Technical Report

An Analysis on the Use of LED Lighting for Video Conferencing

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Abstract

Lighting a Video Conferencing (VTC) environment presents a unique challenge — simultaneously providing equal, excellent visual access to both verbal and non-verbal communications of participants in the room as well as participants in remote locations. Lighting for VTC applications must accommodate the visual requirements of the people and the camera, and provide visibility of any display materials, especially to remote participants. Achieving the proper lighting balance requires the right combination of fixtures and the right combination of control strategies.

Linear fluorescent sources have long been used to provide effective, uniform lighting in VTC environments. The purpose of this paper is to show that similar, or better, results can be achieved using LED solutions, and to present the additional benefits associated with using LEDs. Dimming controls are essential to creating the correct solution in VTC environments regardless of the source, and appropriate control solutions are also detailed.

Presented in this whitepaper–

- Look at both fluorescent and LED fixture options in a typical VTC space
- Detail the optimized lighting layout and control scenarios
- Discuss LED lighting selection, advantages, and important considerations
- Demonstrate that the performance and savings can be easily and accurately modeled

The overall goal of this paper is to help designers and users become more comfortable with the use of LED fixtures and controls in VTC environments, to understand the advantages of the LED sources, and to be able to confidently design with them.

Executive Summary

Even, flicker-free lighting for VTC rooms can be achieved using either fluorescent or LED fixtures with the proper controls. From a facility management and performance perspective, using LED fixtures provides additional and important advantages including –

- Significant energy savings
- Long product life — reduces maintenance and operations costs
- Ability to comply with current and pending energy code changes
- Lower environmental impact – LED sources contain no mercury and no disposal risks

Types of fixtures

During a video conference the camera doesn't "see" the way the human eye does. Improper lighting can cause the camera to produce saturated images or images with dark shadows on them, resulting in poor picture quality for remote participants.

The right combination of strategically placed fixtures improves vertical illumination, creates uniform lighting on surfaces and participants, and with the addition of controls, enhances the ability to adjust contrast in the space.

Critical contrasts include–

- participant-to-rear-walls
- participant-to-side-walls
- participant-to-work-surface
- display-wall-to-video-display

Other factors, including room color and color/texture of furnishings, can also contribute to or detract from effective VTC room design.

To further ensure image clarity, it is important to use a manufacturer that offers fluorescent fixtures with dimming ballasts and/or LED fixtures with dimmable drivers in various form-factors to fit a variety of different space types, and applications.

In either case, a combination of 1x2 and 2x2 indirect fixtures provides both vertical and horizontal illumination, and helps produce images that have better contrast and sharpness. The right combination of fixtures ensures high-quality lighting on the participants, walls, and table surfaces, and the area around the display, screen, or monitor.

Types of Spaces

These lighting guidelines are particularly advantageous in the following space types:

- VTC rooms
- Telepresence rooms
- Distance learning spaces
- Training rooms
- Board rooms and conference rooms that incorporate video capabilities

Fluorescent versus LED Fixture Solutions

Fluorescent fixtures have proven to provide even, controllable lighting in VTC spaces, and lighting designers may be hesitant to veer away from fluorescent solutions without a clear understanding that LEDs offer equivalent lighting with additional advantages.

LED fixtures and controls are becoming less expensive and more widely available, and now they offer a viable alternative design solution, delivering benefits that make LED fixtures highly desirable in virtually any VTC application:

- Efficient – LEDs use less energy initially, and they save energy at a roughly 1:1 ratio as they are dimmed
- Uniform light levels/consistent color temperature – LEDs deliver more consistent color temperature, with little degradation or color shift over their lifetimes
- Longer lifetime – LEDs consistently deliver 50,000+ hour life, even longer when LEDs are dimmed
- Lower heat dissipation – LEDs dissipate very little heat, further increasing energy savings by reducing demand on HVAC cooling systems
- Guaranteed compatibility – The LED light source is included in the fixture, ensuring compatibility between LED module and driver. By choosing a manufacturer who specifically provides fixtures and controls together, you can guarantee compatibility and smooth, flicker-free dimming
- LED fixtures provide the same glare free lighting as their fluorescent counterparts

