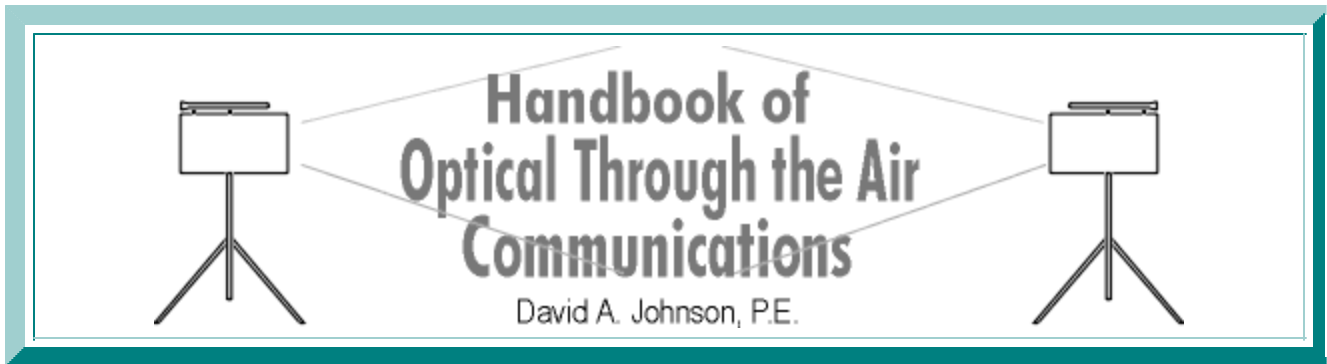




Chapter Four LIGHT SYSTEM CONFIGURATIONS

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- [Diffuse Reflective Configuration](#)
- [Retro Reflective Configuration](#)

Whether you are sending a simple on and off signal or high speed computer data, some kind of light path must be established between the light transmitter and the distant receiver. The three basic ways the information can be transferred are: "Opposed", "diffused reflective" and "retro reflective". Every communications system will use one or more of these methods.

Opposed Configuration

As illustrated in **Figure 4a** an "opposed" or "through beam" configuration points the light transmitter and the receiver directly at each other. Although much of the light launched by the transmitter may never reach the distant receiver assembly, sufficient light is detected to pass information. Since there is only air between the transmitter and receiver, it is the most commonly used configuration to transmit information over long distances. Most optical communications systems rely on this configuration. Remote controllers for televisions, VCRs, audio systems and computers all rely on this direct light link method, since it makes the

most efficient use of the transmitted light.

