

The IR FOCUS technology

The IR LED heating technology is a new method of comfort heating developed by IR FOCUS.

- It is based on the idea of heating people instead of heating spaces and thereby saving a lot of energy.
- It is created from the conviction that comfort is a private feeling and that we as humans are, more than any other living being, capable of mastering our own comfort.



Figur 1 Comfort and well-being is a lot more than a static indoor climate - as illustrated with this Japanese spa

We would be much better served with individually controlled comfort systems than with the existing HVAC driven buildings with its static and inaccessible climate control.

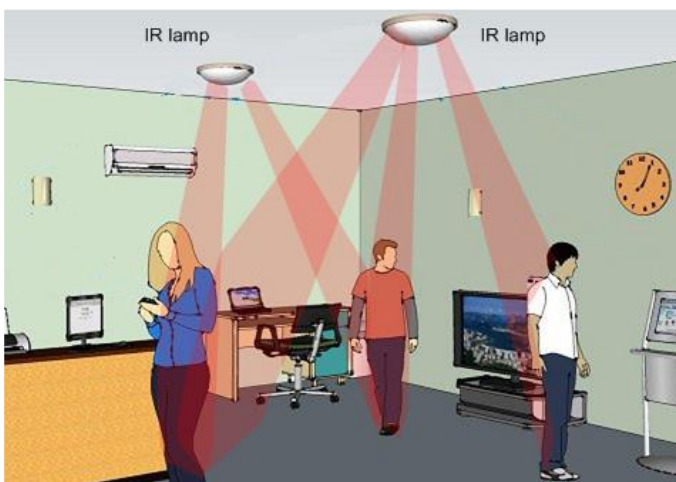
"The building industry needs a fundamental paradigm shift in its notion of comfort, to find low-energy ways of creating more thermally dynamic and non-uniform environments that bring inhabitants pleasure. Strategies for providing enriched thermal environments must be conjoined with reducing energy; these are inseparable for any building striving for high performance. The objective of current comfort standards is to have no more than 20% of occupants dissatisfied, yet buildings are not reaching even that scant goal. A significant energy cost is incurred by the current practice of controlling buildings within a narrow range of temperatures (often over-cooling in the summer). If building designers and operators can find efficient ways to allow building temperatures to float over a wider range, while affording occupants individual control of comfort, the potential for energy savings is enormous." Gail Brager, Hui Zhang and Edward Arens

The IR FOCUS technology approach to personal heating stands on three equally important legs

- The heat lamp, the system thereof and its control
- The personal heating system as a means of improving comfort and well being
- The energy conservation that would be a result of shifting from space heating to personal heating

The IR LED heat lamp

An IR LED heat lamp is basically an ordinary LED lamp, but fitted with IR LED's that emit radiant heat as invisible InfraRed light. Further the IR LED heat lamp has a relative high output where each module produces more than 10 times the output of a traditional lamp.



People being heated

With the IR LED heat lamp the heat is focused as a spotlight on the people to be heated.

Furthermore the users will have the possibility to adjust the heat individually to their preferences.



Empty room, no heating

When the room is empty, the LED lamps are turned off. No energy is used to heat empty rooms and buildings.

There are thus three elements of the IR LED heat lamp

1. The control system to direct the heat spot
2. The user interface UI with the heating system
3. The mechanical design of the heat lamp

Control of the Heat Spot

The LED heat lamps will focus the heat on the people inside the building. In a simple model, the lamp is directed to a fixed spot in the room e.g. a work place or resting place. In a full developed system the lamp will automatically direct the correct amount of heat to each individual inside the building. Each person can interact with the heating system and demand a desired heating level, and from that the control system will follow the person and deliver the heat.

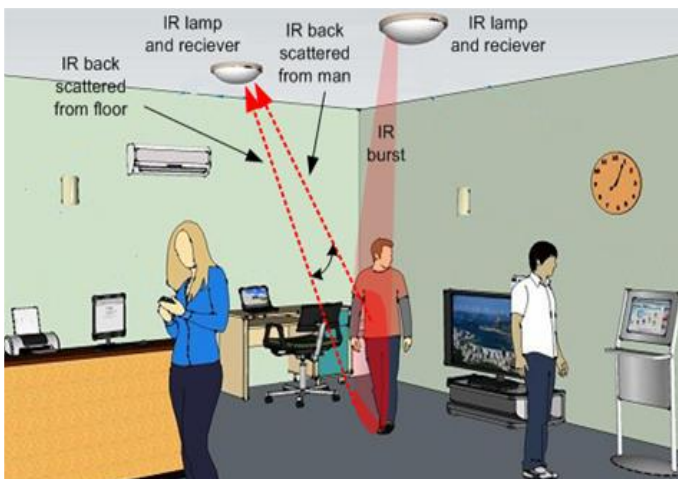
Basics of the IR FOCUS control system

For the system to operate efficiently, it is of major importance that the radiant heat from the lamps actually hit the people to be heated and not some background interior.