The selection of an appropriate driver is not limited to just making sure it matches the LED module being used. The driver is the primary component that determines the best-possible dimming capabilities of the LED lamp or fixture. It is also important to understand what mechanism the LED driver uses to achieve dimming: pulse-width modulation (PWM) or constant current reduction (CCR). Drivers using CCR are critical for video conference applications in order to ensure good performance on camera. More information about PWM vs CCR is available in the Whitepaper, “Dimming LEDs via PWM and CCR” from Lutron Electronics.

Optimized Solutions

The IES standard IESNA DG-17-05 goes into great detail to explain the importance of environment in creating a space ideal for VTC functions. It provides background on optics and details explaining what needs to be done to successfully implement a VTC space. Among the details, it describes what efforts should be taken to ensure appropriate lighting within a space.

The standard calls out ideal specifications for light sources, including a 3000-3500K range for CCT and a CRI of 80 or higher. It also emphasizes the importance of meeting the minimum light level requirements of the camera and providing even contrasts in lighting throughout different parts of the room in order to prevent saturation and washouts.

The standard strongly suggests the use of controls in order to achieve this balance of light levels, to provide the minimum quantity of light without being over lit, and to provide good contrast ratios. A dimming system facilitates the ability to adjust the light levels within the space in order to ensure the proper balance of light.

Modeling vs Performance

When designing a space with such specific requirements, it is vital that the solution can be modeled and the results accurately predicted. Predictive models allow for a designer to "see" what the solution will look like in terms of fixture layout and light output, without investing the time and money in a physical mockup of the space. A trusted model delivers confidence that the proposed solution will meet the space requirements prior to purchasing a piece of equipment.

Predictive modeling can be done using IES files and modeling software. By modeling the space, designing and tweaking the fixture layout, and including the IES file photometric data for the specific fixtures the actual photometric layout of the room can be created and analyzed. The model enables the user to observe and/or analyze the light levels throughout the space as well as the contrasts between dark and bright spots. This allows for further consideration regarding fixture type and placement as well as the application of control systems.

CASE STUDY – IMS

Example of a typical VTC space — a combination of fixtures is used to provide the right light on every room surface.

