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Dimming Systems Characteristics

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Executive Summary

The following report summarizes the findings from a study commissioned by the Northwest Energy Efficiency Alliance (NEEA) to delineate the characteristics of eighteen dimming systems as part of its Luminaire Level Lighting Control (LLLC) Initiative. NEEA contracted with Cascade Engineering Services, Inc. to conduct the testing of the systems.

Within the scope of the Luminaire Level Lighting Control (LLLC) Initiative, NEEA is evaluating system interdependencies that may influence projected energy savings.

Study Description

NEEA intended this study to document the correlation between controller signal (0-10v or DALI) and the monitored response of the driver electronics/light source combination, and to note any variances that may prove problematic in determining "controlled" energy savings of the system. Essentially, testing monitored the correlations of control signal, energy consumption, and light output, and documented their non-linearity.

Test Results

Researchers' tracked sixteen types of electrical measurements throughout each testing cycle, for each ballast, at five percent signal input increments. They defined a testing cycle as a ramp of control signal up from zero percent to one hundred percent, then down (one hundred percent to zero percent). Note that in many cases, a control signal setting of zero percent (0v) did not equate to a full "off" state (0 watts of power consumed). In fact, at a setting of 0 volts control signal input, many ballasts consumed more than ten percent of their rated input power.

- Each ballast's response to a linear control signal input varied and was not linear. The variances ranged from minor (+- two percent) to significant (+- eighteen percent).
- Only a full power disconnect resulted in consumption of zero watts. Dimming to zero percent (control signal) resulted in more than ten percent power consumption in many ballasts.
- Researchers noticed deadband zones (non-linearity, non-response) in almost all ballasts, potentially complicating the implementation of specific control strategies (i.e., Demand Response) among manufacturers' products.
- DALI ballasts performed differently than did standard 0-10 volt input ballasts.

1. Introduction

This report summarizes the findings from a study commissioned by the Northwest Energy Efficiency Alliance (NEEA) to document the characteristics of eighteen dimming systems as part of its Luminaire Level Lighting Control (LLLC) Initiative. NEEA contracted with Cascade Engineering Services, Inc. to conduct the testing of these systems.

The mission of the Northwest Energy Efficiency Alliance (NEEA) is to help transform the market to a more energy efficient future. NEEA does this by occasionally evaluating various emerging technologies for possible energy efficient applications in the Northwest region. Commercial, industrial, and residential products and services are in scope for NEEA's assessments. Should a particular technology, process, or service prove beneficial for increased energy efficiency, NEEA may launch a program to help support an accelerated adoption path with the intention of helping to remove barriers and maximize opportunities that will speed adoption of the technology and generally raise the efficiency standards for that technology.

1.1. Background and Business Value

The application of lighting controls makes possible significant energy savings and non-energy benefits. In fact, given the growing adoption of light emitting diode (LED) lighting and developments increasing the sophistication of lighting controls, NEEA anticipates energy savings of fifty percent or more over uncontrolled lighting. However, the precise integration of the various components can prove challenging.

The full energy savings potential of the LLLC Initiative, at a systems level, depends upon three components:

1) A light source
2) Electronic components that drive the light source (ballast or driver)
3) Controls

Each component must work efficiently in its own right, and must execute the intended control action throughout the system. In theory, this means that adjusting the light level by dimming fifteen percent at the control station (user interface) will have that intended effect (light level or power consumption reduction) at the light source/driver. In practice, this rarely happens. Control signals may not be uniformly translated for a multitude of reasons, leading to differences between the intended and actual results across component manufacturers. This becomes very important for utilities in forecasting the anticipated energy savings of a system when determining associated programs; efficiency organizations could easily overestimate savings and overpay for those anticipated savings. The situation could be exacerbated when implementing an energy strategy requiring instantaneous energy reduction, such as in a demand response scenario, with an incorrectly-executed load-shedding control command, which does not provide the intended load reduction. Therefore, NEEA is focusing on assessments of the interoperability and compatibility of integrated lighting systems (and components) to influence utility-aligned comments, helping to guide the industry to a simpler and more predictable resolution.

1.2. Study Objectives

NEEA intended this study to document the correlation between controller signal (0-10v or DALI) and the monitored response of the driver electronics/light source combination, and to note any variances that may prove problematic in determining “controlled” energy savings of the system. Essentially, testing monitored the correlations of control signal, energy consumption, and light output, and documented their non-linearity.

2. Methodology

The researchers' first step consisted of validating system command "fidelity" (how accurately each component executes the intended action). This consisted of comparing the LLLC target control system (Enlighted[1]) to a known 'reference' signal generator. The Enlighted system (product assessment report posted on NEEA Conduit) tested linear, with controller commands directly corresponding to a linear 0-10 volt output. In other words, the user interface action to set the ballast/driver to 50% resulted in a reduced control signal output (to the ballast) to 5 volts, from 10 volts.

As the second step (the study described in this report), researchers evaluated the actual response of the ballast component and light source to varying control signals from the control system (Enlighted). Researchers selected eighteen dimming fluorescent ballasts for initial testing. The eighteen ballasts had the following distribution:

- Ten controlled by Digital Addressable Lighting Interface (DALI)
- Eight controlled by 0-10 volt signal

Appendix A describes the test equipment and settings for tests for each of the eighteen ballasts.

Researchers tracked sixteen types of electrical measurements throughout each testing cycle, for each ballast, at five percent signal input increments. They defined a testing cycle as a ramp-up of control signal (from zero percent to one hundred percent) followed by a ramp-down (one hundred percent to zero percent). Note that in many cases, a control signal level of zero percent did not equate to zero watts of power consumption. In fact, at zero percent (0v) control signal input, many ballasts consumed more than ten percent of their rated input power.

2.1. Testing Parameters

Table 1 outlines the electrical characteristics measured for this study. The bulleted list that follows the table summarizes other testing information.

Table 1. Measured Electrical Characteristics

	Controller Outputs	**Ballast/Driver Inputs**	**Ballast/Driver/Lamp Outputs**
Characteristics Measured	Voltage	Voltage	Foot-candles
	Current	Current	Flicker
	Power	Power Factor	Striations
		Current at…	Strobing observations throughout dimming range
		3^{rd} harmonic	
		5^{th} harmonic	
		7^{th} harmonic	
		9^{th} harmonic	
		11^{th} harmonic	
		13^{th} harmonic	

[1] Enlighted Inc. provides advanced digital sensors and analytics platforms for smarter buildings. http://www.enlightedinc.com/

- Researchers purchased ballasts through typical supply chain contacts
- The Lighting Design Lab loaned the DALI controller equipment for the study
- Enlighted, Inc. loaned the 0-10 volt controller equipment for the study
- Fixtures and lamps were consistent by lamp type throughout the study
- Researchers calibrated control equipment for each test cycle to industry test specifications
- Researchers allowed each test system to “settle” at each control signal change (five percent increments) to ensure consistent readings

3. Findings

This section highlights the test results for each of the eighteen ballasts evaluated. Appendix A contains detailed test specifications and data for each ballast.

3.1. Crestron Model GLB-DALI-T5-214/35 DALI (T5)

Table 2 summarizes the findings for the Crestron GLB-DALI-T5-214/35. Figure 1 illustrates its performance on percent dimming vs. power and light, and Figure 2 illustrates its performance on percent light vs. percent power. Table 20 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 2. Findings for Crestron GLB-DALI-T5-214/35

Dimming Signal	
Active Range	15% - 100%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.58
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.51%
Power Consumption	
At Zero Dimming Signal	9.3 W
At 50% Dimming Signal	28.4 W
At Full Dimming Signal	57.8 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP28/835/ECO, T5, 28W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 1. Crestron GLB-DALI-T5-214/35: Percent Dimming vs. Power and Light

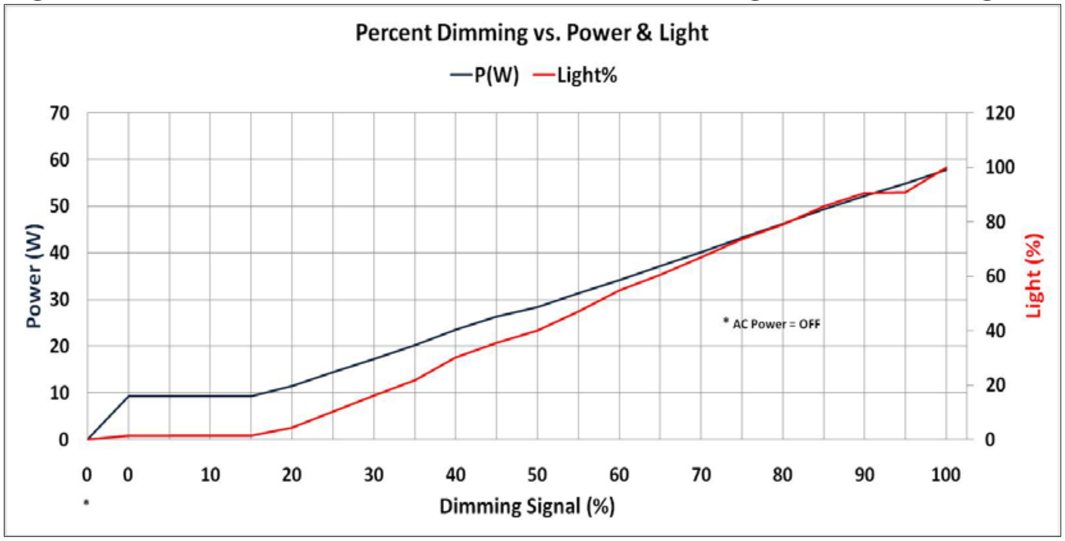
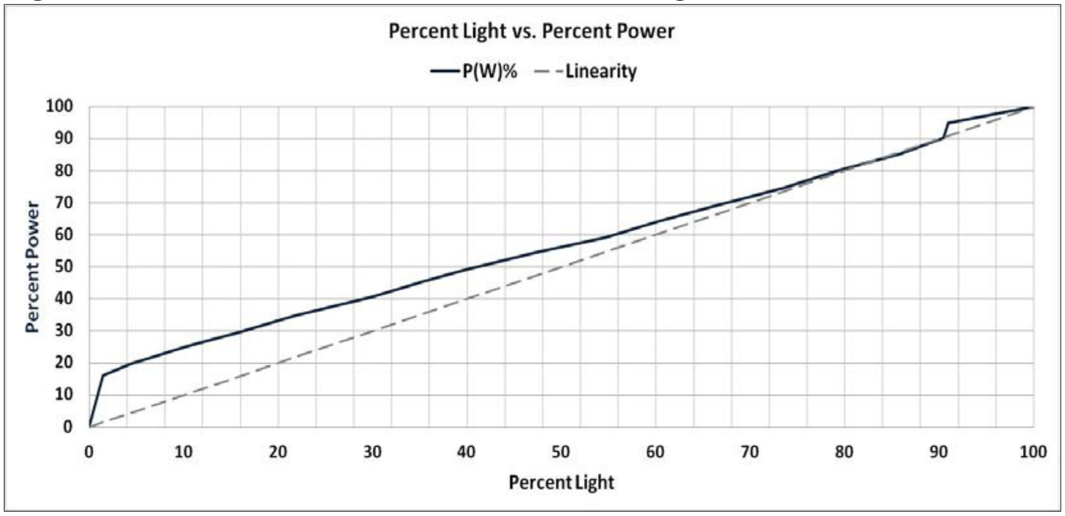


Figure 2. Crestron GLB-DALI-T5-214/35: Percent Light vs. Percent Power



3.2. Crestron Model GLB-DALI-T5HO-254/35 DALI (T5)

Table 3 summarizes the findings for the Crestron Model GLB-DALI-T5HO-254/35. Figure 3 illustrates its performance on percent dimming vs. power and light, and Figure 4 illustrates its performance on percent light vs. percent power. Table 21 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 3. Findings for Crestron GLB-DALI-T5HO-254/35

Dimming Signal	
Active Range	15% - 100%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.58
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.67%
Power Consumption	
At Zero Dimming Signal	9.3 W
At 50% Dimming Signal	50.1 W
At Full Dimming Signal	100.2 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP54/835/HO/ECO, T5, 54W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 3. Crestron GLB-DALI-T5HO-254/35: Percent Dimming vs. Power and Light

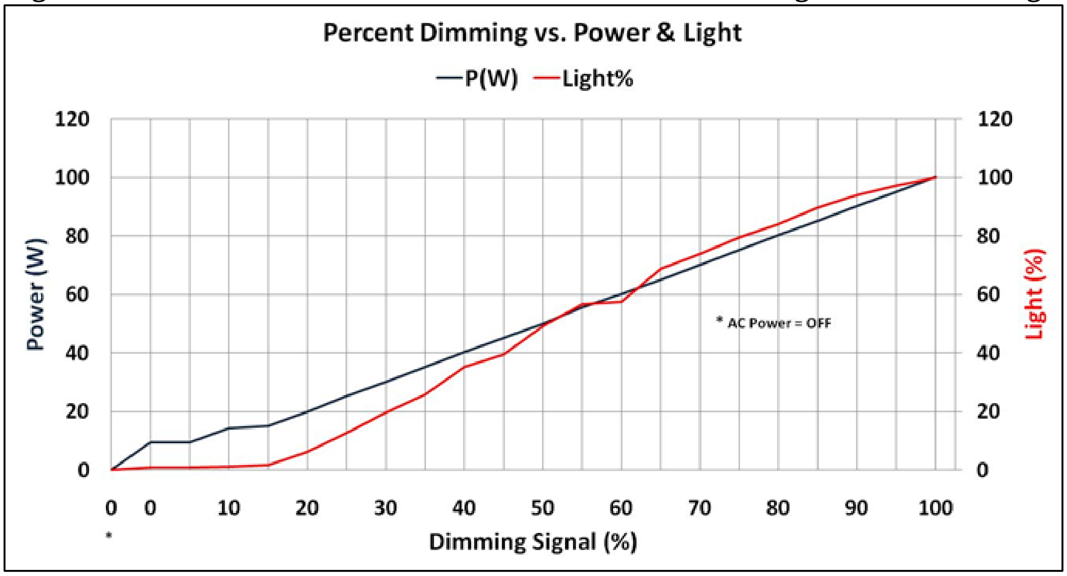
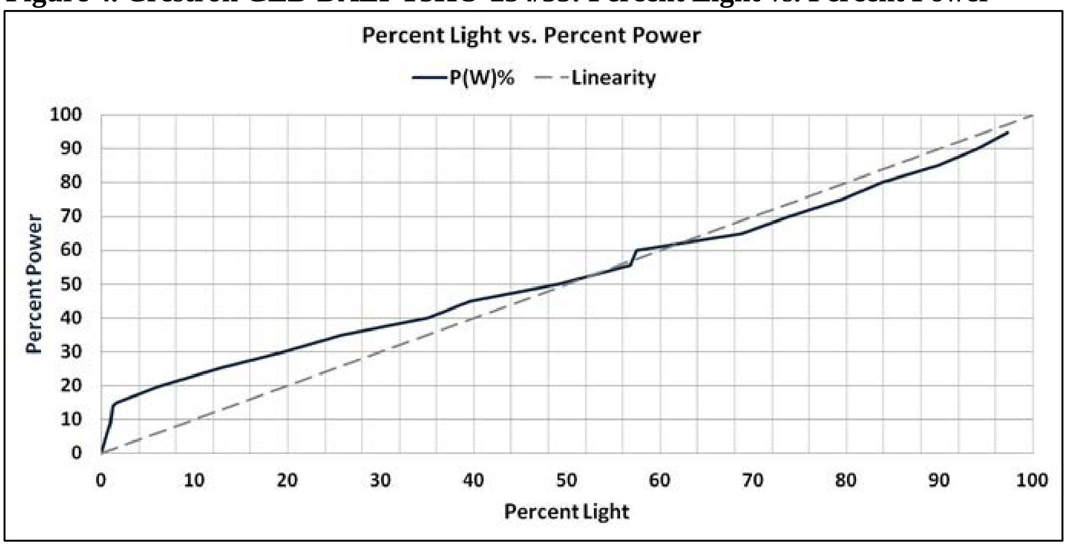