IR FOCUS has developed a system whereby the success of a first lamp to hit a person is analyzed by other lamps installed in the same room. While it is difficult for the first lamp itself to determine if it hits it's the target person or some background, this is much easier for a second lamp installed at another place in the room.

The method developed at IR FOCUS is as follows.

1. A first lamp is emitting the infrared light (radiant heat) to be evaluated.
2. This first lamp directs the infrared light onto the person to be heated. It do so by available information on the position of the person, but since the person may be moving, the correct position has to be continuously updated.
3. A second lamp will detect the back scattered infrared light from the first lamp.
 - a. a part of the back scattered light will be from the direction of the target person,
 - b. another part of the back scattered light will be from directions different to the target person.
4. The measured back scattered light at the second lamp is evaluated and analyzed. Say the first lamp hit too much to the left as it is shown on the picture, then the infrared light missed the target person is back scattered from the floor. Seen from the second lamp, this back scattered light from the floor is clearly arriving from a different direction than the target person and is therefore evaluated as failed heating. Through further analysis it is concluded, that the first lamp has to adjust to the left.
5. The result of this analysis is returned to the first lamp by using the infrared light as the information carrier
6. The first lamp receives the message from the second lamp and will adjust the direction of the infrared light according to the new information.

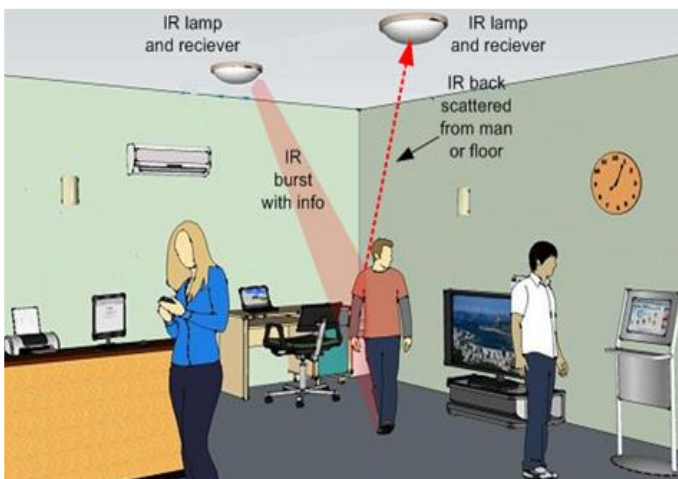


First lamp is emitting the infrared light

A first lamp is emitting the infrared light (radiant heat) to be evaluated

A second lamp will detect the back scattered infrared light from the first lamp

The measured back scattered light at the second lamp is evaluated and analyzed. Say the first lamp hit too much to the left as it is shown on the picture, then the infrared light missed the target person is back scattered from the floor.



Second lamp return information

Through further analysis it is concluded, that the first lamp has to adjust to the left

The result of this analysis is returned to the first lamp by using the infrared light as the information carrier

The first lamp receives the message from the second lamp and will adjust the direction of the infrared light according to the new information.

The IR FOCUS approach to regulation of the heat is thereby a closed loop model where the heat missed the target is continuously monitored, and whereby the system adjusts in real time in order to optimize the heating efficiency and minimize heat and energy losses.

Communication through IR

In a real installation there will be plenty of IR LED heating lamps all producing infrared light. To distinguish between infrared light coming from the various IR lamps, it is possible for one lamp to produce a recognizable IR burst. Such a burst is a flashing with the infrared light at a high, precisely defined frequency and will contain a unique signal of the lamp producing the IR burst. Then other lamps with their IR receiver will recognize the lamp producing the burst and will be able to carry out their evaluation and analysis of the first lamp effectiveness.

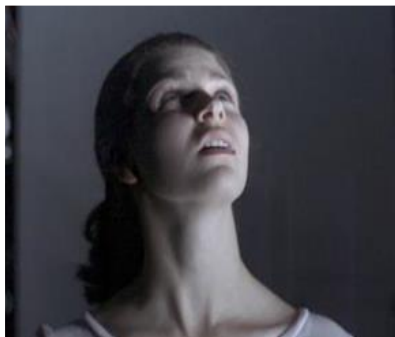
Sending wireless signals with IR burst is a well-known technology and has for decades been used for remote controls. These remote control systems operate/flash at a relatively low frequency

range of 30-40 kHz. However, the technology has recently gathered new interest for broad band communication at GHz levels and as an alternative to Wi-Fi. New developed solutions are known as Visible Light Communication (VLC) and as Li-Fi. Our IR FOCUS solution will benefit from this new development and implement these technologies into our solutions.