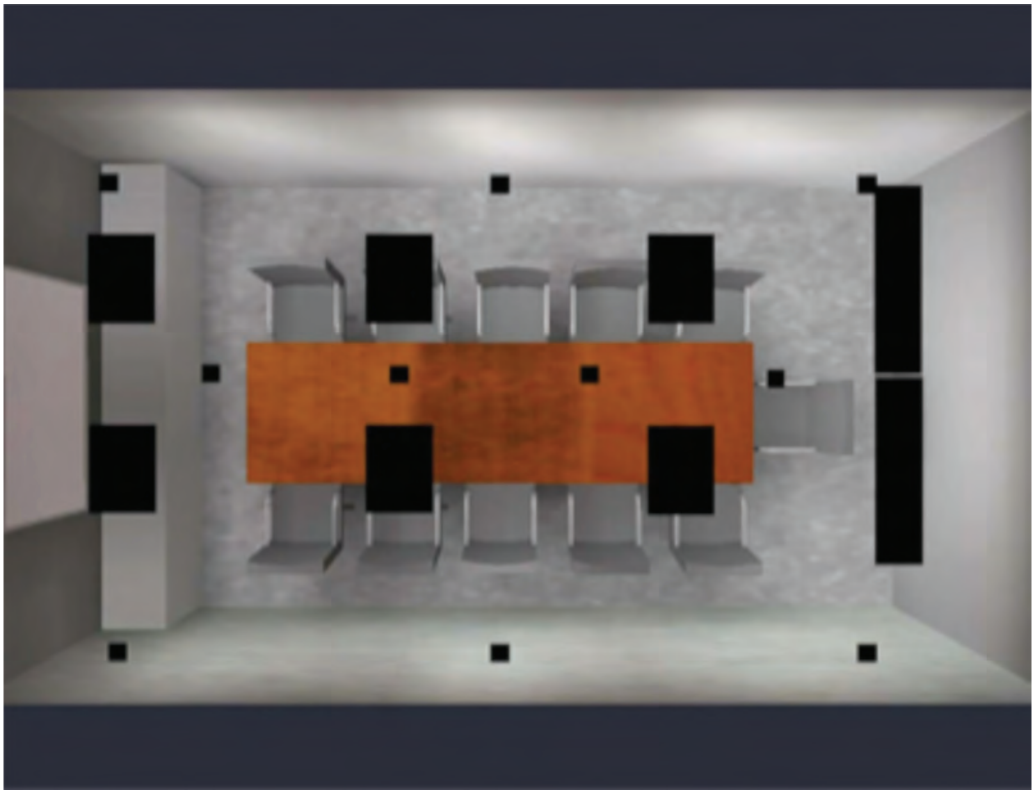

Figure 1 - Fixture layout. Room is 23' 3" x 12' 10" with 8' ceilings.

1. **Wallwash fixtures —** Uniformly illuminate rear and side walls from task height to ceiling, providing good contrast between participants and the background for a quality video image.

2. **Indirect wash fixtures —** Illuminate participants with vertically focused lighting (between a 45º and 60º angle), minimizing shadows on their faces

3. **Recessed downlights —** Illuminate the tabletop surfaces horizontally, minimizing shadows on faces and providing adequate task lighting, illuminate the presentation area with flexible lighting, and adjust contrast on presenters and wall displays.

Procedure:

- **STEP 1** — LED fixtures were installed in the selected VTC room, and measurements were taken at 100% light output. Table 1 shows the resulting measurements, taken at critical locations, of the LED lighting installation.
- **STEP 2** — The LED fixtures were replaced with fluorescent fixtures, and measurements were taken again, (Table 1) as shown below. The measured data was used to determine whether an LED system performs as well as a fluorescent system in a VTC environment (Table 2).
- **STEP 3** — The next issue is to determine whether significant energy savings are realized by using LEDs in a VTC-optimized scenario. The energy consumption of the fluorescent fixtures and the LED fixtures was measured in a test setup, and performed over the entire dimming range (Table 3). This information allowed for comparison of potential energy savings between the two solutions.
- **STEP 4** — The LED lighting was dimmed to the correct levels for optimal VTC purposes as outlined in the IES standard (Tables 4 and 5).
- **STEP 5** — The next thing to consider was how the performance of the system lined up with the model. A model of the test setup was prepared using the IES files and software. The collected data from the case study was then compared to what the model predicted (Table 6).

Measurement Points:

Figure 2 - Wall Measurement Points

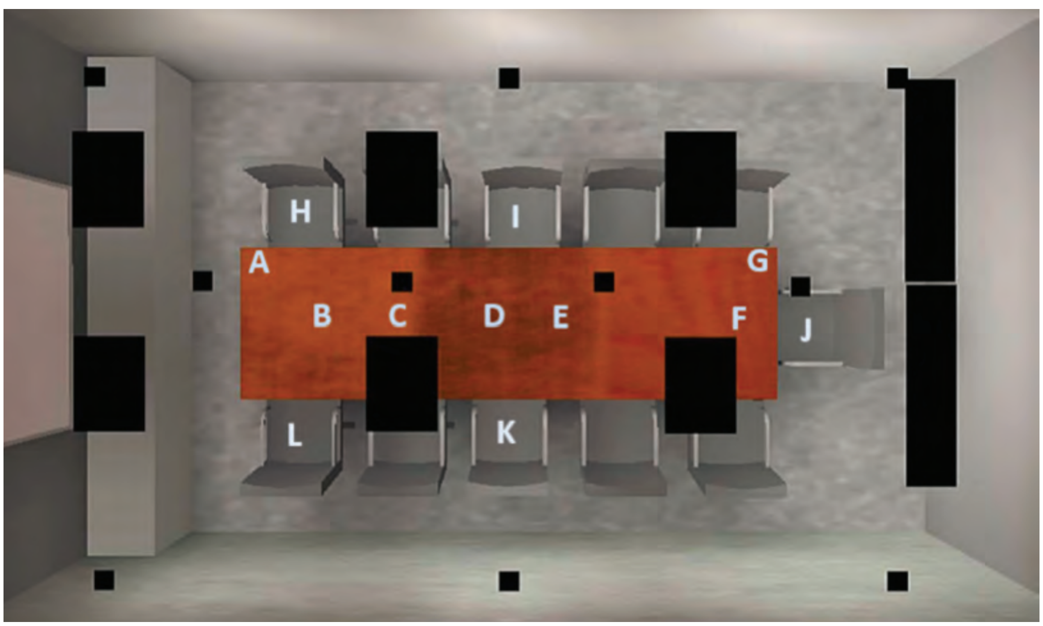

Figure 3 - Table Measurement Points

IMS Case Study Results

This white paper specifically addresses the results of a case study that compared the use of fluorescent fixtures and controls versus LED fixtures and controls in a VTC room.

The data will demonstrate that LED solutions can provide the same, flicker-free 1% dimming that was previously only available with a fluorescent solution. Summarized data from the case study can be found below. The raw data can be found in Appendix A.

Table 1: Fluorescent vs LED Average Luminance

	Fluorescent (Cd/m^2)	LED (Cd/m^2)
Average from walls at 6 ft (sides)	60.3	67.9
Average from walls at 3 ft (sides)	63.4	67.3
Average from Right Wall	102.3	108.0
Average from Front Wall	25.5	21.4
Average from Back Wall	55.9	76.3
Average from Table	78.00	71.7
Average from Face — Looking at Camera	59.4	67.7
Average from Face — 45 degree down	11.4	11.6
Average from Face — Left Light	45.7	45.2
Average from Face — Right Light	46.0	42.6

Table 2: Fluorescent vs LED Data Variance

	Fluorescent (Cd/m^2)	LED (Cd/m^2)
Variance from walls at 6 ft	1038	1584
Variance from Walls at 3 ft	1736	1965
Variance from Right Wall	286	295
Variance from Front Wall	9	13
Variance from Back Wall	40	139
Variance from Table	117.8	82.0
Variance from Face — Looking at Camera	150.2	27.7
Variance from Face — 45 degree down	6.2	21.0
Variance from Face — Left Light	76.0	59.7
Variance from Face — Right Light	62.5	31.3

Table 3: FL vs LED Energy Usage throughout Dimming Range

	2 x 2 2 Lamp 50 W T5 Fluorescent VTC Fixture H3DT550GU210		2 x 2 45 W LED VTC LED Fixture (1.07 A) L3DA4U1UMN-LA107	
% Light Level	**Fixture Input Power (W)**	**% Power Savings**	**Fixture Input Power (W)**	**% Power Savings**
100%	92.5	0%	44.8	0%
90%	86.9	6%	39.9	11%
80%	80.1	13%	35.0	22%
70%	69.0	25%	30.6	32%
60%	60.0	35%	25.7	43%
50%	52.1	44%	21.3	53%
40%	42.3	54%	16.9	62%
30%	37.1	60%	13.4	70%
20%	28.2	69%	9.3	79%
15%	25.4	73%	7.2	84%
10%	22.8	75%	5.3	88%
5%	21.1	77%	3.3	93%
1%	20.1	78%	1.7	96%