Figure 4. Crestron GLB-DALI-T5HO-254/35: Percent Light vs. Percent Power



3.3. Osram Sylvania QHE-2X28T5/UNV DIM-TCL 0-10V (T5)

Table 4 summarizes the findings for the Osram Sylvania QHE-2X28T5/UNV DIM-TCL 0-10V. Figure 5 illustrates its performance on percent dimming vs. power and light, and Figure 6 illustrates its performance on percent light vs. percent power. Table 22 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 4. Findings for Osram Sylvania QHE-2X28T5/UNV DIM-TCL 0-10V

Dimming Signal	
Active Range	15% - 85%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	85% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.99
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.29%
Power Consumption	
At Zero Dimming Signal	9.4 W
At 50% Dimming Signal	37.5 W
At Full Dimming Signal	60.3 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP28/835/HO/ECO, T5, 28W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 5. Osram Sylvania QHE-2X28T5/UNV DIM-TCL 0-10V: Percent Dimming vs. Power and Light

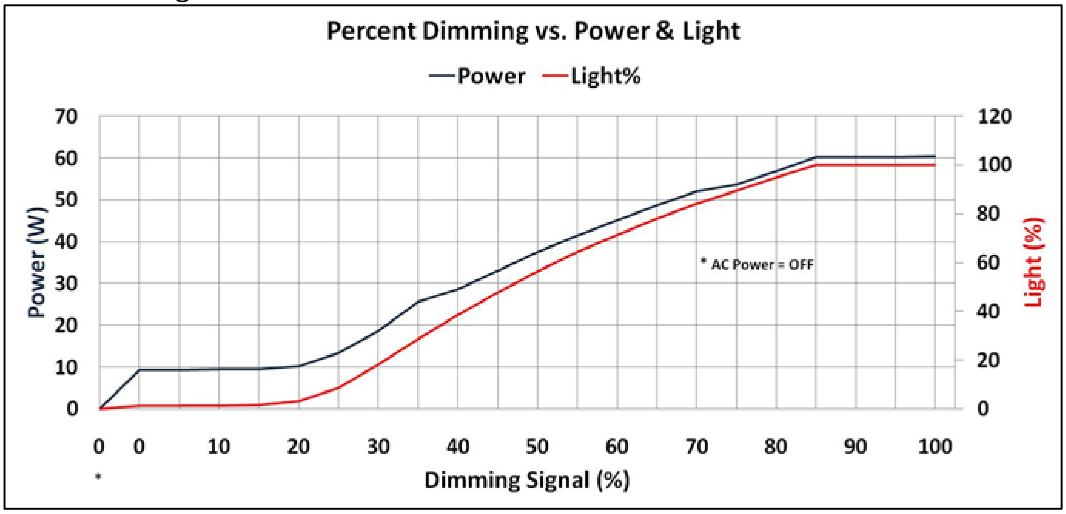
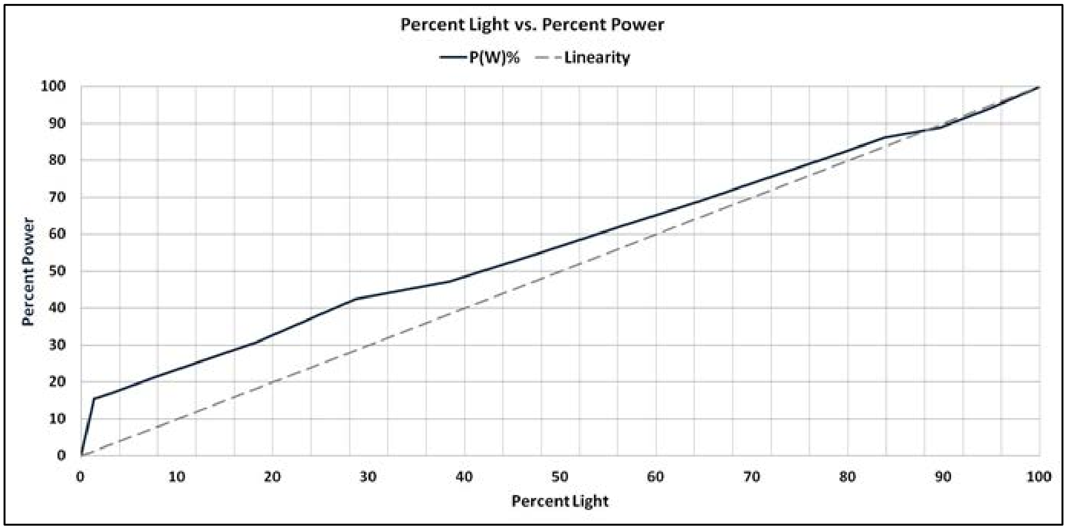


Figure 6. Osram Sylvania QHE-2X28T5/UNV DIM-TCL 0-10V: Percent Light vs. Percent Power



3.4. Osram Sylvania QHE-2X28T5/UNV DALI (T5)

Table 5 summarizes the findings for the Osram Sylvania QHE-2X28T5/UNV DALI. Figure 7 illustrates its performance on percent dimming vs. power and light, and Figure 8 illustrates its performance on percent light vs. percent power. Table 23 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 5. Findings for Osram Sylvania QHE-2X28T5/UNV DALI

Dimming Signal	
Active Range	15% - 100%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.63
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.42%
Power Consumption	
At Zero Dimming Signal	9.4 W
At 50% Dimming Signal	30.1 W
At Full Dimming Signal	60.5 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP28/835/HO/ECO, T5, 28W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 7. Osram Sylvania QHE-2X28T5/UNV DALI: Percent Dimming vs. Power and Light

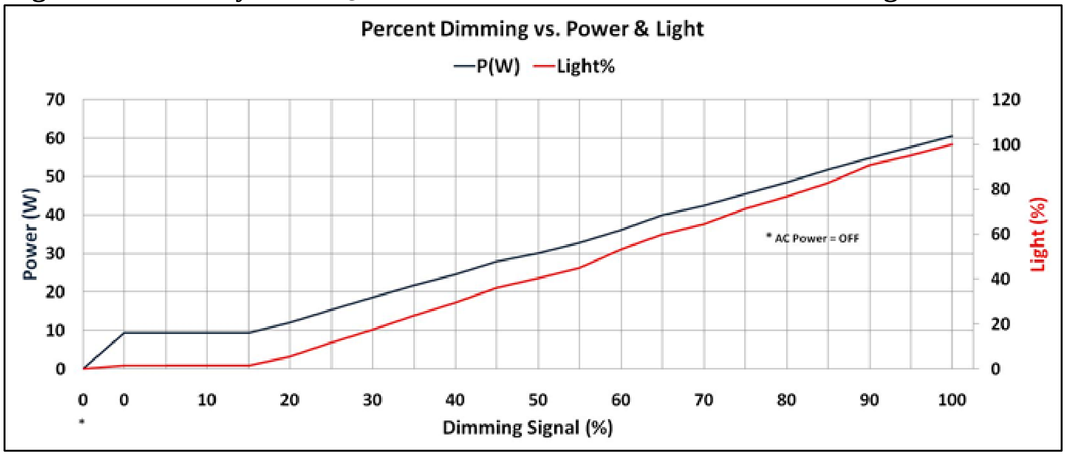
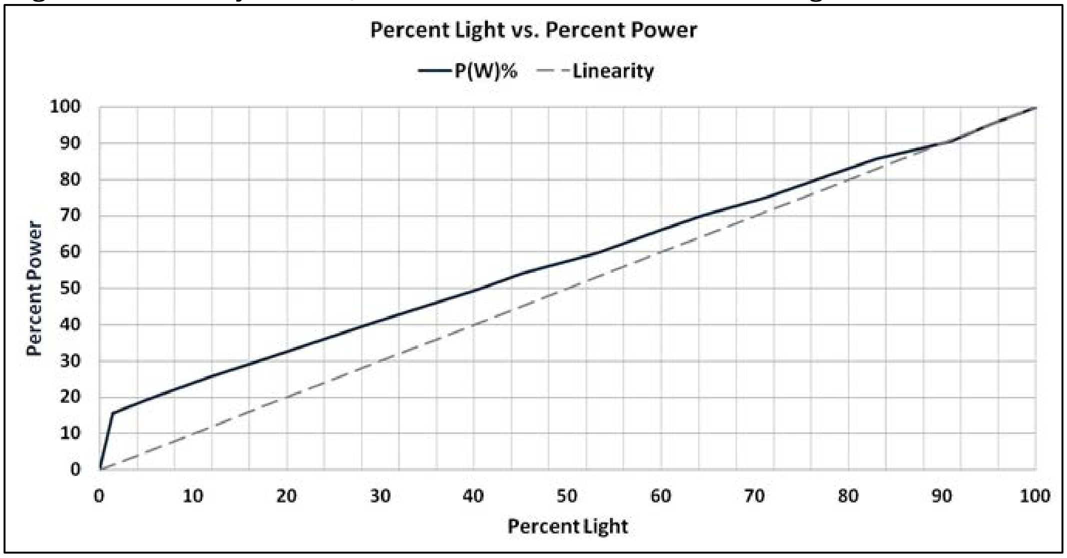


Figure 8. Osram Sylvania QHE-2X28T5/UNV DALI: Percent Light vs. Percent Power



3.5. Osram Sylvania QHE-2X32T8/UNV DALI (T8)

Table 6 summarizes the findings for the Osram Sylvania QHE-2X32T8/UNV DALI. Figure 9 illustrates its performance on percent dimming vs. power and light, and Figure 10 illustrates its performance on percent light vs. percent power. Table 24 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 6. Findings for Osram Sylvania QHE-2X32T8/UNV DALI

Dimming Signal	
Active Range	20% - 100%
Lower End Dead Travel	0% - 20%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.76
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.27%
Power Consumption	
At Zero Dimming Signal	12.8 W
At 50% Dimming Signal	32.3 W
At Full Dimming Signal	64.1 W

Notes: Reference Fixture: Lamp: Sylvania Octron F032/835/ECO, 32W, T8, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 9. Osram Sylvania QHE-2X32T8/UNV DALI: Percent Dimming vs. Power and Light

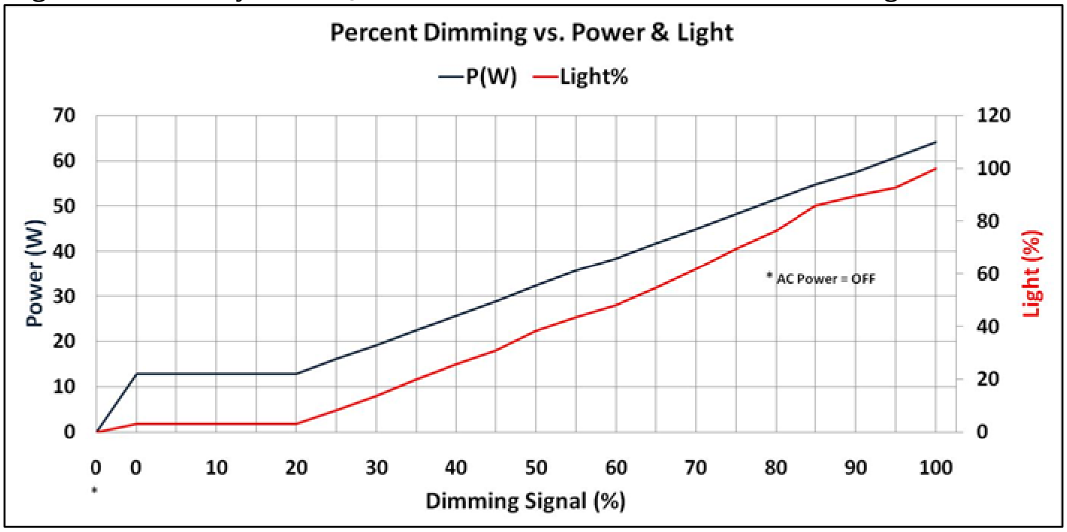
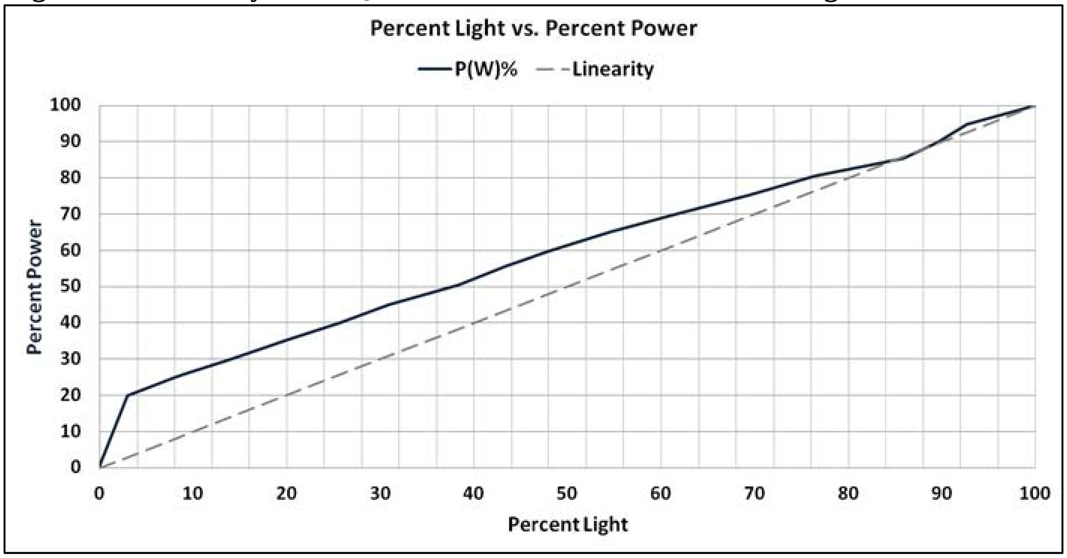


Figure 10. Osram Sylvania QHE-2X32T8/UNV DALI: Percent Light vs. Percent Power



3.6. Osram Sylvania QHE-2X54T5HO/UNV DIM-TCL 0-10V (T5)

Table 7 summarizes the findings for the Osram Sylvania QHE-2X54T5HO/UNV DIM-TCL 0-10V. Figure 11 illustrates its performance on percent dimming vs. power and light, and Figure 12 illustrates its performance on percent light vs. percent power. Table 25 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 7. Findings for Osram Sylvania QHE-2X54T5HO/UNV DIM-TCL 0-10V

Dimming Signal	
Active Range	15% - 85%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	85% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.99
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.24%
Power Consumption	
At Zero Dimming Signal	14.2 W
At 50% Dimming Signal	64.7 W
At Full Dimming Signal	113.1 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP54/835/HO/ECO, T5, 54W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 11. Osram Sylvania QHE-2X54T5HO/UNV DIM-TCL 0-10V: Percent Dimming vs. Power and Light