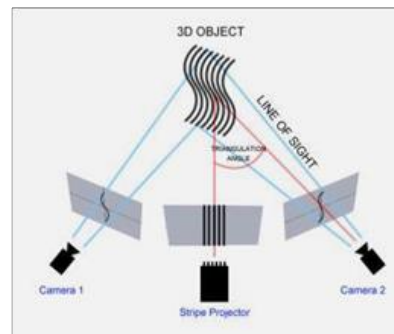
3D imaging with LED technology

Another interesting new development of importance is Spatially Varying Lighting whereby it is possible to produce a virtual 3D model of a room, an object or even a face of a person. This is done by flashing with LED lamps from various directions as well as recording the back scattered light from various positions. By combining the information, the 3D images can be produced. This will be a very closely related solution to the IR FOCUS control system and we will make use of this development.

Recording in process



Setup of recording devices



Processed virtual 3D model



A complete control system

For both mentioned technologies, the Li-Fi and the 3D recording/tracking system, the speed and resolution exceed by far what is needed for a well-functioning IR LED heating system. However, the combination of all three parts (signaling, 3D tracking and infrared spot heating) is new and needs development.

UI – User Interface

Also there are other issues that may not be solved best with the mentioned technologies. One is the first detection of a person entering a room. When first detected, the above mentioned

technologies could be used to keep track on a person, but they may fail to continuously scanning the space for new persons to enter. Here other technologies could be used such as camera that produces radiant images of the surface temperatures inside the room. With this system, new persons entering a room would firstly be recognized immediately by the camera and then secondly the other systems would be applied to determine the exact position of this person.

Also a more general user-interaction with the heating system will require other technologies to be implemented. They may be apps for smart phones, physical contacts on the wall or other means of user interfaces. It may be that a variety of UIs will be used depending on actual needs, or it may be that a few types of UIs will be dominant. However, we cannot at this point present a qualified view on which UI will eventually be useful for the IR LED heat lamp. It will instead be an important issue for development of the IR FOCUS technologies.

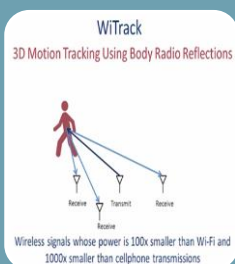
Other control systems

While the choice of control system is very important to IR FOCUS heating system, the importance is alone to those the best and/or not miss what could become a de facto standard – there is, however, no risk that we will not find a technology with the capacity needed for the IR FOCUS heating system. Therefore IR FOCUS will monitor any developments within control system relevant to IR LED heating, and already now there are several alternatives to consider, the following two should be taken just as examples.



Kinect

- Motion sensing system for Xbox
- A system developed at Micro Soft

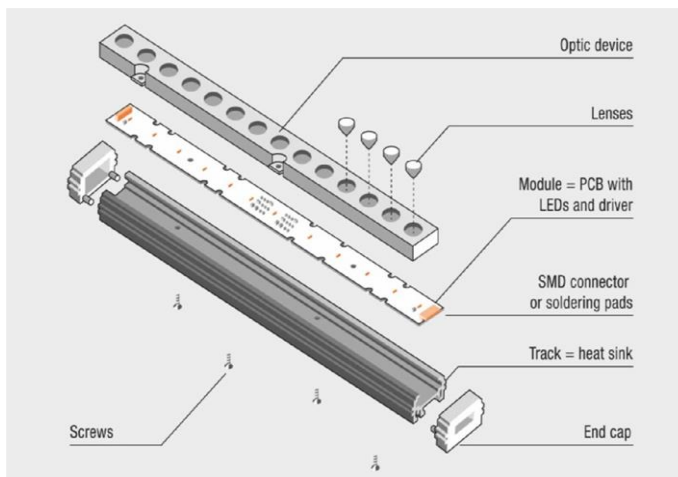


WiTrack

- 3D motion tracking using body radio reflections
- A system developed at MIT

IR FOCUS heater – mechanical design

At its basics there is nothing special about the design of an IR LED heat lamp. It follows the design of any other LED lamp and includes heatsinks, LED module, optics and optical carrier with end caps and a Power Supply Unit



Components of the LED lamp

An IR LED heat lamp is developed through same design-convention as any other LED lamp.

By this design-convention the entire module consists of the main components heatsinks, LEDs, LED module, optics, optical carrier with end caps and a Power Supply Unit (either integrated on LED module or separate).