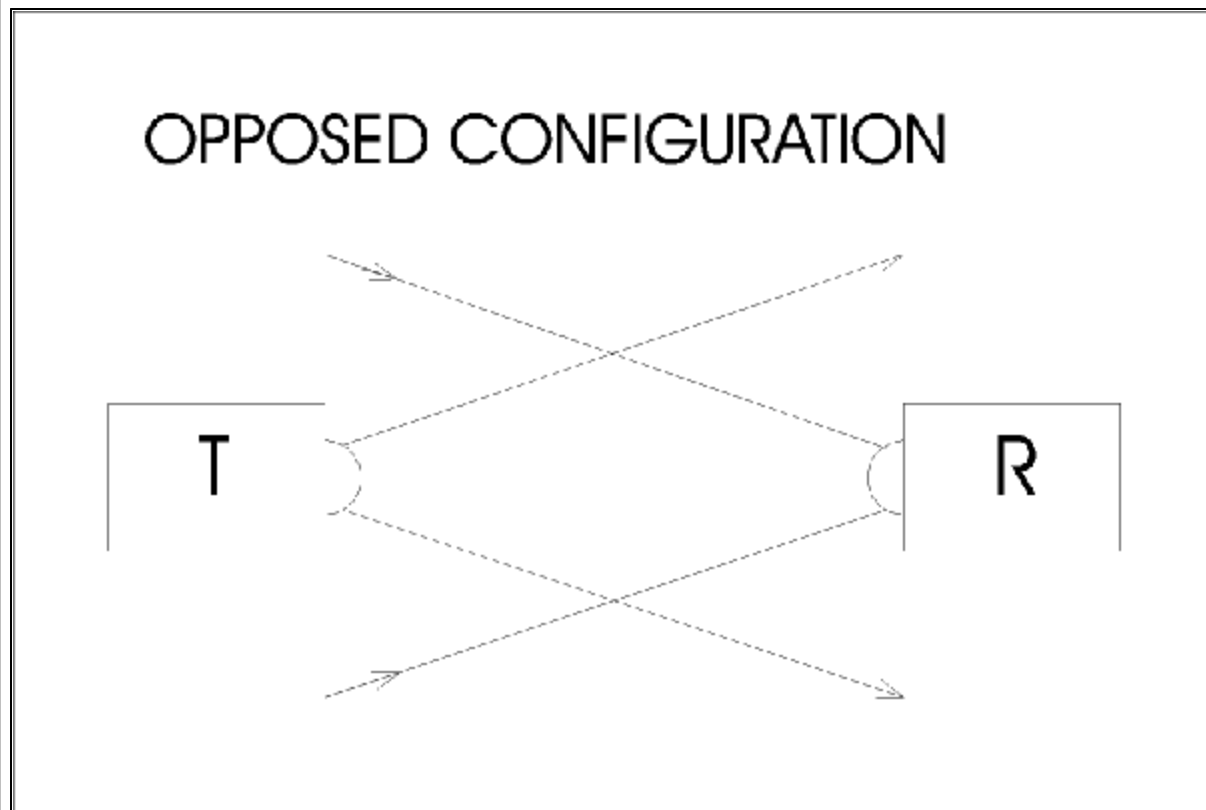


Figure 4a

As the light emerges from the end of the transmitter it immediately begins spreading out. The light forms a cone shaped pattern of illumination. The spreading out of the light beam means the area being illuminated at the distant receiver will always exceed the receiver's light collecting area. The light that does not actually strike the receiver assembly is therefore lost. If you tried to design a system so all the launched light hit the receiver you would soon discover that it would be impossible to maintain proper alignment. Small vibrations, building sway and even air disturbances could bend the light beam enough to miss the receiver assembly altogether. An intentional over-illumination scheme works the best, since it allows for some misalignment without the complete loss of the light signal. When designing a system using an opposed configuration you can use the range equation discussed in the last section as a way of predicting how much light will strike the receiver, how much light power needs to be launched and what kind of divergence angle is needed to establish a communications link over a specified distance.

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Diffuse Reflective Configuration

When you look at the stars at night, car headlights or at the sun, your eyes collect the light that is coming

directly from the light source. When you look at the moon, a movie screen or when you look at the light reflected off walls from a table lamp, you don't see the source of the light, but the light that happens to reflect off the object being illuminated by the source. Unless the object has a mirrored surface, the light that strikes the object spreads out in all directions. The light that you see is only a very small portion of the total light that actually illuminates the object. This "diffuse reflective" configuration, as shown in **Figure 4b** is a technique that is very useful in some communications systems. It is especially good for short distances when multiple reflections allow the light receiver to be aimed, not at the light source directly, but at objects being illuminated by the source. Some cordless stereo headsets use such a method to give a person some freedom of movement as he listens to music. These systems bounce the light off the walls, ceilings and floors with sufficient power that enough light finds its way to a light detector attached to the headset, no matter how the headset detector is oriented.