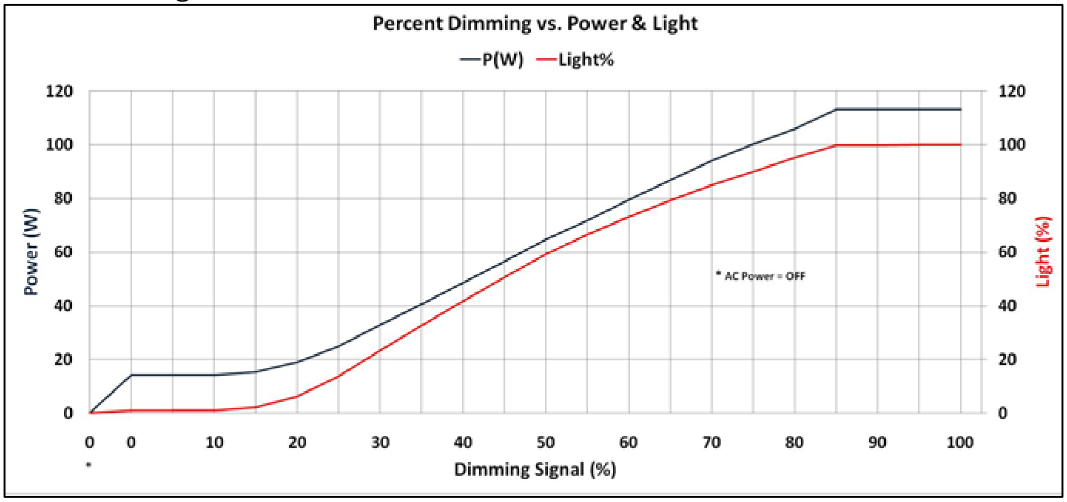
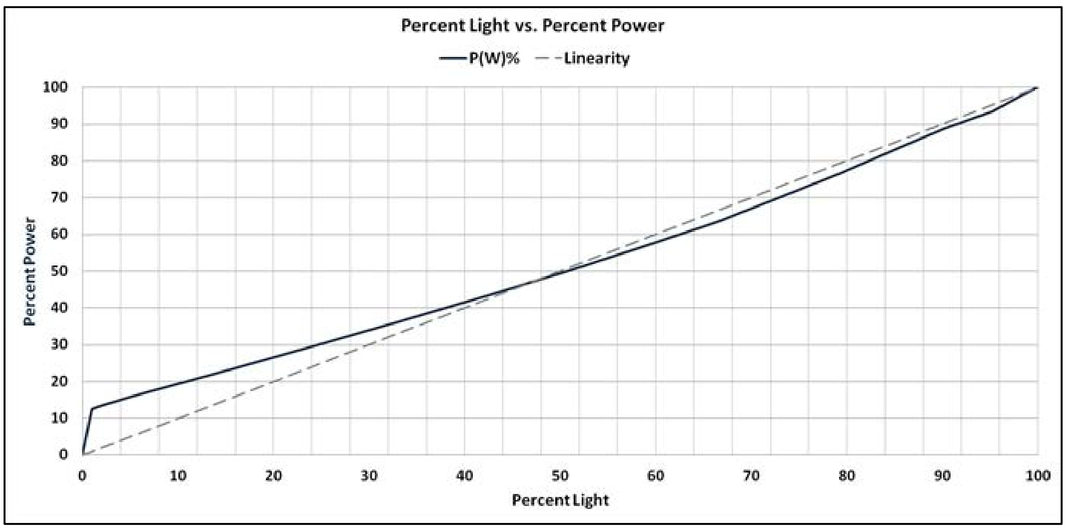


Figure 12. Osram Sylvania QHE-2X54T5HO/UNV DIM-TCL 0-10V: Percent Light vs. Percent Power



3.7. Osram Sylvania QHE-2X54T5HO/UNV DALI (T5)

Table 8 summarizes the findings for the Osram Sylvania QHE-2X54T5HO/UNV DALI. Figure 13 illustrates its performance on percent dimming vs. power and light, and Figure 14 illustrates its performance on percent light vs. percent power. Table 26 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 8. Findings for Osram Sylvania QHE-2X54T5HO/UNV DALI

Dimming Signal	
Active Range	10% - 100%
Lower End Dead Travel	0% - 10%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.76
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.45%
Power Consumption	
At Zero Dimming Signal	14.6 W
At 50% Dimming Signal	58.2 W
At Full Dimming Signal	116.8 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP54/835/HO/ECO, T5, 54W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 13. Osram Sylvania QHE-2X54T5HO/UNV DALI: Percent Dimming vs. Power and Light

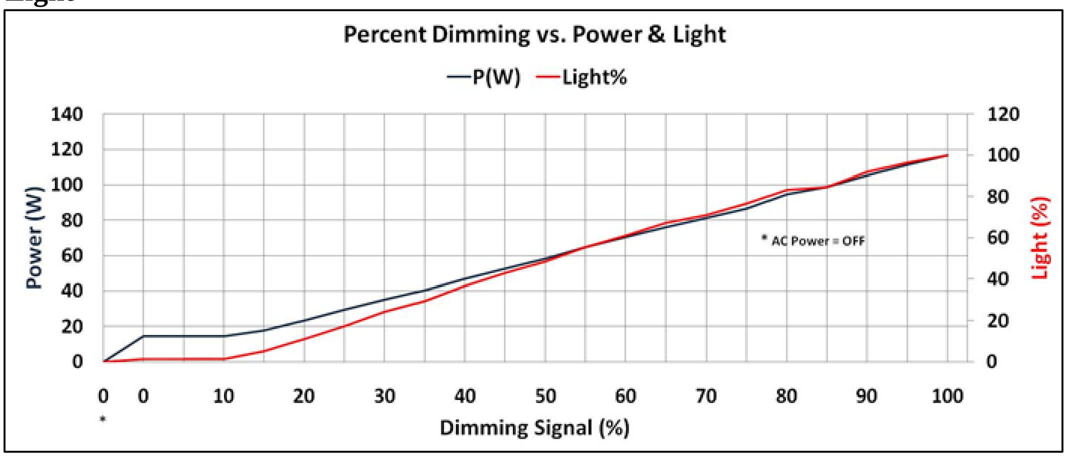
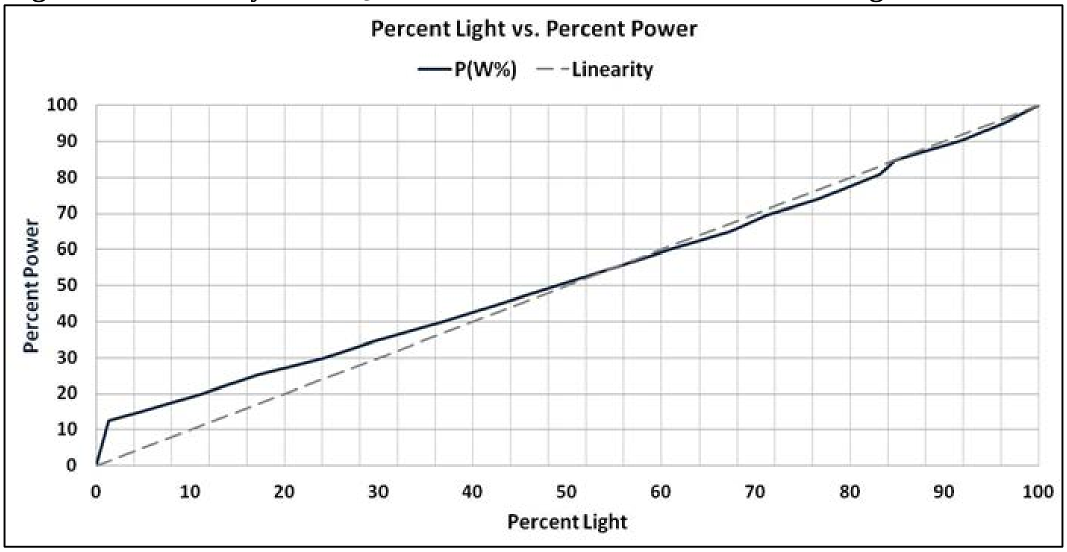


Figure 14. Osram Sylvania QHE-2X54T5HO/UNV DALI: Percent Light vs. Percent Power



3.8. Osram Sylvania QTP-2X32T8/UNV DIM-TC 0-10V (T8)

Table 9 summarizes the findings for the Osram Sylvania QTP-2X32T8/UNV DIM-TC 0-10V. Figure 15 illustrates its performance on percent dimming vs. power and light, and Figure 16 illustrates its performance on percent light vs. percent power. Table 27 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 9. Findings for Osram Sylvania QTP-2X32T8/UNV DIM-TC 0-10V

Dimming Signal	
Active Range	15% - 85%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	85% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.99
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.23%
Power Consumption	
At Zero Dimming Signal	13.9 W
At 50% Dimming Signal	39.8 W
At Full Dimming Signal	60.4 W

Notes: Reference Fixture: Lamp: Sylvania Octron F032/835/ECO, T8, 32W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 15. Osram Sylvania QTP-2X32T8/UNV DIM-TC 0-10V: Percent Dimming vs. Power and Light

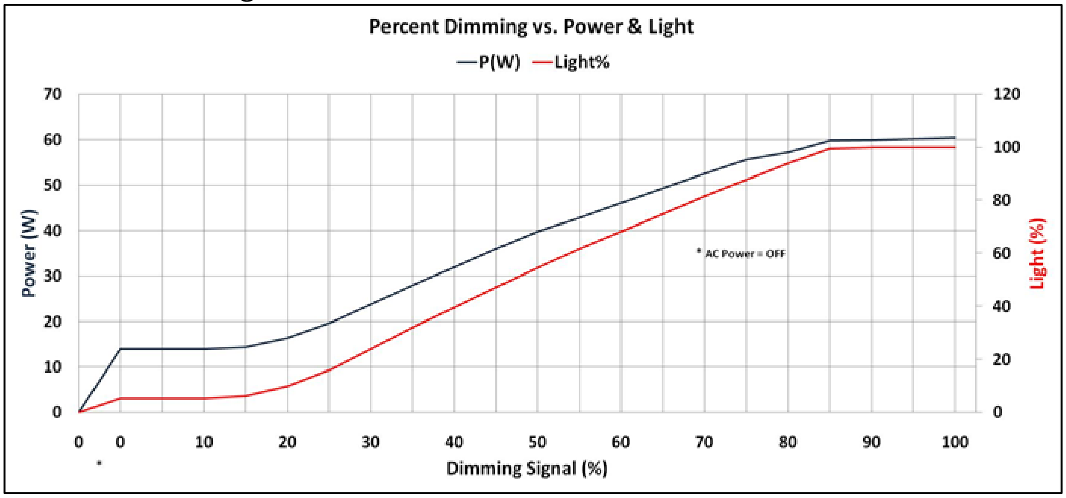
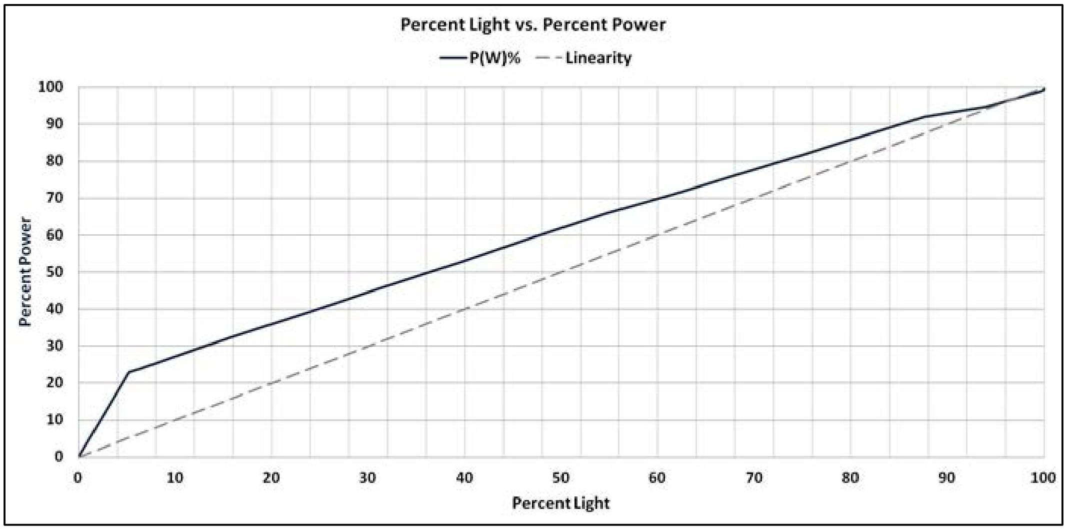


Figure 16. Osram Sylvania QTP-2X32T8/UNV DIM-TC 0-10V: Percent Light vs. Percent Power



3.9. Philips Advance IDA-2S28-D DALI (T5)

Table 10 summarizes the findings for the Philips Advance IDA-2S28-D DALI. Figure 17 illustrates its performance on percent dimming vs. power and light, and Figure 18 illustrates its performance on percent light vs. percent power. Table 28 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 10. Findings for Philips Advance IDA-2S28-D DALI

Dimming Signal	
Active Range	15% - 100%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.97
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.23%
Power Consumption	
At Zero Dimming Signal	10.5 W
At 50% Dimming Signal	31.4 W
At Full Dimming Signal	63.1 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP28/835/ECO, T5, 28W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 17. Philips Advance IDA-2S28-D DALI: Percent Dimming vs. Power and Light

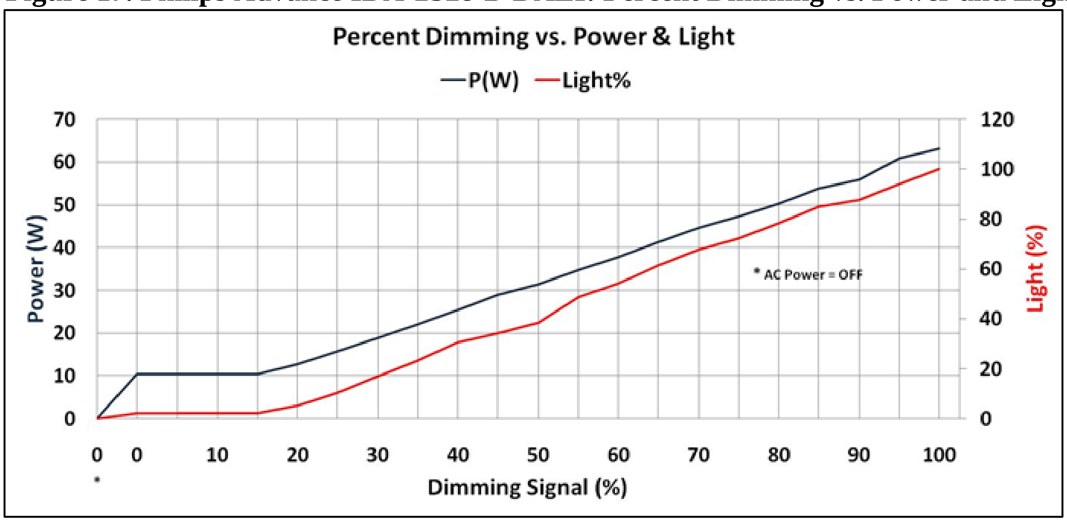
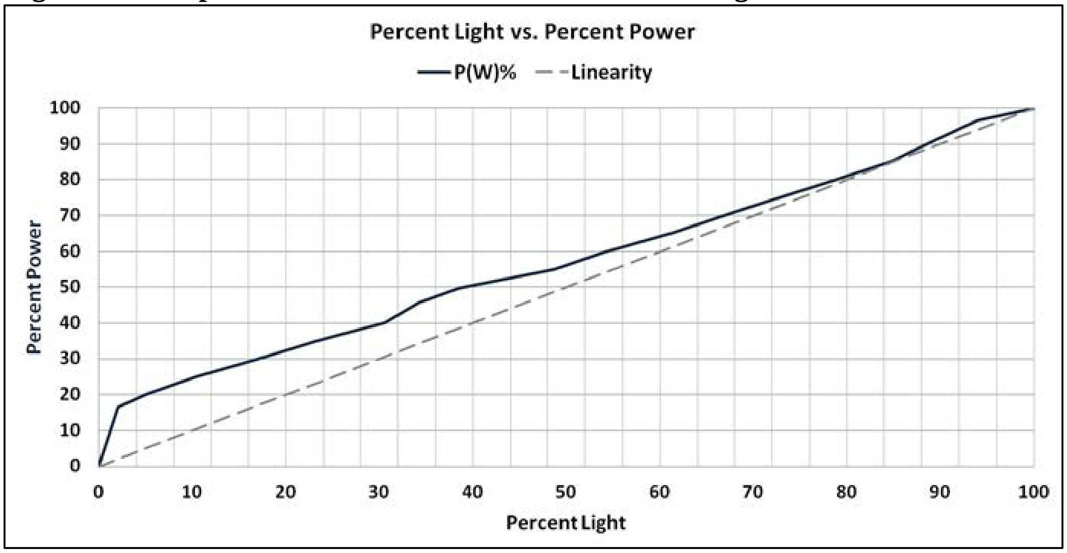


