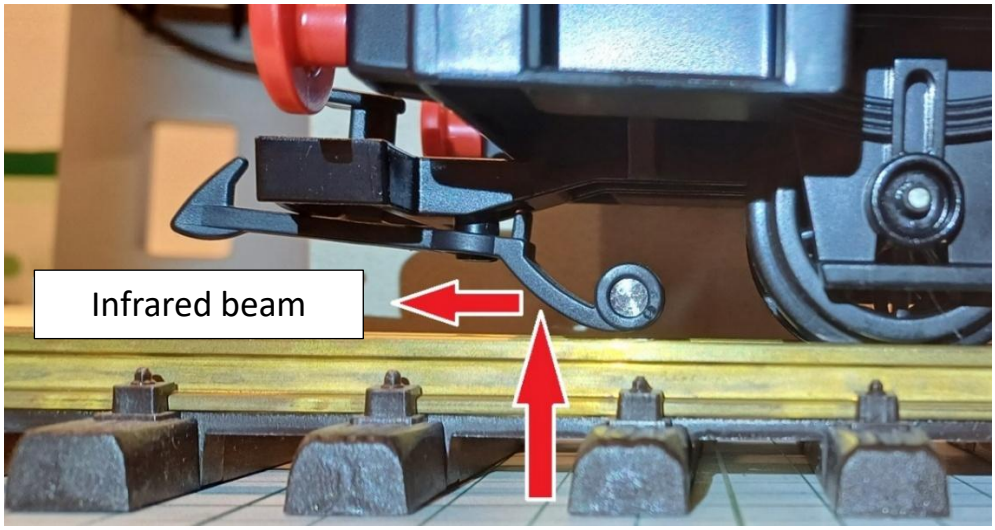
If bright environments interfere with the sensor, it is advantageous to mount aluminum tape on the infrared transmitter and receiver. Note that the range is reduced a few centimeters. Experimentation is recommended.

Mounting 9 mm Ø5 mm aluminium tubes is a good protection against ambient light disturbance, but the range is reduced to less than half! It's contra intuitive!

Angle of the object

The optimal range is achieved when the sensor's transmitter and receiver are 90 degrees perpendicular to the object to be detected. The range is reduced at oblique angles and further at small objects.

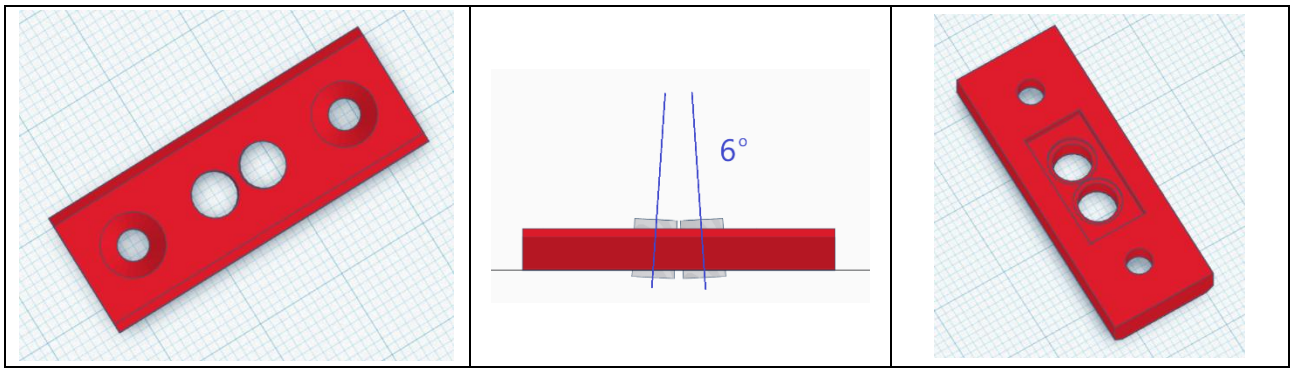
When detecting vertically under **stopped** model locomotives and train cars, a fault situation can occur where the infrared beam is not reflected sufficiently. Typically with smaller objects. This error situation can be minimized by mounting two FC-51 sensors next to each other and connecting them in parallel.