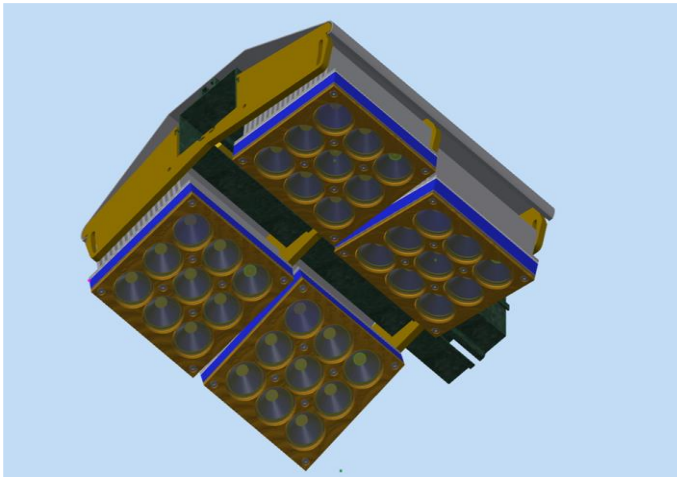
The lenses are available in various beam angles. The LEDs are available with different colors and power outputs. The layout, the aesthetic design and the mechanical properties of different LED lamp will vary greatly. However at this time of writing, 2015, the major components of any LED lamp are essentially the same for any LED lamp. It is a very well developed design-convention with almost unlimited possibilities of matching existing components into new LED lamp designs. It supports very quick and cheap development of new lamp designs and it is very low entrance costs to full production.

As a result (or cause) of this design-convention, the LED lamp industry is divided into distinct business along the value chain, these are; producers of LED semiconductors, PSU/LED drivers, optics/lenses, SMD/pcb/LED modules and LED lamps.

Future developments could chance the way LED lamps are build. The extraordinary flexibility of designing lamps today could indicate that more integrated solutions will materialize in the future. These integrated designs could benefit from high performance and/or low price over flexibility. The LED industry is currently very fast moving and shifts in the way LED lamps are produced could turn the industry completely within a few years. Therefore, at IR FOCUS we will monitor this development very carefully, but also with an arm length since the production of LED lamp is not our core business and we should not be too enrolled in specific LED lamp designs.

The static IR LED heater

There exist plenty possible uses for the IR LED heaters also without any control system to direct the focused heat on the persons. These non-controlled heaters produces a static heating, but different from traditional heating the static IR LED heater still produces a highly focused heating. Static heaters are useful when installed at locations where the users' position can be precisely predicted or may be indirectly guided to the position under the heat spot. Static IR LED heaters are also useful at cold locations where the heating itself is attractive and people may find the way to the heat spot simply by following visual signs.



An IR LED patioheater

A patioheater based on IR LED has been designed. The picture show one module measuring 25 x 30 cm. Each module carry 4 IR LED light engines and each of these holds 9 high power IR LEDs. Each IR LED produces 1.4 W of radiant heat that is focused through the lens.

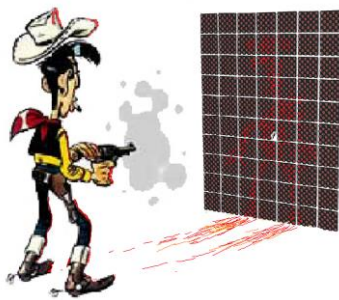
A fully installed patio heater could include 4 modules. This gives a total heat output of 200 W radiant heat. The heat stay focused at up to 3 meters.

The heater with tracking capability

For an IR LED heater system to follow a person it has to be possible to move the heat spot. As shown below, there exist least 3 different possibilities. Each may have its own uses. The development of these systems has not yet started at IR FOCUS, but its development is central to the future IR LED heater and will be highly prioritized.

The first two mentioned solutions are rather straight forward and the integration into the IR LED heater can be done within a well-defined project. The third, and possibly most attractive solution, depends on future development of LED systems and is not possible to control from IR FOCUS.

Wall of IR LEDs



The first is to cover a large area with IR LED spots. Each of them is fixed, but they will be turned on and of depending on needs. A drawback is the size of the system, but especially at locations with high density of people, this could become a favorable solution

2-axis Heat Spot



The second is to build a movable spot. Spotlights are well-known from the entertainment industry and could readily be applied for IR LED heating too. The technology could have some drawbacks in that the mechanical system will get complicated and too vulnerable for many applications

Heat Projector



The third is to use a projector-like technology. The common projectors are not useful since the optical efficiency of these is very low. There are however new developments that could later become of interest. These new technologies make use of an array of small LEDs to directly produce the emitted light.