Figure 18. Philips Advance IDA-2S28-D DALI: Percent Light vs. Percent Power



3.10. Philips Advance IDA-2S32-SC DALI (T8)

Table 11 summarizes the findings for the Philips Advance IDA-2S32-SC DALI. Figure 19 illustrates its performance on percent dimming vs. power and light, and Figure 20 illustrates its performance on percent light vs. percent power. Table 29 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 11. Findings for Philips Advance IDA-2S32-SC DALI

Dimming Signal	
Active Range	20% - 100%
Lower End Dead Travel	0% - 20%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.91
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.20%
Power Consumption	
At Zero Dimming Signal	12.1 W
At 50% Dimming Signal	32.4 W
At Full Dimming Signal	64.2 W

Notes: Reference Fixture: Lamp: Sylvania Octron F032/835/ECO, T8, 32W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 19. Philips Advance IDA-2S32-SC DALI: Percent Dimming vs. Power and Light

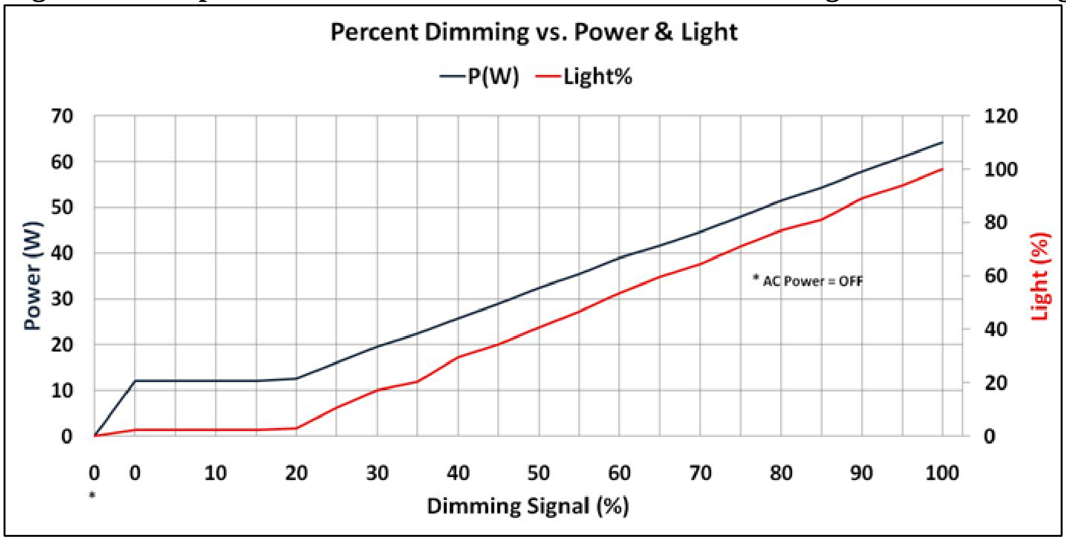
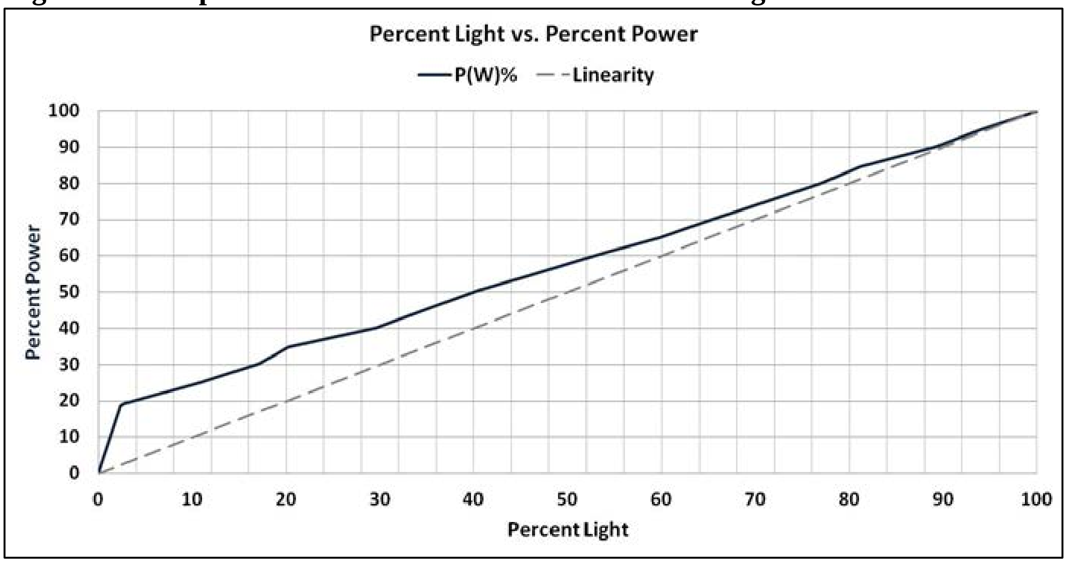


Figure 20. Philips Advance IDA-2S32-SC DALI: Percent Light vs. Percent Power



3.11. Philips Advance IZT-2S28-D 0-10V (T5)

Table 12 summarizes the findings for the Philips Advance IZT-2S28-D 0-10V. Figure 21 illustrates its performance on percent dimming vs. power and light, and Figure 22 illustrates its performance on percent light vs. percent power. Table 30 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 12. Findings for Philips Advance IZT-2S28-D 0-10V

Dimming Signal	
Active Range	10% - 75%
Lower End Dead Travel	0% - 10%
Upper End Dead Travel	75% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.96
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.22%
Power Consumption	
At Zero Dimming Signal	11.5 W
At 50% Dimming Signal	45.5 W
At Full Dimming Signal	62.0 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP28/835/ECO, T5, 28W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 21. Philips Advance IZT-2S28-D 0-10V: Percent Dimming vs. Power and Light

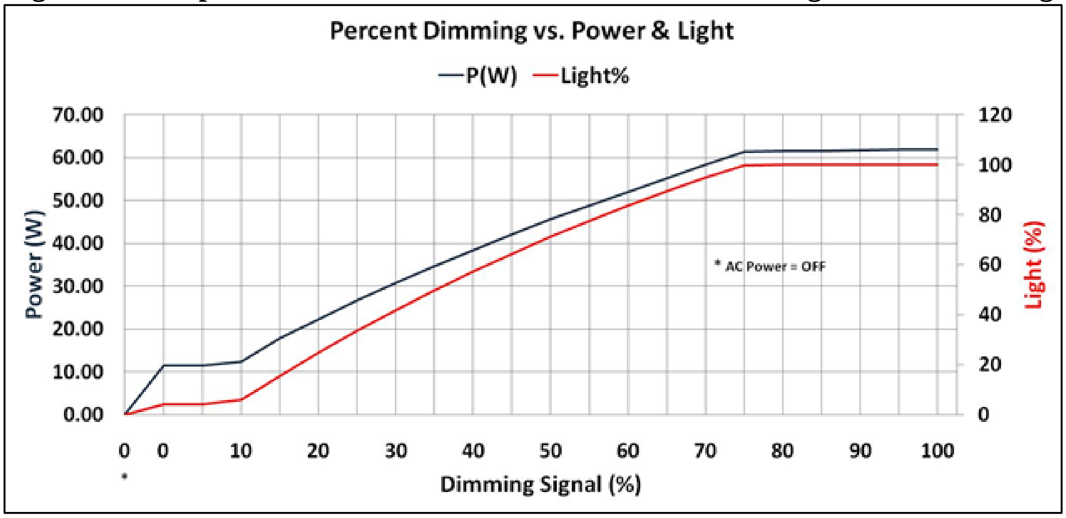
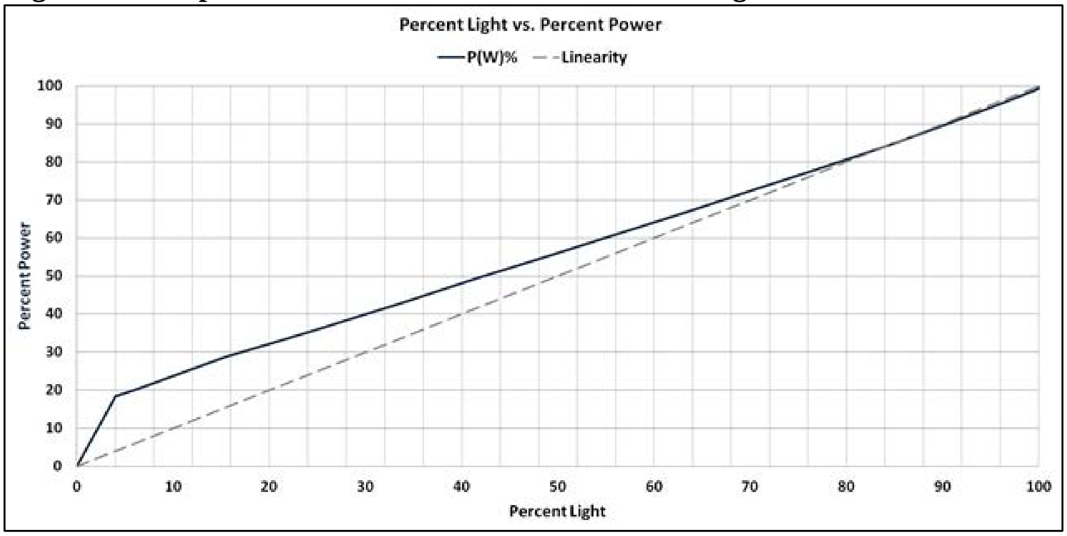


Figure 22. Philips Advance IZT-2S28-D 0-10V: Percent Light vs. Percent Power



3.12. Philips Advance Mark 7 IZT-2S32-SC 0-10V (T8)

Table 13 summarizes the findings for the Philips Advance Mark 7 IZT-2S32-SC 0-10V. Figure 23 illustrates its performance on percent dimming vs. power and light, and Figure 24 illustrates its performance on percent light vs. percent power. Table 31 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 13. Findings for Philips Advance Mark 7 IZT-2S32-SC 0-10V

Dimming Signal	
Active Range	10% - 75%
Lower End Dead Travel	0% - 10%
Upper End Dead Travel	75% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.93
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.24%
Power Consumption	
At Zero Dimming Signal	11.8 W
At 50% Dimming Signal	45.0 W
At Full Dimming Signal	63.3 W

Notes: Reference Fixture: Lamp: Sylvania Octron F032/835/ECO, T8, 32W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 23. Philips Advance Mark 7 IZT-2S32-SC 0-10V: Percent Dimming vs. Power and Light

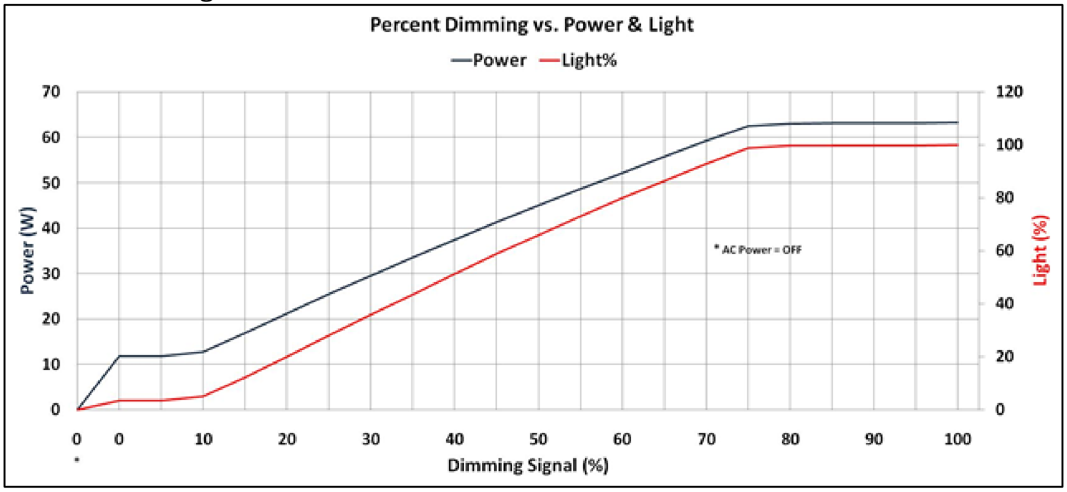
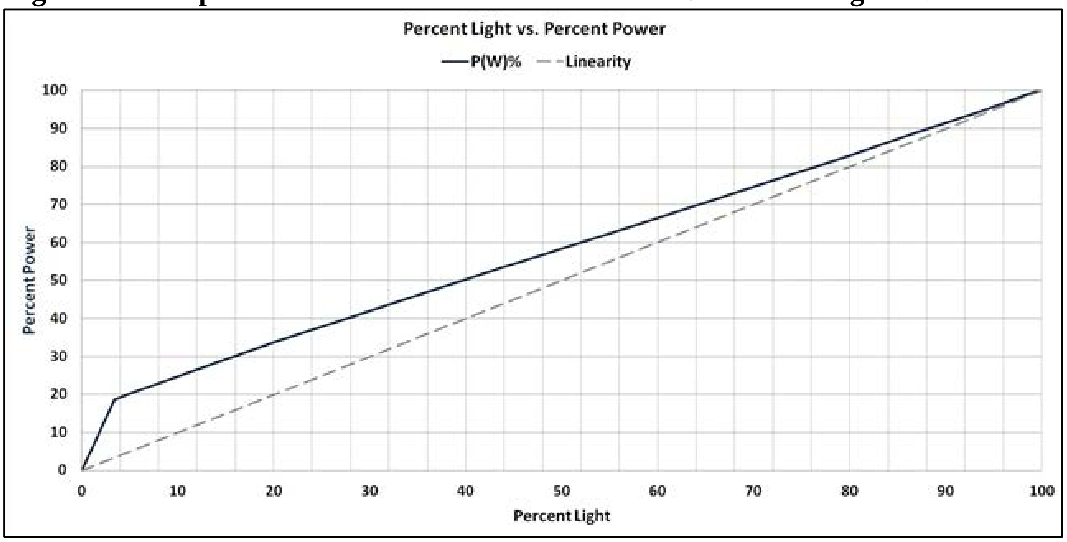


Figure 24. Philips Advance Mark 7 IZT-2S32-SC 0-10V: Percent Light vs. Percent Power



3.13. Philips Advance IZT-2S54-D 0-10V (T5)

Table 14 summarizes the findings for the Philips Advance IZT-2S54-D 0-10V. Figure 25 illustrates its performance on percent dimming vs. power and light, and Figure 26 illustrates its performance on percent light vs. percent power. Table 32 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 14. Findings for Philips Advance IZT-2S54-D 0-10V

Dimming Signal	
Active Range	15% - 75%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	75% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.66
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.31%
Power Consumption	
At Zero Dimming Signal	12.2 W
At 50% Dimming Signal	89.0 W
At Full Dimming Signal	107.1 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP54/835/HO/ECO, T5, 54W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 25. Philips Advance IZT-2S54-D 0-10V: Percent Dimming vs. Power and Light