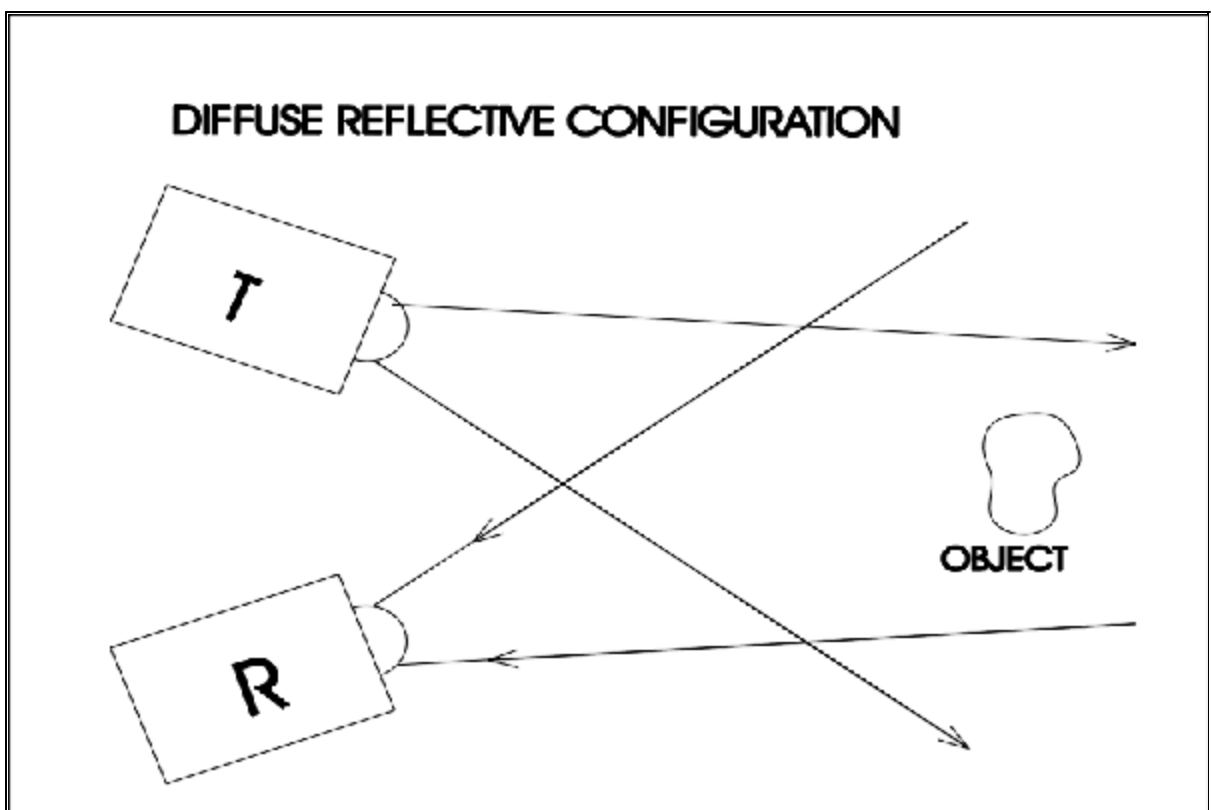


Figure 4b

The amount of light detected by the receiver is very dependent on the nature of object's surface that reflects the light. As an example, walls painted with white paint will reflect more light than those painted with dark paint. Also, rough surfaces will tend to reflect less light than smooth surfaces. Most surfaces reflect the light in a hemispherical pattern with more light being bounced straight back toward the light source then off to the sides. When you are trying to predict the behavior of such reflections it is best to think of the area of illumination as an independent light source, which has a 90 degree half-angle divergence pattern. Then, if you know the acceptance angle of the light receiver and its collection area,

you can use the range equation to calculate how much of the total light reflected will be collected by the light receiver.

If a single surface reflection is to be used, it is best to try to illuminate the smallest area possible. This concept can be illustrated by imagining how your eyes respond better to a brightly lit spot reflected off a wall than to a broad flood light. By concentrating most of the light onto a small area more light will be reflected back to a nearby receiver that is aimed at the illuminated area. However, when multiple reflections are desired, such as done with the stereo headsets, a small or large illuminated area will work just about the same. In detecting light from single reflections you should plan to use a large collection area, with a small acceptance angle. The receiver would be aimed directly at the illuminated spot. However, for multiple reflection applications it is best to use a detector with a very wide acceptance angle. Detectors using large lens collectors will have little effect in multiple reflection cases, since they would have narrow acceptance angles.

As food for thought, it may be possible to use fluffy white clouds as diffuse reflectors to link two distant light transceivers. Some preliminary test results indicate that such a scheme may be possible if sufficient light power is launched by a transmitter, using a narrow light beam and an equally efficient light receiver with a large light collector is used. Such a method may be very useful in allowing one powerful transmitter to be received by multiple light receivers that do not have a direct line-of-sight path to the transmitter. The imagined scheme might resemble the bright search lights often used to attract people to some gala event. Even the tiny amount of light reflected off dust particles in the air allow you to see the search light beam moving up toward the clouds many miles away. This concept would be a great area for an experimenter to try to see if such a system could actually be made to work.

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Retro Reflective Configuration

As illustrated in **Figure 4c** if a special mirror reflector, called a "corner cube" reflector, is used to bounce light from a transmitter to a nearby light receiver, the light transmitter and receiver are said to be linked using a "retro reflective" configuration. A corner cube reflector can be made from a specially ground piece of glass or from positioning three mirrors at right angles to each other as shown in figure 4d. Some plastic reflectors often used on bicycles and roadside indicators are actually large arrays of miniature molded corner cube reflectors. A corner cube has the unique characteristic that will return much of the light striking the assembly directly back to the light source in a parallel path, independent of the position of the emitter. However, because of the parallel path, the light transmitter and receiver must be positioned very close to each other. Some very accurately made corner cube reflectors send the light back in a path that is so parallel that the light receiver must actually be placed inside the light transmitter to properly detect the light being returned.