Table 4: LED Optimized Average Luminance

	LED (Cd/m^2)
Average from walls at 6 ft	29.0
Average from walls at 3 ft	26.0
Average from Table	21.7
Average from Face — Looking at Camera	17.9

Table 5: LED Optimized Maximum Ratio (Max:Min)

	LED (Cd/m^2)
Max Ratio from walls at 6 ft	1.44:1
Max Ratio from walls at 3 ft	1.8:1
Max Ratio from Right Wall	1.44:1
Max Ratio from Back Wall	1.6:1
Max Ratio from Faces - Looking at Camera	1.3:1

Table 6: LED Predicted vs Measured Luminance

	% Difference
Table: Point A	7.7%
Table: Point B	18.6%
Table: Point C	26.1%
Table: Point D	3.9%
Table: Point E	14.4%
Table: Point F	2.9%
Table: Point G	2.9%
Average	10.9%

DISCUSS RESULTS

LED sources applied in the same way as their fluorescent counterparts can provide equivalent light with lower energy use. As shown by the average luminance data in Table 1 for for the two solutions at 100%, the light output of the LED solution is capable of producing the same quantity of light as the fluorescent solution. Looking at the variance data in Table 2, we can see that the variation in light output across the different surfaces is also very similar.

The variance in the data set is a measurement in the spread of the values away from the mean of the set. In this analysis, the measurements can be used to represent overall difference in light measurements along a surface. It cannot be determined from this data set, what an acceptable variance is for each surface, but to compare the overall light environment provided by the two solutions.

If looked at surface-by-surface, the data set variances between the fluorescent and LED solutions tend to mirror each other along a surface. This illustrates that the fluorescent and LED solutions provide equivalent light outputs, and the variance in light level is most likely due to the fixture layout, rather than differences in the light sources themselves.

As discussed previously, LED solutions have intrinsic benefits. The primary benefit addressed by the data in this analysis is that of energy savings. The direct comparison of equivalent 2x2 LED and fluorescent fixtures shows that at 100% output, the LED fixture uses about half the power of the fluorescent fixture. This also saves energy linearly resulting in even further energy savings as the fixture is dimmed. This is especially true as the fixtures are dimmed toward their low end. This is very important to consider since these fixtures should be paired with a dimming system and dimmed down in order to optimize the light output.

For this analysis, the optimized solution was implemented with all light source types present in the room, including the wallwash fixtures, indirect wash fixtures, and recessed downlights. Having already tested, analyzed, and determined that the LED VTC fixtures could output light equivalent to a fluorescent VTC fixture, it was most prudent to analyze an optimized solution as it would appear in normal use than to prepare an optimized solution with just the indirect wash fixtures.

The values for this optimization were found to be wallwash at 30%, indirect wash at 20%, and recessed downlights at 10%. The IES standard suggests a maximum luminance ratio of 1.5:1 from the maximum to minimum of the walls behind the participants or from the faces of participants in order to provide quality video feed from the space. The results in Table 5 show that the optimized LED solution maximum to minimum ratios were all around 1.5:1. Table 4 shows that the average light level on the table while achieving these proportions was at an acceptable meeting light level.

Finally, the predicted vs measured data in Table 6 proves that the results of using a video conferencing fixture layout with control system can be accurately predicted. In this data set, there is an average variation of 10.9% between what was predicted and what was experienced on site. The difference can be attributed to the slight variation in fixtures, variations in the surfaces within the room, as well as slight changes in the control system adjusting the light levels up and down. What this data does confirm is that the results can be predictably modeled within a reasonable margin of error. This allows for designing and tweaking of VTC room lighting and control design to gain the desired results prior to the investment in equipment or time on site.

Conclusion

As LED sources become more available and more cost effective, lighting designers can be confident that LEDs deliver the performance and flexibility their clients have come to expect from fluorescents. Knowing that LEDs can offer equivalent light levels empowers the client to focus on the intrinsic benefits of an LED solution, namely energy savings and longer life. Understanding those benefits, it becomes critical to be able to reliably design a solution with confidence and without requiring substantial investment.