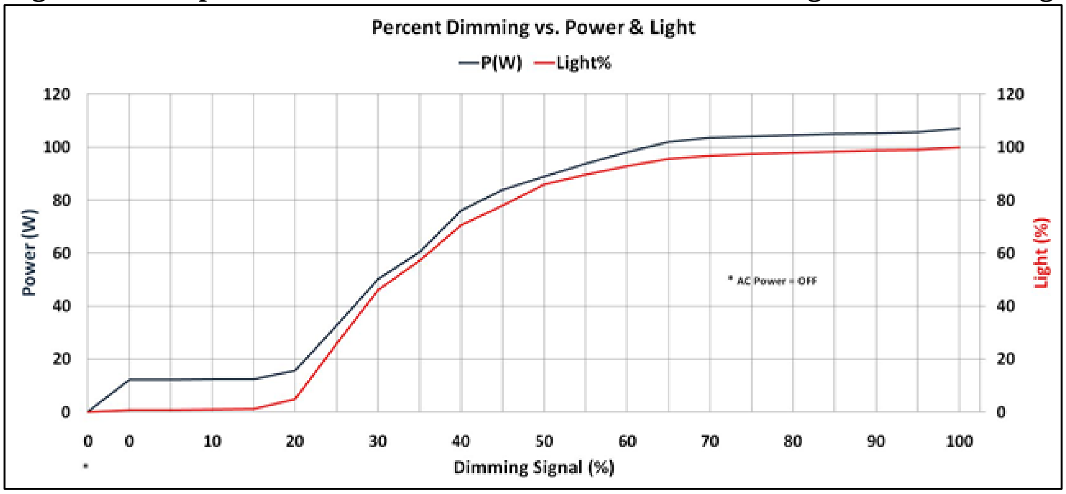
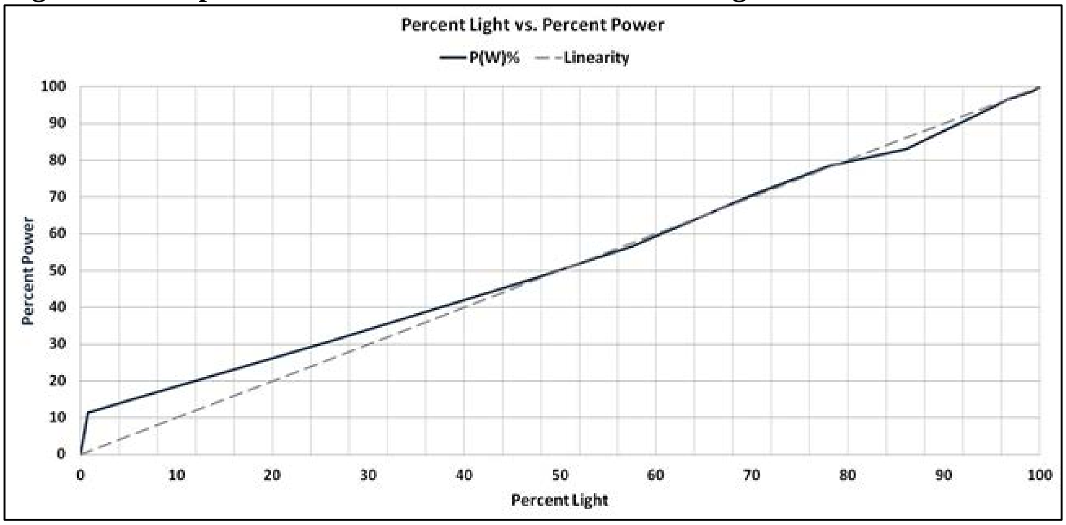


Figure 26. Philips Advance IZT-2S54-D 0-10V: Percent Light vs. Percent Power



3.14. Universal B228PUNVDV1 DALI (T5)

Table 15 summarizes the findings for the Universal B228PUNVDV1 DALI. Figure 27 illustrates its performance on percent dimming vs. power and light, and Figure 28 illustrates its performance on percent light vs. percent power. Table 33 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 15. Findings for Universal B228PUNVDV1 DALI

Dimming Signal	
Active Range	15% - 100%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.81
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.16%
Power Consumption	
At Zero Dimming Signal	8.9 W
At 50% Dimming Signal	29.7 W
At Full Dimming Signal	59.3 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP28/835/ECO, T5, 28W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 27. Universal B228PUNVDV1 DALI: Percent Dimming vs. Power and Light

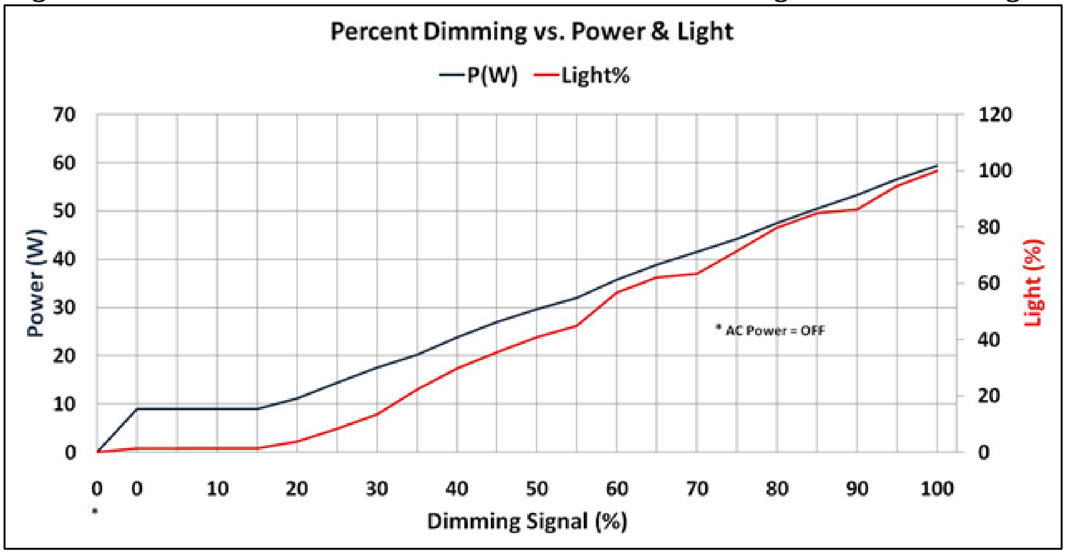
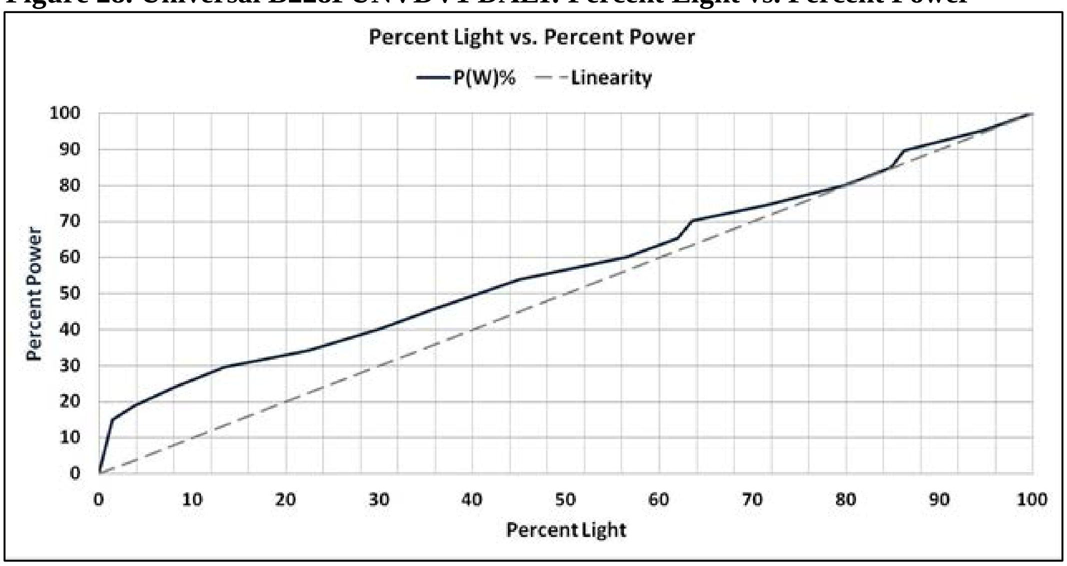


Figure 28. Universal B228PUNVDV1 DALI: Percent Light vs. Percent Power



3.15. Universal B228PUNVSV3-D 0-10V (T5)

Table 16 summarizes the findings for the Universal B228PUNVSV3-D 0-10V. Figure 29 illustrates its performance on percent dimming vs. power and light, and Figure 30 illustrates its performance on percent light vs. percent power. Table 34 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 16. Findings for Universal B228PUNVSV3-D 0-10V

Dimming Signal	
Active Range	15% - 80%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	80% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.79
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.16%
Power Consumption	
At Zero Dimming Signal	11.9 W
At 50% Dimming Signal	39.1 W
At Full Dimming Signal	60.7 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP28/835/ECO, T5, 28W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 29. Universal B228PUNVSV3-D 0-10V: Percent Dimming vs. Power and Light

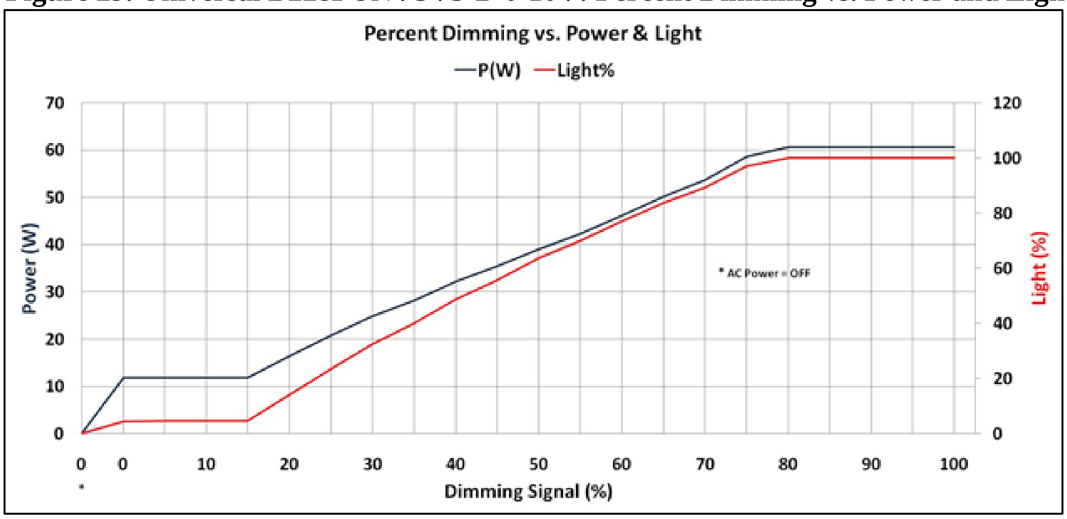
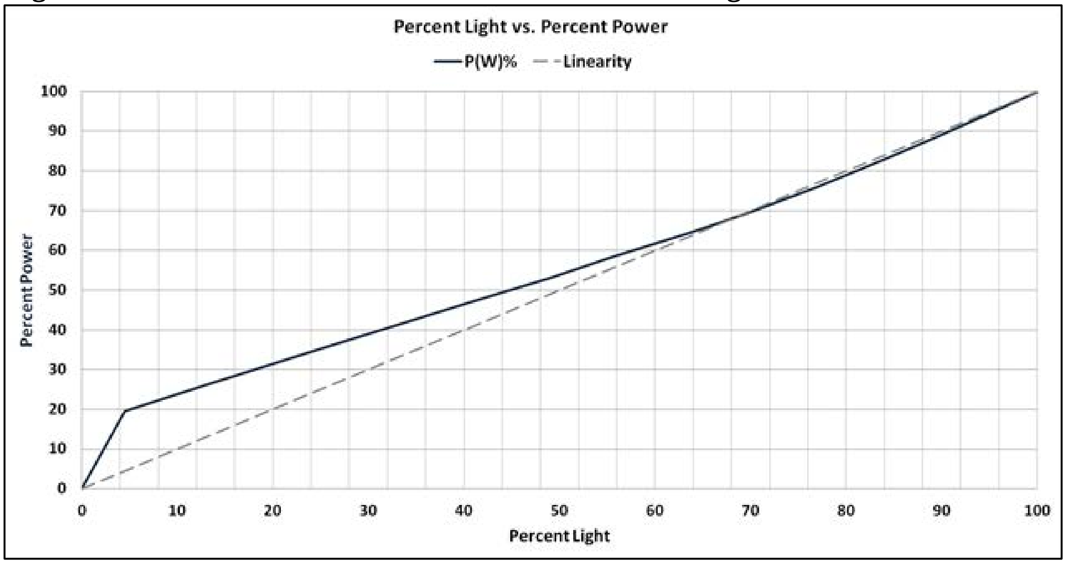


Figure 30. Universal B228PUNVSV3-D 0-10V: Percent Light vs. Percent Power



3.16. Universal B232PUNVDV1 DALI (T8)

Table 17 summarizes the findings for the Universal B232PUNVDV1 DALI. Figure 31 illustrates its performance on percent dimming vs. power and light, and Figure 32 illustrates its performance on percent light vs. percent power. Table 35 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 17. Findings for Universal B232PUNVDV1 DALI

Dimming Signal	
Active Range	15% - 100%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.74
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.22%
Power Consumption	
At Zero Dimming Signal	11.8 W
At 50% Dimming Signal	33.9 W
At Full Dimming Signal	67.4 W

Notes: Reference Fixture: Lamp: Sylvania Octron F032/835/ECO, T8, 32W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 31. Universal B232PUNVDV1 DALI: Percent Dimming vs. Power and Light

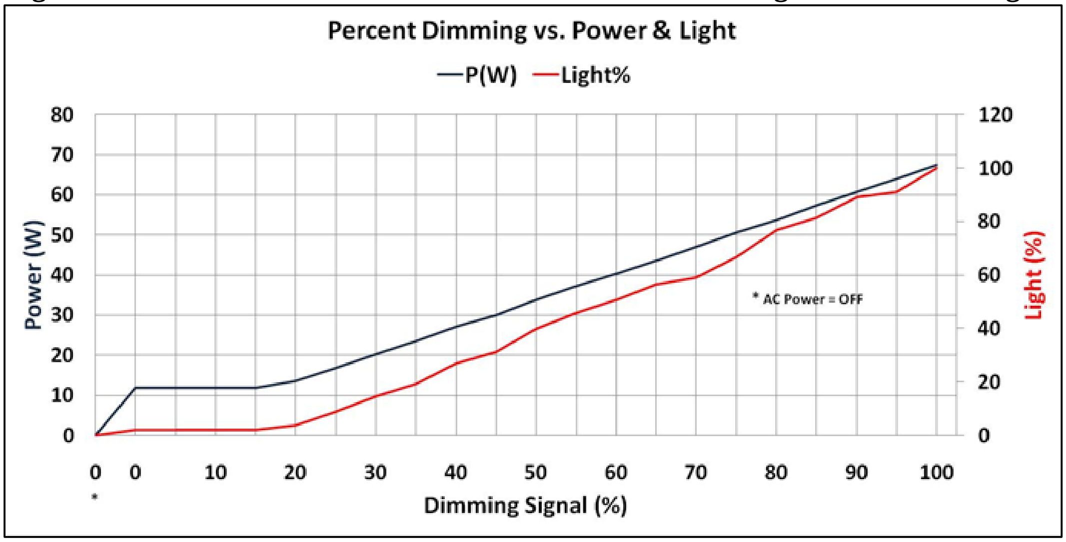
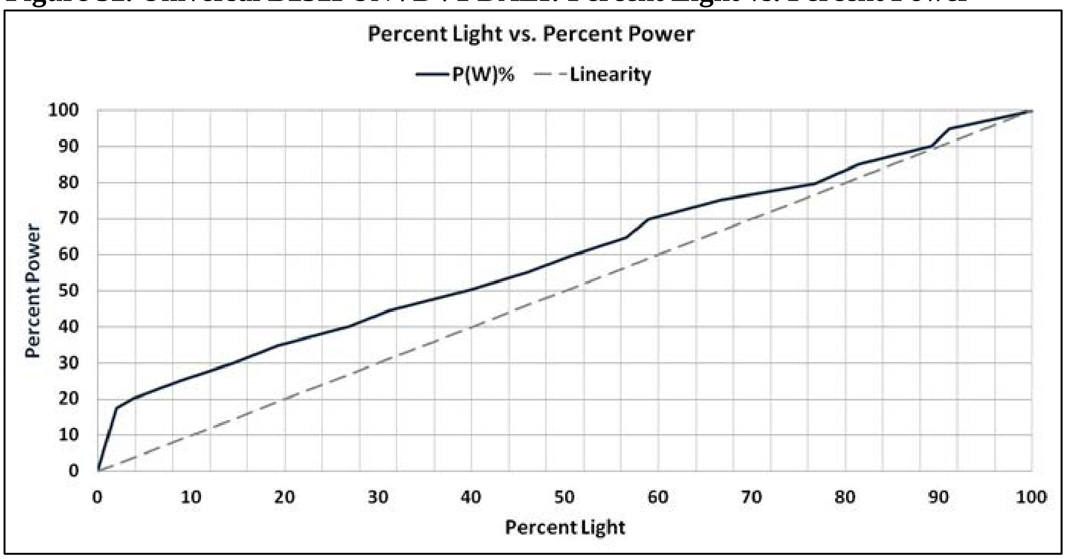