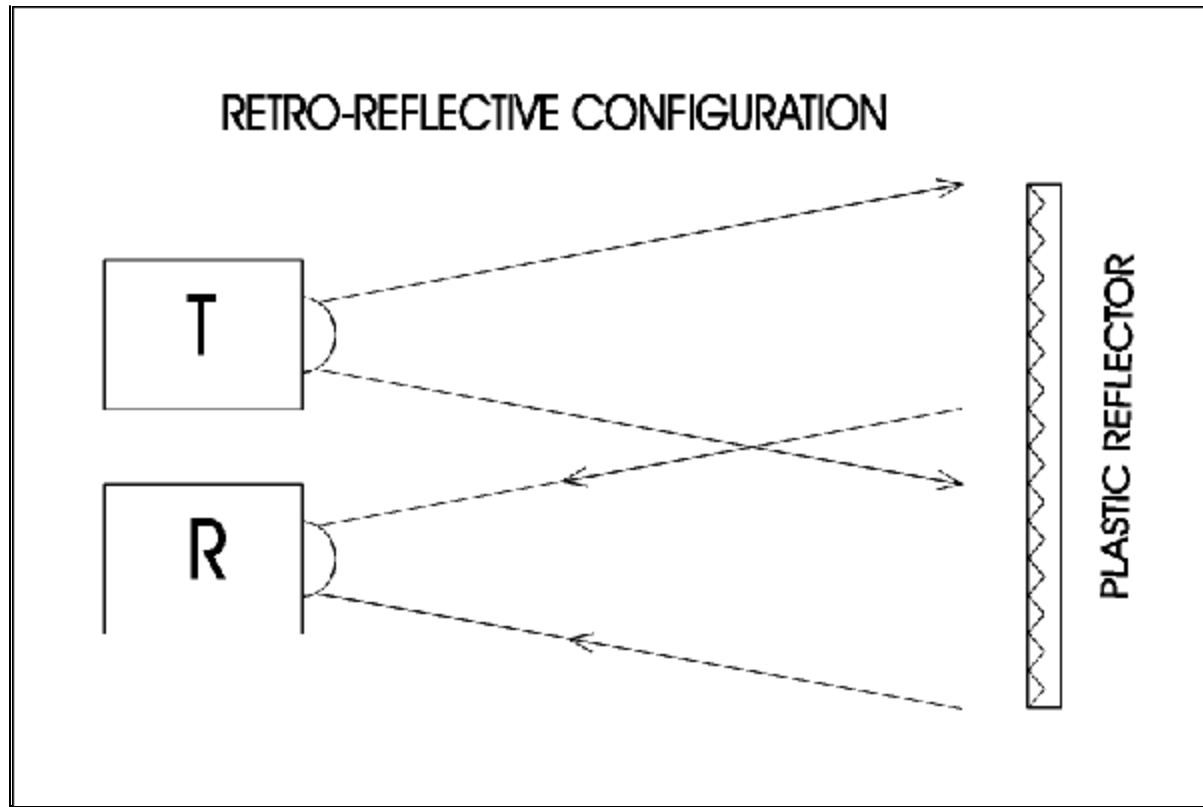


Figure 4c

corner cube reflectors have a wide variety of applications. Several highly accurate corner cube arrays were left on the moon during some of the Apollo moon missions in the early 1970s. Scientists have been using powerful lasers and specially modified telescopes to bounce light off of the reflectors. By measuring the time the light pulses take to make the round trip from the earth, to the moon and back, the distance can be measured down to inches. Electronic distance measurement devices (EDMs), used by survey crews, also use corner cubes and "time of flight" techniques to measure distances accurate to inches. Some systems have effective ranges of several miles. Remember, light travels about one foot in one nanosecond, so for a round trip of 10,000 feet would cause a pulse delay of 10,000 nanoseconds or 10 microseconds.

Some alarm systems also use the retro-reflective technique. Pulsed light is bounced off a distant plastic reflector and is collected by a nearby light receiver. Objects moving between the light transmitter and the reflector break the established light path, setting off the alarm. Some industrial systems also use the technique to monitor products moving down a production line.