The fact that these solutions can be accurately modeled, and the results reliably predicted, is great news for good design and experimentation without requiring investment of time and resources.

Seeing the equivalence between LED sources, understanding the intrinsic benefits, and being able to accurately model and predict performance removes any obstacles for LED solution and opens the door for them to be used as the new standard for VTC spaces.

Further Reading

For more information on how to select the correct combination of LED lamps, drivers and controls, read the Controlling LEDs whitepaper from Lutron.

Appendix A: Raw Data from IMS Case Study

Fluorescent vs LED at 100%

Wall Data

Location	Placement†	Height*	Fluoresecent (Cd/m^2)	LED (Cd/m^2)
Right wall	A	6 ft	82	75
		3 ft	93	107
	B	6 ft	112	119
		3 ft	123	123
	C	6 ft	87.5	114
		3 ft	116	110
Front wall	D	6 ft	26	24
		3 ft	25.5	17
	E	6 ft	31	26
		3 ft	24	22
	F	6 ft	24	22
		3 ft	22.5	17.5
Back wall	G	6 ft	64	90
		3 ft	55	80
	H	6 ft	56	73
		3 ft	48.5	62

Table Data

Location	Placement†	Fluorsecent (Cd/m^2)	LED (Cd/m^2)
Table	A		
	B	60	77
	C	69	86
	D	85.7	70.5
	E	84.5	71
	F	83.8	65.5
	G	85	60

Notes:
† See Measurement Points 1 diagram
* Height is measurement from the floor
# See Measurement Points 2 diagram

Simulated Occupant Data

Location	Placement†	Fluorsecent (Cd/m²)	LED (Cd/m²)
Looking at camera	H	45.5	66
	I	74.4	64
	J	65	77
	K	64	66
	L	48	65.5
45 Degree angle down	H	8.3	8.5
	I	11.8	12.7
	J	14.3	18.6
	K	13.2	11.5
	L	9.6	6.7
Left Light	H	35.4	42
	I	58.8	57
	J	42.3	44
	K	48.7	47
	L	43.3	36
Right Light	H	46.7	38
	I	43	44
	J	47.7	51
	K	57.1	43
		35.3	37

Notes:
† See Measurement Points 1 diagram
* Height is measurement from the floor
# See Measurement Points 2 diagram

Optimized LED

2 x 2 VTC is 20%; IW is 30%; Finiré at 10%

Wall Data

Location	Placement†	Height*	LED (Cd/m²)
Right wall	A	6 ft	25
		3 ft	28
	B	6 ft	36
		3 ft	34
	C	6 ft	27
		3 ft	31
Front wall	D	6 ft	9
		3 ft	8
	E	6 ft	N/A– screen
		3 ft	
	F	6 ft	9
		3 ft	7
Back wall	G	6 ft	30
		3 ft	19
	H	6 ft	27
		3 ft	18

Table Data

Location	Placement#	LED (Cd/m²)
Table	A	19
	B	29
	C	18
	D	24
	E	18
	F	24
	G	20

Simulated Occupants

Location	Placement#	LED (Cd/m²)
Table	H	15.5
	I	20
	J	19.5
	K	18.5
	Looking at camera	16

Notes:
† See Measurement Points 1 diagram
* Height is measurement from the floor
\# See Measurement Points 2 diagram

Optimized LED Predicted vs Measured

Table Data

Location	Placement†	LED (fc)	Predicted (fc)	% Difference
Table	A	30	27.7	7.7%
	B	34.5	28.1	18.6%
	C	37.5	27.7	26.1%
	D	35.5	34.1	3.9%
	E	37.5	32.1	14.4%
	F	34.5	35.5	2.9%
	G	34.5	35.5	2.9%

Notes:
† See Measurement Points 1 diagram
* Height is measurement from the floor
# See Measurement Points 2 diagram