Figure 32. Universal B232PUNVDV1 DALI: Percent Light vs. Percent Power



3.17. Universal B232PUNVSV3-A 0-10V (T8)

Table 18 summarizes the findings for the Universal B232PUNVSV3-A 0-10V. Figure 33 illustrates its performance on percent dimming vs. power and light, and Figure 34 illustrates its performance on percent light vs. percent power. Table 36 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 18. Findings for Universal B232PUNVSV3-A 0-10V

Dimming Signal	
Active Range	15% - 75%
Lower End Dead Travel	0% - 15%
Upper End Dead Travel	75% - 100%
Power Factor (PF) Throughout Dimming Range	> 0.92
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.13%
Power Consumption	
At Zero Dimming Signal	12.2 W
At 50% Dimming Signal	39.1 W
At Full Dimming Signal	55.9 W

Notes: Reference Fixture: Lamp: Sylvania Octron F032/835/ECO, T8, 32W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 33. Universal B232PUNVSV3-A 0-10V: Percent Dimming vs. Power and Light

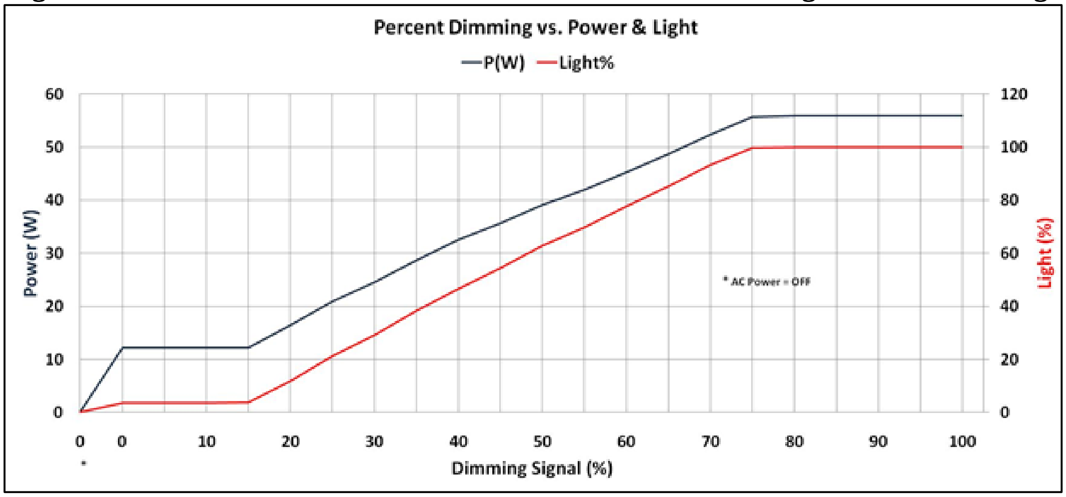
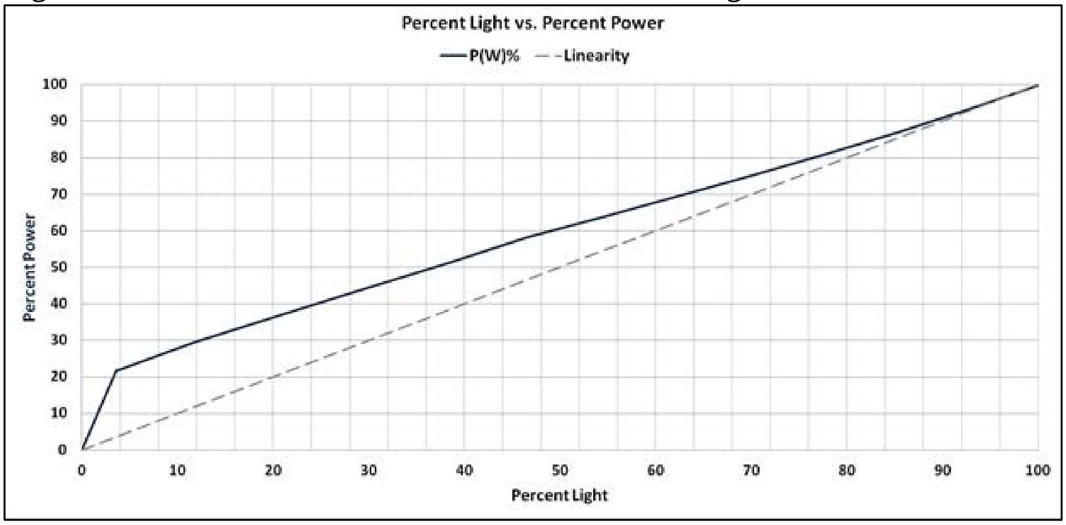


Figure 34. Universal B232PUNVSV3-A 0-10V: Percent Light vs. Percent Power



3.18. Universal B254PUNVDV1 DALI (T5)

Table 19 summarizes the findings for the Universal B254PUNVDV1 DALI. Figure 35 illustrates its performance on percent dimming vs. power and light, and Figure 36 illustrates its performance on percent light vs. percent power. Table 37 in Appendix A contains additional specifications and detailed experimental data for this ballast.

Table 19. Findings for Universal B254PUNVDV1 DALI

Dimming Signal	
Active Range	10% - 100%
Lower End Dead Travel	0% - 10%
Upper End Dead Travel	None
Power Factor (PF) Throughout Dimming Range	> 0.71
Total Harmonic Distortion (V_{thd}) Throughout Dimming Range	< 0.26%
Power Consumption	
At Zero Dimming Signal	14.8 W
At 50% Dimming Signal	51.0 W
At Full Dimming Signal	101.9 W

Notes: Reference Fixture: Lamp: Sylvania Pentron FP54/835/HO/ECO, T5, 54W, 3500K (Qty 2); Troffer: Lithonia Lighting, 2x4 ft, Recessed

Figure 35. Universal B254PUNVDV1 DALI: Percent Dimming vs. Power and Light

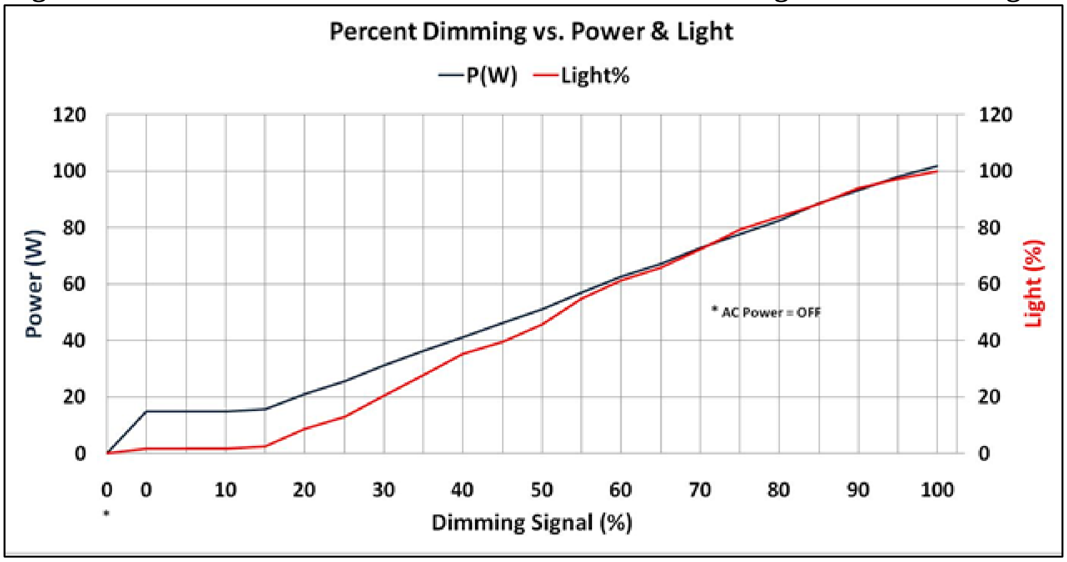
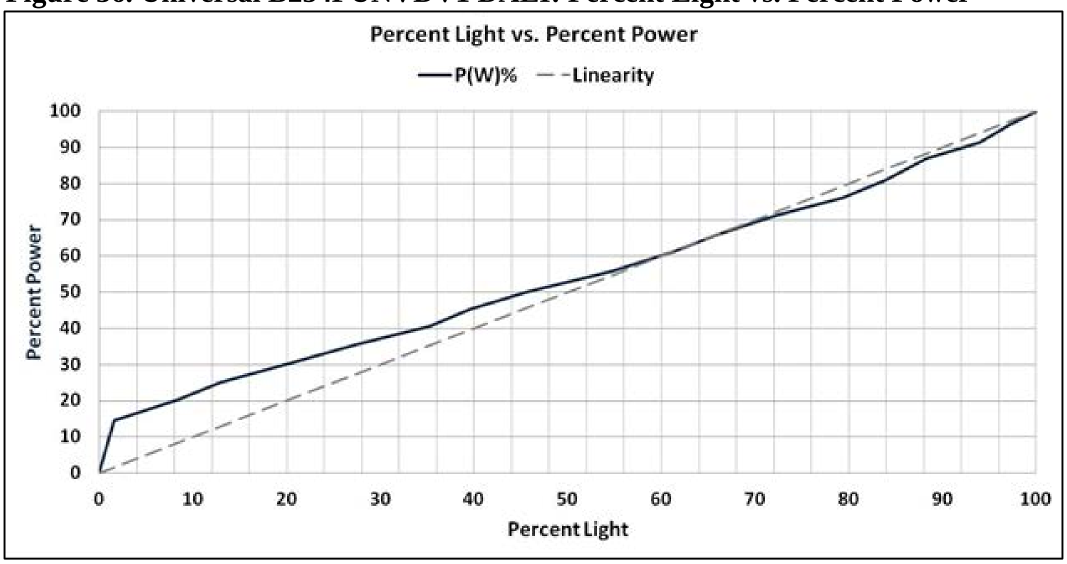


Figure 36. Universal B254PUNVDV1 DALI: Percent Light vs. Percent Power



4. Conclusions

The findings of this study can help to identify incongruences in controlling integrated systems with the goal of energy savings. The traditional premise that dimming by a specific percentage will net an equal percentage in energy savings or light level is not consistent with the results of this study.

- Most ballasts were NOT linear: "dimming" via the control signal by a certain percentage did not lead to the ballast/lamp combination light output dimming by that percentage.
- Most ballasts exhibited a deadband (lack of response to control signal) at the top and bottom of their respective dimming curves. Implementing a "real-time" control scenario to adjust light levels or power, by adjusting the control signal (such as for Demand Response), may result in no change (deadband).
- Most ballasts still consumed significant power when the control signal was set to zero (zero percent). If a control scenario is to dim the lighting system to zero percent at night to save energy, many ballasts would still be consuming ten percent or more of their connected power.
- LLLC devices with embedded and tightly integrated components (including energy reporting capabilities) may monitor actual power consumption and light level to provide a feedback loop to system controllers. Receiving actual energy consumption and light level measurements, when implementing control scenarios, is critical for determining actual savings and program benefits.

These results are consistent with other studies and presentations (e.g., Poplawski 2013).

Next Steps

Future efforts of the Dimming Systems Characteristics study should consist of performing identical tests on LED drivers/sources. This should include the testing of an emerging LED category called "Tubular Light Emitting Diodes" (TLEDs), which are intended to directly replace tubular fluorescent lamps in existing fixtures. Additional efforts could also track and map standards developments toward greater system fidelity, thereby improving utility program planning efforts.

5. References

Poplawski, M. 2013. *Controls Integration: The Matching Game.* Prepared for the U.S. Department of Energy. Richland, WA: Pacific Northwest National Laboratory. Page 28. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/poplawski_controls_portland2013.pdf.

Appendix A – Test Specifications and Data

Table 20. Detailed Specifications and Data for Crestron GLB-DALI-T5-214/35

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Crestron	GLB-DALI-T5-214/35	DALI		
FL Tubes	Sylvania Pentron	FP28/835/ECO x2	T5	28W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.65	19.279	0mV	29.66mV/KLux

Crestron GLB-DALI-T5-214/35 T5 DALI Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
57.8	0.962	0.22%	57.8	100%	73.7	2185.9	
54.9	0.960	0.21%	54.9	95%	67.0	1987.2	
52.2	0.958	0.21%	52.0	90%	66.7	1976.8	
49.3	0.955	0.20%	49.1	85%	63.2	1874.5	
46.2	0.952	0.19%	46.2	80%	58.2	1726.2	
43.2	0.948	0.19%	43.4	75%	54.3	1610.5	
40.1	0.943	0.18%	40.5	70%	49.2	1459.3	
37.2	0.939	0.18%	37.6	65%	44.5	1319.9	
34.2	0.932	0.18%	34.7	60%	40.3	1195.3	
31.4	0.925	0.17%	31.8	55%	34.7	1029.2	
28.4	0.915	0.18%	28.9	50%	29.5	875.0	
26.3	0.906	0.18%	26.0	45%	26.1	774.1	
23.5	0.888	0.19%	23.1	40%	22.1	655.5	
20.2	0.866	0.19%	20.2	35%	16.1	478.4	
17.2	0.837	0.18%	17.3	30%	11.8	351.2	
14.5	0.767	0.28%	14.5	25%	7.6	223.9	
11.4	0.662	0.47%	11.6	20%	3.3	96.7	
9.3	0.586	0.51%	8.7	15%	1.1	32.0	
9.3	0.586	0.51%	5.8	10%	1.1	32.0	
9.3	0.586	0.51%	2.9	5%	1.1	32.0	
9.3	0.586	0.51%	0.0	0%	1.1	32.0	
0.3	0.041	0.16%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF

Table 21. Detailed Specifications and Data for Crestron GLB-DALI-T5HO-254/35

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Crestron	GLB-DALI-T5HO-254/35	DALI		
FL Tubes	Sylvania Pentron	FP54/835/HO/ECO x2	T5	54W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.65	19.279	0mV	29.66mV/KLux

Crestron GLB-DALI-T5HO-254/35 T5 DALI Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
100.2	0.964	0.41%	100.2	100%	114.6	3399.0	
95.1	0.961	0.38%	95.2	95%	111.5	3307.1	
90.2	0.961	0.36%	90.2	90%	107.7	3194.4	
85.2	0.959	0.35%	85.2	85%	102.9	3051.1	
80.3	0.956	0.35%	80.2	80%	96.2	2853.3	
75.2	0.952	0.33%	75.2	75%	91.2	2705.0	
70.1	0.951	0.30%	70.1	70%	84.7	2510.7	
65.1	0.948	0.28%	65.1	65%	78.7	2334.2	
60.1	0.944	0.26%	60.1	60%	65.8	1951.6	
55.7	0.940	0.25%	55.1	55%	65.1	1930.9	
50.1	0.934	0.24%	50.1	50%	56.3	1669.3	
45.1	0.926	0.23%	45.1	45%	45.3	1343.6	
40.2	0.915	0.22%	40.1	40%	40.2	1192.3	
35.1	0.898	0.23%	35.1	35%	29.5	874.4	
30.1	0.878	0.23%	30.1	30%	22.6	671.2	
25.2	0.852	0.23%	25.1	25%	14.6	433.6	
20.0	0.744	0.35%	20.0	20%	7.2	213.6	
15.0	0.629	0.61%	15.0	15%	1.9	55.5	
14.2	0.608	0.67%	10.0	10%	1.4	40.3	
9.3	0.586	0.51%	5.0	5%	1.1	32.0	
9.3	0.586	0.51%	0.0	0%	1.1	32.0	
0.3	0.033	0.16%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF

Table 22. Detailed Specifications and Data for Osram Sylvania QHE-2X28T5/UNV DIM-TCL 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Osram/Sylvania	QHE 2X28T5/UNV DIM-TCL	0-10V		
FL Tubes	Sylvania Pentron	FP28/835/HO/ECOx2	T5	28W	3500K

Reference Data Test Setup

Reference Lamp			Light Sensor				
Type	**Voltage**	**Current**	**Type**	**Output (mV)**	**Lux**	**Offset**	**Cal Sensitivity**
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Osram Sylvania QHE 2X28T5/UNV DIM-TCL Data Capture (Input: 277VAC, 60Hz)

Power Quality Variables			Dimming from Max to Min (100% to 0%)				
			Dimming Control		Light Sensor		
P(W)	**PF**	**Vthd%**	**Input (Vdc)**	**%**	**Output (mV)**	**Lux**	**Notes**
60.3	0.999	0.16%	10.00	100%	78.4	2325.3	
60.3	0.999	0.16%	9.50	95%	78.4	2323.9	
60.2	0.999	0.16%	9.00	90%	78.3	2322.7	
60.2	0.999	0.16%	8.50	85%	78.3	2321.8	
56.8	0.999	0.16%	8.00	80%	74.4	2206.4	
53.6	0.999	0.16%	7.50	75%	70.3	2083.6	
52.0	0.999	0.17%	7.00	70%	65.8	1951.6	
48.7	0.999	0.17%	6.50	65%	61.1	1812.2	
45.2	0.999	0.17%	6.00	60%	55.9	1658.6	
41.5	0.999	0.17%	5.50	55%	50.4	1494.9	
37.5	0.999	0.17%	5.00	50%	44.1	1308.0	
33.1	0.999	0.17%	4.50	45%	37.4	1109.3	
28.5	0.998	0.17%	4.00	40%	30.1	893.7	
25.6	0.998	0.18%	3.50	35%	22.4	664.4	
18.5	0.998	0.18%	3.00	30%	14.3	424.1	
13.3	0.997	0.18%	2.50	25%	6.6	195.2	
10.2	0.999	0.29%	2.00	20%	2.4	69.7	
9.4	0.999	0.29%	1.50	15%	1.3	38.0	
9.3	0.999	0.28%	1.00	10%	1.0	30.3	
9.3	0.999	0.28%	0.50	5%	1.0	30.3	
9.4	0.999	0.28%	0.00	0%	1.0	30.5	
0.00	0.00	0.00	0.00	0%	0.00	0.00	AC Power OFF

Table 23. Detailed Specifications and Data for Osram Sylvania QHE-2X28T5/UNV DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Osram/Sylvania	QHE 2X28T5/UNV DALI	DALI		
FL Tubes	Sylvania Pentron	FP28/835/ECOx2	T5	28W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Osram Sylvania QHE 2X28T5HO/UNV T5 DALI Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
60.5	0.990	0.22%	60.5	100%	77.3	2292.7	
57.6	0.989	0.22%	57.5	95%	73.5	2180.0	
54.8	0.987	0.22%	54.5	90%	70.3	2083.6	
51.8	0.986	0.22%	51.4	85%	64.1	1901.8	
48.5	0.984	0.23%	48.4	80%	59.3	1758.8	
45.4	0.980	0.23%	45.4	75%	55.1	1632.8	
42.5	0.977	0.23%	42.4	70%	49.9	1480.0	
39.9	0.973	0.23%	39.3	65%	46.3	1372.7	
36.1	0.965	0.23%	36.3	60%	41.1	1219.0	
32.8	0.956	0.24%	33.3	55%	34.9	1033.9	
30.1	0.938	0.41%	30.3	50%	31.3	926.9	
27.9	0.928	0.41%	27.2	45%	27.9	827.5	
24.6	0.906	0.38%	24.2	40%	22.8	675.7	
21.7	0.890	0.36%	21.2	35%	18.5	547.2	
18.5	0.837	0.34%	18.2	30%	13.6	401.9	
15.4	0.778	0.31%	15.1	25%	9.0	266.3	
12.0	0.709	0.30%	12.1	20%	4.3	126.9	
9.4	0.633	0.28%	9.1	15%	1.1	31.7	
9.4	0.637	0.28%	6.1	10%	1.1	31.7	
9.4	0.637	0.28%	3.0	5%	1.1	31.7	
9.4	0.637	0.28%	0.0	0%	1.1	31.7	
0.00	0.00	0.00		0%	0.00	0.00	AC Power OFF

Table 24. Detailed Specifications and Data for Osram Sylvania QHE-2X32T8/UNV DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Osram/Sylvania	QHE 2X32T8/UNV DALI	DALI		
FL Tubes	Sylvania Octron	F032/835/ECO x2	T8	32W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Osram/Sylvania QHE 2X32/UNV DALI T8 Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
64.1	0.989	0.20%	64.1	100%	78.1	2316.4	
60.8	0.989	0.20%	60.9	95%	72.4	2147.4	
57.5	0.987	0.20%	57.7	90%	69.9	2073.2	
54.7	0.986	0.20%	54.5	85%	67.1	1990.2	
51.6	0.984	0.20%	51.3	80%	59.7	1770.7	
48.3	0.982	0.20%	48.1	75%	54.3	1610.5	
44.9	0.979	0.20%	44.9	70%	48.2	1429.6	
41.7	0.975	0.20%	41.7	65%	42.6	1263.5	
38.4	0.971	0.20%	38.5	60%	37.5	1113.4	
35.7	0.967	0.21%	35.3	55%	33.9	1005.5	
32.3	0.959	0.21%	32.1	50%	29.9	886.8	
28.8	0.949	0.21%	28.8	45%	24.1	714.8	
25.6	0.934	0.21%	25.6	40%	20.0	593.2	
22.5	0.916	0.22%	22.4	35%	15.6	461.8	
19.1	0.885	0.22%	19.2	30%	10.7	318.3	
16.1	0.834	0.27%	16.0	25%	6.4	188.9	
12.8	0.764	0.26%	12.8	20%	2.3	68.5	
12.8	0.764	0.26%	9.6	15%	2.3	68.5	
12.8	0.764	0.26%	6.4	10%	2.3	68.5	
12.8	0.764	0.26%	3.2	5%	2.3	68.5	
12.8	0.764	0.26%	0.0	0%	2.3	68.5	
0.3	0.062	0.17%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF

Table 25. Detailed Specifications and Data for Osram Sylvania QHE-2X54T5HO/UNV DIM-TCL 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Osram/Sylvania	QHE 2X54T5HO/UNV DIM-TCL	0-10V		
FL Tubes	Sylvania Pentron	FP54/835/HO/ECOx2	T5	54W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Osram Sylvania QHE 2X54T5HO/UNV DIM-TCL Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	Input (Vdc)	%	Output (mV)	Lux	Notes
113.1	0.999	0.17%	10.00	100%	125.8	3731.2	
113.1	0.999	0.17%	9.50	95%	125.7	3728.3	
113.1	0.999	0.17%	9.00	90%	125.6	3725.3	
113.1	0.999	0.17%	8.50	85%	125.6	3725.3	
105.8	0.999	0.17%	8.00	80%	119.8	3553.3	
100.3	0.999	0.17%	7.50	75%	113.3	3360.5	
94.0	0.999	0.17%	7.00	70%	106.9	3170.7	
86.7	0.998	0.17%	6.50	65%	99.7	2957.1	
79.4	0.998	0.17%	6.00	60%	92.0	2728.7	
71.8	0.998	0.17%	5.50	55%	83.7	2482.5	
64.7	0.997	0.17%	5.00	50%	74.5	2209.7	
56.4	0.996	0.18%	4.50	45%	63.6	1886.4	
48.5	0.996	0.18%	4.00	40%	52.6	1560.1	
40.7	0.995	0.18%	3.50	35%	41.1	1219.0	
32.9	0.991	0.19%	3.00	30%	29.3	869.0	
24.9	0.999	0.24%	2.50	25%	17.3	513.1	
18.9	0.999	0.21%	2.00	20%	7.9	232.8	
15.3	0.999	0.20%	1.50	15%	2.7	81.3	
14.1	0.999	0.20%	1.00	10%	1.2	36.5	
14.1	0.999	0.20%	0.50	5%	1.3	37.4	
14.2	0.999	0.20%	0.00	0%	1.3	38.9	
0.00	0.00	0.00	0.00	0%	0.00	0.00	AC Power OFF

Table 26. Detailed Specifications and Data for Osram Sylvania QHE-2X54T5HO/UNV DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Osram/Sylvania	QHE 2X54T5HO/UNV DALI	DALI		
FL Tubes	Sylvania Pentron	FP54/835/HO/ECO x2	T5	54W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Osram Sylvania QHE 2X54T5HO/UNV T5 DALI Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
116.8	0.997	0.21%	116.8	100%	133.2	3950.7	
111.4	0.997	0.22%	111.0	95%	128.6	3814.3	
105.4	0.997	0.22%	105.1	90%	122.4	3630.4	
98.9	0.996	0.22%	99.3	85%	112.8	3345.6	
94.5	0.996	0.21%	93.4	80%	110.8	3286.3	
86.5	0.995	0.22%	87.6	75%	102.1	3028.3	
81.2	0.995	0.22%	81.8	70%	94.8	2811.8	
76.0	0.994	0.22%	75.9	65%	89.6	2658.1	
70.2	0.993	0.22%	70.1	60%	81.4	2414.3	
64.7	0.992	0.22%	64.2	55%	73.8	2188.9	
58.2	0.900	0.22%	58.4	50%	64.7	1919.0	
52.6	0.987	0.22%	52.6	45%	57.4	1702.2	
46.7	0.983	0.23%	46.7	40%	48.8	1447.4	
40.3	0.976	0.23%	40.9	35%	39.2	1161.2	
34.9	0.960	0.45%	35.0	30%	32.1	950.9	
29.4	0.941	0.42%	29.2	25%	22.9	677.7	
23.3	0.904	0.39%	23.4	20%	14.6	433.0	
17.7	0.832	0.33%	17.5	15%	6.6	196.9	
14.6	0.766	0.30%	11.7	10%	1.8	53.4	
14.6	0.766	0.30%	5.8	5%	1.8	53.4	
14.6	0.766	0.30%	0.0	0%	1.8	53.4	
0.3	0.054	0.25%	0.0	Group Off	0.0	0.0	AC Power On
0.00	0.00	0.00	0.00	Group Off	0.00	0.00	AC Power OFF

Table 27. Detailed Specifications and Data for Osram Sylvania QTP-2X32T8/UNV DIM-TC 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Osram/Sylvania	QTP 2X32T8/UNV DIM-TC	0-10V		
FL Tubes	Sylvania Octron	F032/835/ECO x 2	T8	32W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Osram Sylvania QTP 2X32T8/UNV DIM-TC Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	Input (Vdc)	%	Output (mV)	Lux	Notes
60.4	0.9995	0.23%	10.00	100%	68.6	2034.7	
60.1	1.0000	0.23%	9.50	95%	68.6	2034.7	
60.0	1.0000	0.22%	9.00	90%	68.6	2034.7	
59.7	1.0000	0.22%	8.50	85%	68.3	2025.8	
57.2	1.0000	0.22%	8.00	80%	64.4	1910.1	
55.6	0.9999	0.23%	7.50	75%	60.1	1782.6	
52.5	0.9999	0.22%	7.00	70%	55.9	1657.4	
49.3	0.9999	0.22%	6.50	65%	51.4	1524.5	
46.1	0.9999	0.22%	6.00	60%	46.8	1387.8	
42.9	0.9998	0.21%	5.50	55%	42.3	1253.1	
39.8	0.9997	0.22%	5.00	50%	37.4	1110.5	
36.0	0.9996	0.21%	4.50	45%	32.4	960.7	
31.9	0.9994	0.21%	4.00	40%	27.2	805.9	
27.9	0.9990	0.21%	3.50	35%	21.9	649.6	
23.7	0.9980	0.21%	3.00	30%	16.4	487.0	
19.6	0.9980	0.22%	2.50	25%	10.9	321.8	
16.4	0.9970	0.21%	2.00	20%	6.8	201.1	
14.4	0.9960	0.22%	1.50	15%	4.3	128.4	
13.9	0.9950	0.22%	1.00	10%	3.6	105.9	
13.9	0.9950	0.22%	0.50	5%	3.6	105.9	
13.9	0.9950	0.22%	0.00	0%	3.6	105.9	
0.00	0.00	0.00	0.00	0%	0.00	0.00	AC Power OFF

Table 28. Detailed Specifications and Data for Philips Advance IDA-2S28-D DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Philips Advance	IDA-2S28-D	DALI		
FL Tubes	Sylvania Pentron	FP28/835/ECOx2	T5	28W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Philips Advance IDA-2S28-D T5 DALI Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
63.1	0.998	0.23%	63.1	100%	78.2	2319.4	
60.9	0.998	0.22%	59.9	95%	73.5	2180.0	
56.0	0.998	0.21%	56.8	90%	68.5	2031.7	
53.8	0.998	0.20%	53.6	85%	66.4	1968.2	
50.3	0.998	0.19%	50.5	80%	61.2	1815.2	
47.2	0.997	0.18%	47.3	75%	56.6	1679.6	
44.7	0.997	0.17%	44.2	70%	53.0	1570.8	
41.3	0.997	0.16%	41.0	65%	48.1	1426.6	
37.8	0.997	0.16%	37.9	60%	42.3	1254.6	
34.8	0.996	0.15%	34.7	55%	38.1	1130.6	
31.4	0.995	0.14%	31.6	50%	30.1	892.8	
28.9	0.995	0.14%	28.4	45%	26.8	794.6	
25.4	0.994	0.13%	25.2	40%	23.9	708.3	
22.1	0.993	0.13%	22.1	35%	18.2	541.0	
19.0	0.991	0.14%	18.9	30%	13.3	395.7	
15.8	0.987	0.15%	15.8	25%	8.1	239.7	
12.7	0.983	0.15%	12.6	20%	4.0	117.8	
10.5	0.975	0.17%	9.5	15%	1.6	47.2	
10.5	0.975	0.17%	6.3	10%	1.6	47.2	
10.5	0.975	0.17%	3.2	5%	1.6	47.2	
10.5	0.975	0.17%	0.0	0%	1.6	47.2	
1.2	0.698	0.17%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF

Table 29. Detailed Specifications and Data for Philips Advance IDA-2S32-SC DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Philips Advance	IDA-2S32-SC	DALI		
FL Tubes	Sylvania Octron	F032/835/ECO x2	T8	32W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Philips Advance IDA-2S32-SC T8 DALI Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
64.2	0.994	0.19%	64.2	100%	73.3	2174.1	
61.0	0.993	0.19%	61.0	95%	69.0	2045.4	
57.8	0.993	0.18%	57.8	90%	65.4	1938.3	
54.3	0.992	0.18%	54.6	85%	59.5	1764.8	
51.4	0.991	0.17%	51.4	80%	56.5	1674.6	
48.0	0.990	0.17%	48.2	75%	52.0	1542.0	
44.6	0.989	0.17%	44.9	70%	47.4	1404.7	
41.7	0.987	0.16%	41.7	65%	43.8	1297.6	
38.9	0.986	0.16%	38.5	60%	39.3	1165.6	
35.4	0.984	0.16%	35.3	55%	34.2	1013.2	
32.4	0.982	0.15%	32.1	50%	29.8	882.4	
28.9	0.978	0.15%	28.9	45%	25.3	750.4	
25.8	0.975	0.15%	25.7	40%	21.7	642.1	
22.4	0.969	0.15%	22.5	35%	14.8	439.9	
19.5	0.960	0.15%	19.3	30%	12.6	373.4	
16.0	0.947	0.15%	16.1	25%	7.7	229.3	
12.5	0.921	0.16%	12.8	20%	2.1	62.3	
12.1	0.917	0.16%	9.6	15%	1.8	51.9	
12.1	0.917	0.16%	6.4	10%	1.8	51.9	
12.1	0.917	0.16%	3.2	5%	1.8	51.9	
12.1	0.917	0.16%	0.0	0%	1.8	51.9	
1.7	0.471	0.17%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF

Table 30. Detailed Specifications and Data for Philips Advance IZT-2S28-D 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Philips Advance	IZT-2S28-D	0-10V		
FL Tubes	Sylvania Pentron	FP28/835/ECOx2	T5	28W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Philips Advance IZT-2S28-D Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	Input (Vdc)	%	Output (mV)	Lux	Notes
62.0	0.998	0.22%	10.00	100%	76.0	2253.9	
61.8	0.998	0.22%	9.50	95%	76.0	2255.0	
61.7	0.998	0.21%	9.00	90%	76.0	2255.0	
61.6	0.998	0.22%	8.50	85%	76.0	2254.8	
61.6	0.998	0.21%	8.00	80%	76.0	2254.2	
61.3	0.998	0.21%	7.50	75%	75.7	2246.2	
58.4	0.997	0.21%	7.00	70%	72.2	2140.3	
55.2	0.997	0.19%	6.50	65%	68.0	2016.0	
52.0	0.997	0.18%	6.00	60%	63.6	1885.8	
48.7	0.997	0.17%	5.50	55%	59.0	1749.6	
45.5	0.996	0.16%	5.00	50%	54.1	1604.9	
42.0	0.996	0.15%	4.50	45%	48.9	1451.3	
38.4	0.995	0.14%	4.00	40%	43.5	1290.5	
34.7	0.994	0.13%	3.50	35%	37.8	1121.7	
30.8	0.993	0.13%	3.00	30%	31.9	945.0	
26.6	0.992	0.12%	2.50	25%	25.6	757.8	
22.2	0.989	0.11%	2.00	20%	18.9	559.4	
17.8	0.983	0.13%	1.50	15%	11.7	346.7	
12.4	0.971	0.11%	1.00	10%	4.5	132.3	
11.5	0.965	0.12%	0.50	5%	3.2	93.7	
11.5	0.965	0.12%	0.00	0%	3.1	91.4	
0.00	0.00	0.00	0.00	0%	0.00	0.00	AC Power OFF

Table 31. Detailed Specifications and Data for Philips Advance Mark 7 IZT-2S32-SC 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Philips Advance (Mark 7)	IZT-2S32-SC	0-10V		
FL Tubes	Sylvania Octron	F032/835/ECO x 2	T8	32W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Philips Advance Mark 7 IZT-2S32-SC Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	Input (Vdc)	%	Output (mV)	Lux	Notes
63.3	0.995	0.24%	10.00	100%	73.5	2180.0	
63.2	0.995	0.24%	9.50	95%	73.4	2177.0	
63.1	0.995	0.24%	9.00	90%	73.4	2177.0	
63.1	0.995	0.24%	8.50	85%	73.3	2174.1	
63.0	0.995	0.24%	8.00	80%	73.3	2174.1	
62.5	0.995	0.24%	7.50	75%	72.6	2152.1	
59.2	9.995	0.22%	7.00	70%	68.3	2025.8	
55.8	0.994	0.21%	6.50	65%	63.6	1886.4	
52.2	0.993	0.19%	6.00	60%	58.8	1744.0	
48.7	0.993	0.18%	5.50	55%	53.8	1595.1	
45.0	0.991	0.17%	5.00	50%	48.5	1438.5	
41.3	0.990	0.16%	4.50	45%	43.2	1281.3	
37.5	0.988	0.14%	4.00	40%	37.7	1118.2	
33.5	0.986	0.13%	3.50	35%	32.0	949.1	
29.5	0.984	0.13%	3.00	30%	26.3	778.9	
25.4	0.979	0.11%	2.50	25%	20.5	608.6	
21.2	0.973	0.11%	2.00	20%	14.7	435.4	
16.9	0.960	0.11%	1.50	15%	8.9	264.3	
12.7	0.938	0.12%	1.00	10%	3.6	107.4	
11.8	0.931	0.12%	0.50	5%	2.6	75.6	
11.8	0.931	0.12%	0.00	0%	2.5	74.7	
0.00	0.00	0.00	0.00	0%	0.00	0.00	AC Power OFF

Table 32. Detailed Specifications and Data for Philips Advance IZT-2S54-D 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Philips Advance	IZT-2S54-D	0-10V		
FL Tubes	Sylvania Pentron	FP54/835/HO/ECOx2	T5	54W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Philips Advance IZT-2S54-D Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	Input (Vdc)	%	Output (mV)	Lux	Notes
107.1	0.987	0.25%	10.000	100%	123.3	3657.1	
105.6	0.987	0.25%	9.500	95%	122.2	3624.5	
105.3	0.987	0.25%	9.000	90%	121.7	3609.6	
104.9	0.987	0.25%	8.500	85%	121.3	3597.8	
104.5	0.987	0.25%	8.000	80%	120.7	3580.0	
104.1	0.987	0.25%	7.500	75%	120.2	3565.1	
103.5	0.987	0.24%	7.000	70%	119.2	3535.5	
102.0	0.987	0.24%	6.500	65%	117.9	3496.9	
98.0	0.986	0.24%	6.000	60%	114.4	3393.1	
93.7	0.985	0.24%	5.500	55%	110.5	3277.4	
89.0	0.984	0.24%	5.000	50%	106.1	3146.9	
83.9	0.982	0.23%	4.500	45%	96.1	2850.3	
76.2	0.979	0.22%	4.000	40%	87.0	2580.4	
60.5	0.969	0.21%	3.500	35%	70.8	2099.9	
50.2	0.959	0.21%	3.000	30%	56.9	1687.7	
32.8	0.918	0.20%	2.500	25%	31.9	946.2	
15.7	0.745	0.21%	2.000	20%	6.0	178.6	
12.4	0.663	0.23%	1.500	15%	1.3	39.7	
12.3	0.662	0.31%	1.000	10%	1.1	32.3	
12.3	0.662	0.31%	0.500	5%	1.0	30.5	
12.2	0.662	0.31%	0.000	0%	1.0	29.1	
0.00	0.00	0.00	0.000	0%	0.00	0.00	AC Power OFF

Table 33. Detailed Specifications and Data for Universal B228PUNVDV1 DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Universal	B228PUNVDV1	DALI		
FL Tubes	Sylvania Pentron	FP28/835/ECOx2	T5	28W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Universal B228PUNVDV1 T5 Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
59.3	0.991	0.14%	59.3	100%	74.8	2218.3	
56.5	0.991	0.14%	56.3	95%	70.8	2099.9	
53.2	0.990	0.14%	53.4	90%	64.5	1913.1	
50.4	0.989	0.14%	50.4	85%	63.5	1881.9	
47.5	0.987	0.14%	47.4	80%	59.7	1770.7	
44.2	0.986	0.13%	44.5	75%	53.5	1586.8	
41.6	0.985	0.13%	41.5	70%	47.5	1408.9	
38.8	0.982	0.13%	38.5	65%	46.3	1374.1	
35.7	0.980	0.13%	35.6	60%	42.3	1255.2	
32.0	0.976	0.13%	32.6	55%	33.6	997.8	
29.7	0.972	0.13%	29.7	50%	30.5	905.8	
26.9	0.968	0.13%	26.7	45%	26.5	786.0	
23.8	0.961	0.13%	23.7	40%	22.4	664.4	
20.3	0.949	0.13%	20.8	35%	16.7	496.5	
17.6	0.937	0.13%	17.8	30%	10.0	297.8	
14.4	0.911	0.15%	14.8	25%	6.2	182.7	
11.2	0.871	0.14%	11.9	20%	2.9	85.4	
8.9	0.819	0.15%	8.9	15%	1.1	31.4	
8.9	0.819	0.15%	5.9	10%	1.1	31.4	
8.9	0.819	0.15%	3.0	5%	1.1	31.4	
8.9	0.819	0.15%	0.0	0%	1.1	31.4	
1.2	0.273	0.16%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF

Table 34. Detailed Specifications and Data for Universal B228PUNVSV3-D 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Universal	B228PUNVSV3-D	0-10V		
FL Tubes	Sylvania Pentron	FP28/835/ECO x 2	T5	28W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/ KLux

Universal B228PUNVSV3-D Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	Input (Vdc)	%	Output (mV)	Lux	Notes
60.7	0.988	0.16%	10.00	100%	77.7	2303.7	
60.7	0.988	0.16%	9.50	95%	77.7	2303.7	
60.7	0.988	0.16%	9.00	90%	77.7	2303.7	
60.7	0.988	0.16%	8.50	85%	77.7	2303.7	
60.6	0.988	0.16%	8.00	80%	77.7	2303.7	
58.7	0.987	0.16%	7.50	75%	75.4	2235.5	
53.7	0.985	0.15%	7.00	70%	69.4	2058.1	
50.2	0.983	0.15%	6.50	65%	65.1	1929.4	
46.1	0.980	0.15%	6.00	60%	59.8	1772.5	
42.3	0.977	0.15%	5.50	55%	54.3	1609.4	
39.1	0.973	0.15%	5.00	50%	49.4	1466.4	
35.4	0.967	0.14%	4.50	45%	43.2	1280.7	
32.2	0.961	0.13%	4.00	40%	38.0	1125.9	
28.3	0.951	0.13%	3.50	35%	31.2	924.8	
24.8	0.939	0.13%	3.00	30%	25.2	746.8	
20.8	0.916	0.13%	2.50	25%	18.2	541.0	
16.4	0.877	0.13%	2.00	20%	10.9	323.3	
11.8	0.796	0.13%	1.50	15%	3.5	103.8	
11.8	0.796	0.13%	1.00	10%	3.5	104.1	
11.8	0.798	0.13%	0.50	5%	3.5	104.4	
11.9	0.799	0.13%	0.00	0%	3.5	104.4	
0.00	0.00	0.00	0.00	0%	0.00	0.00	AC Power OFF

Table 35. Detailed Specifications and Data for Universal B232PUNVDV1 DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Universal	B232PUNVDV1	DALI		
FL Tubes	Sylvania Octron	F032/835/ECO x2	T8	32W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Universal B232PUNVDV1 T8 DALI Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
67.4	0.987	0.22%	67.4	100%	77.7	2304.6	
64.0	0.986	0.21%	64.0	95%	70.8	2099.9	
60.7	0.985	0.20%	60.7	90%	69.3	2055.4	
57.3	0.983	0.19%	57.3	85%	63.3	1877.5	
53.7	0.981	0.18%	53.9	80%	59.6	1767.7	
50.7	0.979	0.18%	50.6	75%	51.9	1538.8	
47.0	0.976	0.17%	47.2	70%	45.8	1358.4	
43.6	0.972	0.16%	43.8	65%	44.0	1303.6	
40.3	0.968	0.16%	40.4	60%	39.4	1168.6	
37.2	0.963	0.16%	37.1	55%	35.7	1059.5	
33.9	0.957	0.15%	33.7	50%	31.0	919.5	
30.0	0.948	0.15%	30.3	45%	24.2	717.8	
27.1	0.939	0.15%	27.0	40%	20.9	619.3	
23.5	0.923	0.15%	23.6	35%	14.9	443.1	
20.2	0.904	0.15%	20.2	30%	11.3	336.0	
16.9	0.876	0.15%	16.9	25%	6.8	202.0	
13.6	0.802	0.25%	13.5	20%	3.0	89.0	
11.8	0.748	0.28%	10.1	15%	1.5	45.1	
11.8	0.748	0.16%	6.7	10%	1.5	45.1	
11.8	0.748	0.16%	3.4	5%	1.5	45.1	
11.8	0.748	0.16%	0.0	0%	1.5	45.1	
1.2	0.193	0.17%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF

Table 36. Detailed Specifications and Data for Universal B232PUNVSV3-A 0-10V

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Universal	B232PUNVSV3-A	0-10V		
FL Tubes	Sylvania Octron	F032/835/ECO x 2	T8	32W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Universal B232PUNVSV3-A Data Capture (Input: 277VAC, 60Hz)							
			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	Input (Vdc)	%	Output (mV)	Lux	Notes
55.9	0.995	0.10%	10.00	100%	65.8	1951.6	
55.9	0.995	0.10%	9.50	95%	65.8	1951.6	
55.9	0.995	0.10%	9.00	90%	65.8	1951.6	
55.9	0.995	0.10%	8.50	85%	65.8	1951.6	
55.9	0.995	0.10%	8.00	80%	65.8	1951.6	
55.7	0.995	0.10%	7.50	75%	65.6	1945.7	
52.4	0.994	0.10%	7.00	70%	61.3	1818.8	
48.7	0.994	0.11%	6.50	65%	56.1	1663.3	
45.3	0.993	0.11%	6.00	60%	51.1	1515.6	
41.9	0.992	0.10%	5.50	55%	45.9	1360.2	
39.1	0.990	0.11%	5.00	50%	41.4	1226.7	
35.7	0.989	0.11%	4.50	45%	35.8	1062.7	
32.6	0.987	0.11%	4.00	40%	30.7	910.0	
28.7	0.983	0.11%	3.50	35%	25.3	750.1	
24.5	0.977	0.11%	3.00	30%	19.2	568.6	
20.9	0.970	0.12%	2.50	25%	14.0	414.6	
16.5	0.954	0.13%	2.00	20%	7.8	229.9	
12.2	0.921	0.13%	1.50	15%	2.4	70.9	
12.2	0.921	0.13%	1.00	10%	2.4	70.6	
12.2	0.921	0.13%	0.50	5%	2.4	70.6	
12.2	0.920	0.13%	0.00	0%	2.4	70.6	
0.00	0.00	0.00	0.00	0%	0.00	0.00	AC Power OFF

Table 37. Detailed Specifications and Data for Universal B254PUNVDV1 DALI

Device	Mfr	M/N	Type	P(W)	Lumens
Ballast	Universal	B254PUNVDV1	DALI		
FL Tubes	Sylvania Pentron	FP54/835/HO/ECO x2	T5	54W	3500K

Reference Data Test Setup							
Reference Lamp			Light Sensor				
Type	Voltage	Current	Type	Output (mV)	Lux	Offset	Cal Sensitivity
Halogen Krypton	5.00	0.949	Photopic Detector	0.66	19.576	0mV	29.66mV/KLux

Universal B254PUNVDV1 T5 Data Capture (Input: 277VAC, 60Hz)

			Dimming from Max to Min (100% to 0%)				
Power Quality Variables			Dimming Control		Light Sensor		
P(W)	PF	Vthd%	%FS_Calc (W)	%	Output (mV)	Lux	Notes
101.9	0.989	0.26%	103.5	100%	117.3	3479.1	
98.1	0.988	0.25%	98.3	95%	113.9	3378.3	
93.2	0.988	0.24%	93.2	90%	110.2	3268.5	
88.6	0.986	0.23%	88.0	85%	103.6	3073.4	
82.5	0.985	0.21%	82.8	80%	98.4	2917.1	
77.5	0.983	0.21%	77.6	75%	93.1	2761.3	
72.7	0.981	0.20%	72.5	70%	84.8	2514.9	
67.1	0.978	0.19%	67.3	65%	77.3	2292.1	
62.5	0.976	0.19%	62.1	60%	71.9	2132.6	
56.9	0.973	0.19%	56.9	55%	64.2	1904.2	
51.0	0.972	0.19%	51.8	50%	53.7	1592.1	
46.2	0.962	0.18%	46.6	45%	46.5	1377.7	
41.2	0.955	0.18%	41.4	40%	41.2	1222.9	
36.4	0.046	0.18%	36.2	35%	32.5	962.5	
31.1	0.931	0.13%	31.1	30%	24.0	711.8	
25.5	0.888	0.32%	25.9	25%	15.1	447.9	
20.9	0.828	0.41%	20.7	20%	10.0	296.6	
15.6	0.735	0.44%	15.5	15%	2.8	82.8	
14.8	0.719	0.44%	10.4	10%	1.8	54.6	
14.8	0.719	0.44%	5.2	5%	1.8	54.6	
14.8	0.719	0.44%	0.0	0%	1.8	54.6	
1.5	0.191	0.17%	NA	Group OFF	0.0	0.0	AC Power ON
0.00	0.00	0.00	NA	Group OFF	0.0	0.0	AC Power OFF