When using the retro reflective technique you have to treat the reflector as a distant light source with its own emitting area and divergence angle. The amount of light sent back by the reflector will depend on the ratio of the illuminated area and the reflector's area. A typical plastic reflector has an equivalent divergence angle of about 0.5 degrees. For long range applications a large reflector will be needed.

Figure 4d shows a large corner cube reflector you can make yourself. It is made by gluing three glass tile mirrors together. A sturdy cardboard box will help position the mirrors. One mirror is positioned at the bottom of the box and the other two converge at the box sides. You would align such an assembly so the light would enter at a 30 degree angle relative to the bottom. The target for such an assembly would be the point where the three mirrors converge. I have used such a simple mirror for some experiments and was able to detect reflections over a distance of 10 miles. Larger mirror assemblies or even multi-reflector arrays are also possible to increase the effective range. Perhaps you might experiment with your own large reflector to see if a long range distant measuring systems could be devised. Using two such reflectors it might be possible to pinpoint your location using triangulation techniques.

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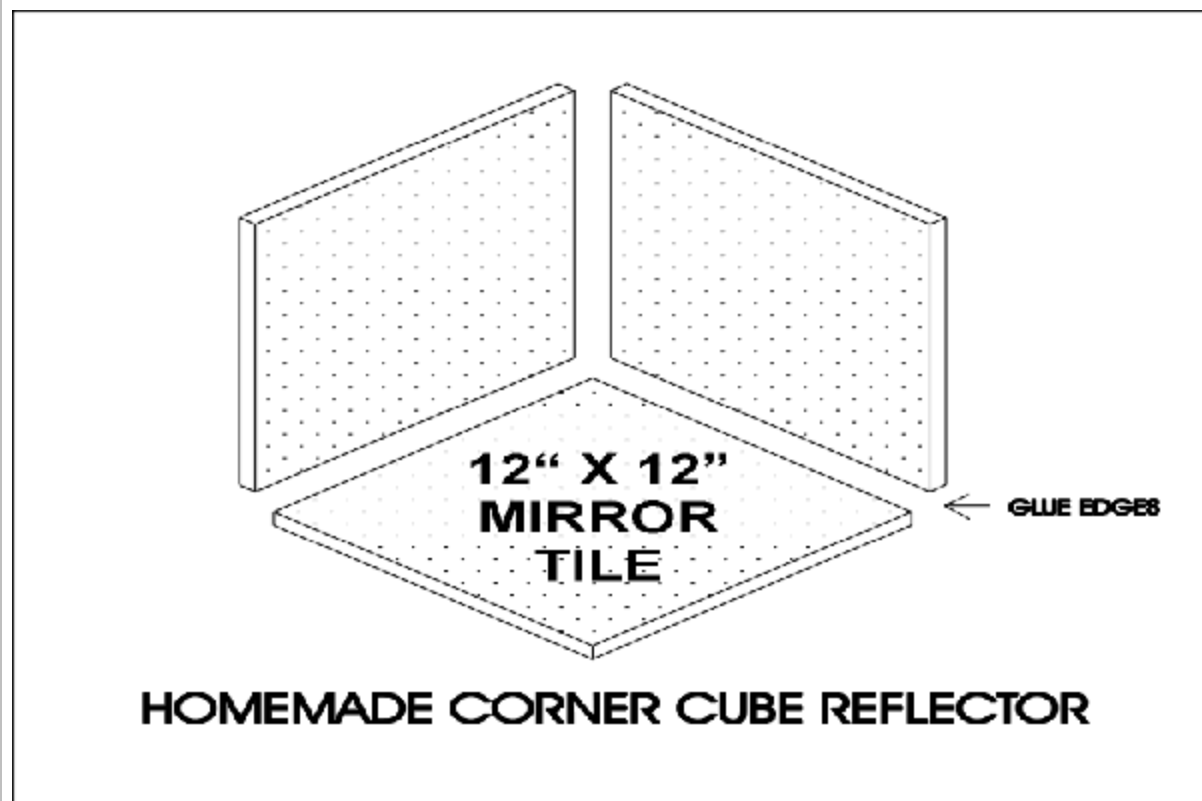


Figure 4d

David A. Johnson, P.E.

E-mail: DAJPE@imagineeringezine.com

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