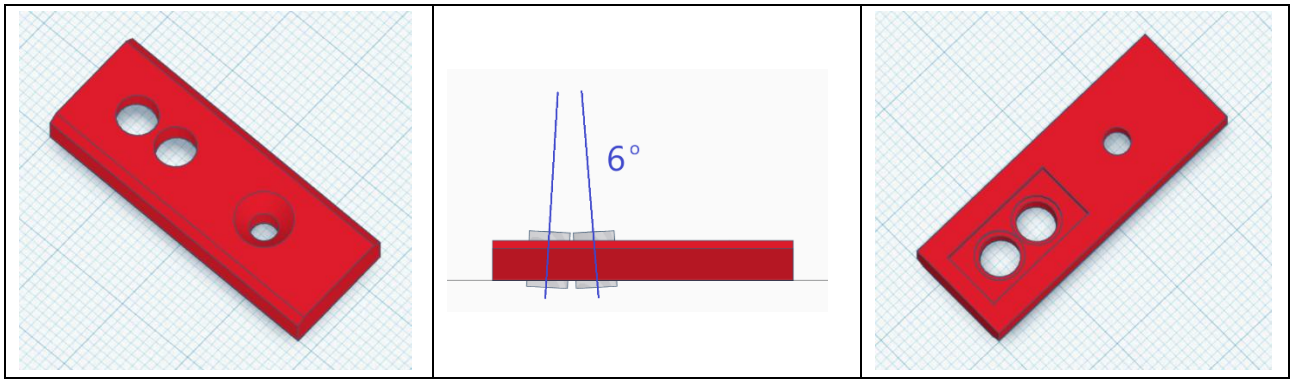
3D print holder

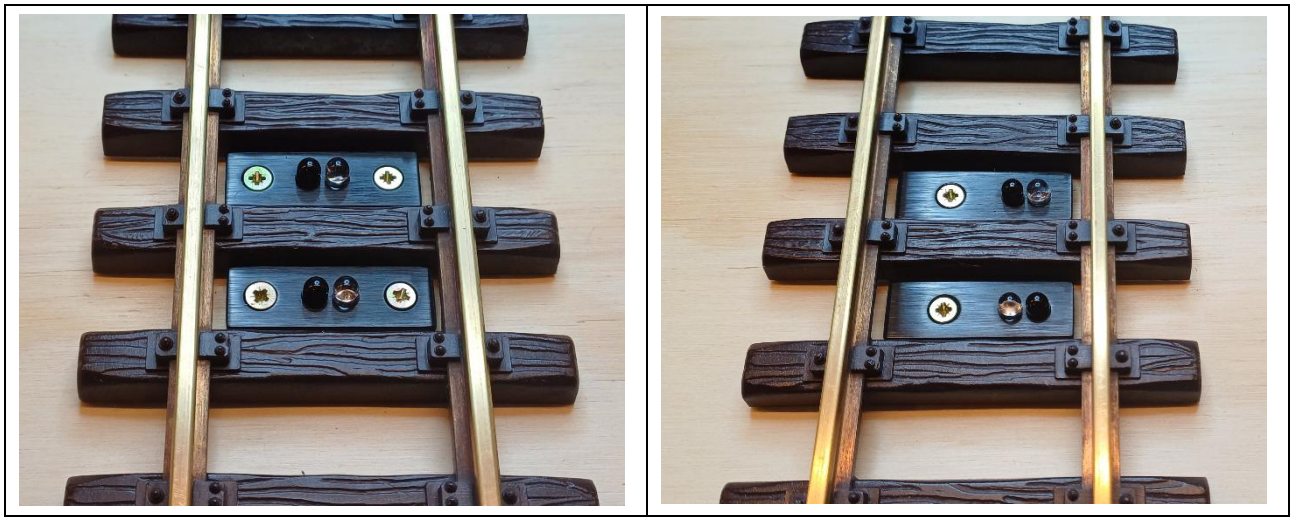
Two holders have been designed to fit between the sleepers for model train track G.
The thickness is 3 mm at the transmitter and receiver and for optimal strength, 5 mm in its entirety,

holder for FC-51 Infrared sensor for vertical mounting by JEBM-DK - Thingiverse



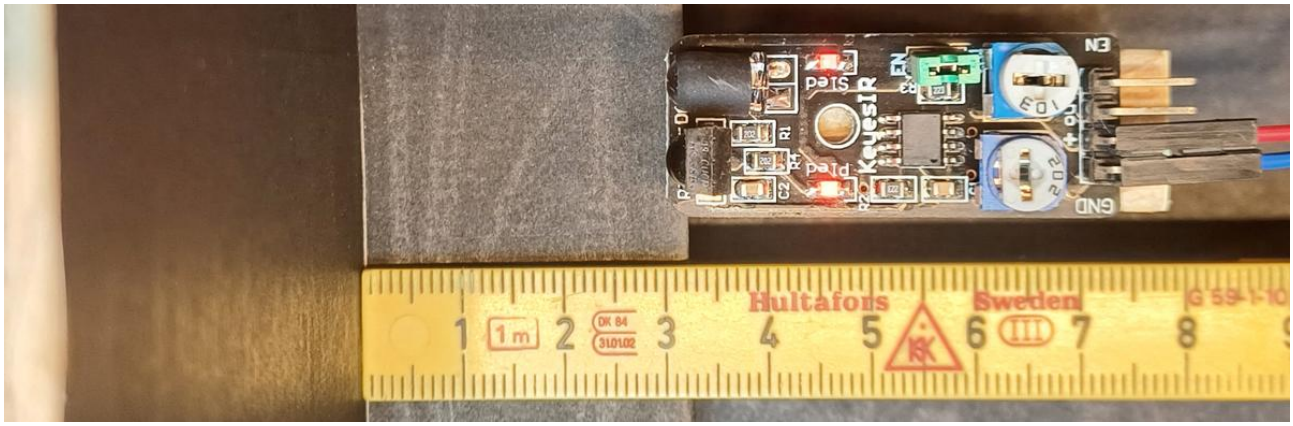
Decentered holder for FC-51 Infrared sensor for vertical mounting by JEBM-DK - Thingiverse





IR sensor KY-032IR

This infrared sensor is technically more complicated, and has a very short range for dark objects. Changing the angle between transmitter and receiver does not have a significant effect. The KY-032IR is directly compatible with the FC-51 and can therefore be easily replaced with the FC-51 IR sensor (recommended).



FC-51 IR sensor in poor quality

If the purchased FC-51 is of poor quality (short range), it is recommended to replace the transmitter LED and receiver phototransistor, with cheap quality components from the Taiwanese manufacturer Everligth

1. IR transmitter 940 nm Ø5 mm, 200 link: IR333C-A
2. IR Receiver 940nm Ø5 mm: PT334-6B