ANALYSIS OF ELECTRICAL CHARACTERISTICS OF COMMERCIAL LED FLAT PANEL LIGHTs DURING DIMMING PROCESS

Hau-Chen Yen[1*] Shih-An Yin [2]

[1] *Department of Electrical Engineering, Far East University, Tainan, Taiwan*

[2]*Department of Mechanical Engineering, Chienkuo Technology University, Changhua, Taiwan*

**Email: yenc66@yahoo.com.tw*

Abstract

The development of LED technology has made LED lighting widely used. High-efficiency LED drivers enable LED lamps to achieve energy conservation and carbon reduction, which has become a major trend in world lighting. This paper measures the electrical characteristics of 100%, 75%, 50%, 25%, 10%, and 0% of the rated power of commercial LED panel lights, and observes the power factor, current total harmonic distortion, and conversion efficiency. The measurement results of 10 sets of LED panel lights show that the electrical characteristics at rated power all comply with safety regulations, but when dimmed to less than 50% of rated power, many electrical characteristics do not comply with safety regulations. In addition, the rated power of commercial LED panel lights is designed to be below 40W. Although they can operate on 230V, their power factor, current total harmonic distortion, and conversion efficiency are worse than those operating on 120V.

Keywords: LED FLAT PANEL LIGHT, POWER FACTOR, CURRENT TOTAL HARMONIC DISTORTION, and CONVERSION EFFICIENCY

1. Introduction

Since the 1950s, the global usage of artificial lighting has been increasing at a rate of approximately 6% per year. According to data from the International Energy Agency, in 2005, lighting accounted for 19% of the world‘s total electricity consumption, amounting to 2,651 TWh (terawatt-hours). LED light bulbs are compared to Compact Fluorescent Lamps (CFLs) and incandescent lights, have lower environmental impacts. The U.S. Department of Energy (DOE) also pointed out that widespread adoption of LED lighting in the United States by 2030 could result in nearly a 50% reduction in energy consumption. It is estimated that the cumulative electricity savings between 2010 and 2030 could reach 2,700 TWh, which is equivalent to saving $250 billion in expenses and reducing carbon dioxide emissions by 1.8 billion metric tons. The quantity and variety of LED lighting products are continuously expanding, and their applications are continually broadening, leading to remarkable growth in the global LED lighting and photonics market.

2. Measurement Architecture

To swiftly respond to environmental demands and adjust light intensity, there's a growing trend toward implementing smart lighting systems that can be remotely monitored. Communication technologies for smart lighting systems can be broadly categorized into wired and wireless options. This paper focuses on the electrical characteristics measurement of LED lighting fixtures available in Taiwan, all of which feature dimming capabilities, as shown in Figure 1.

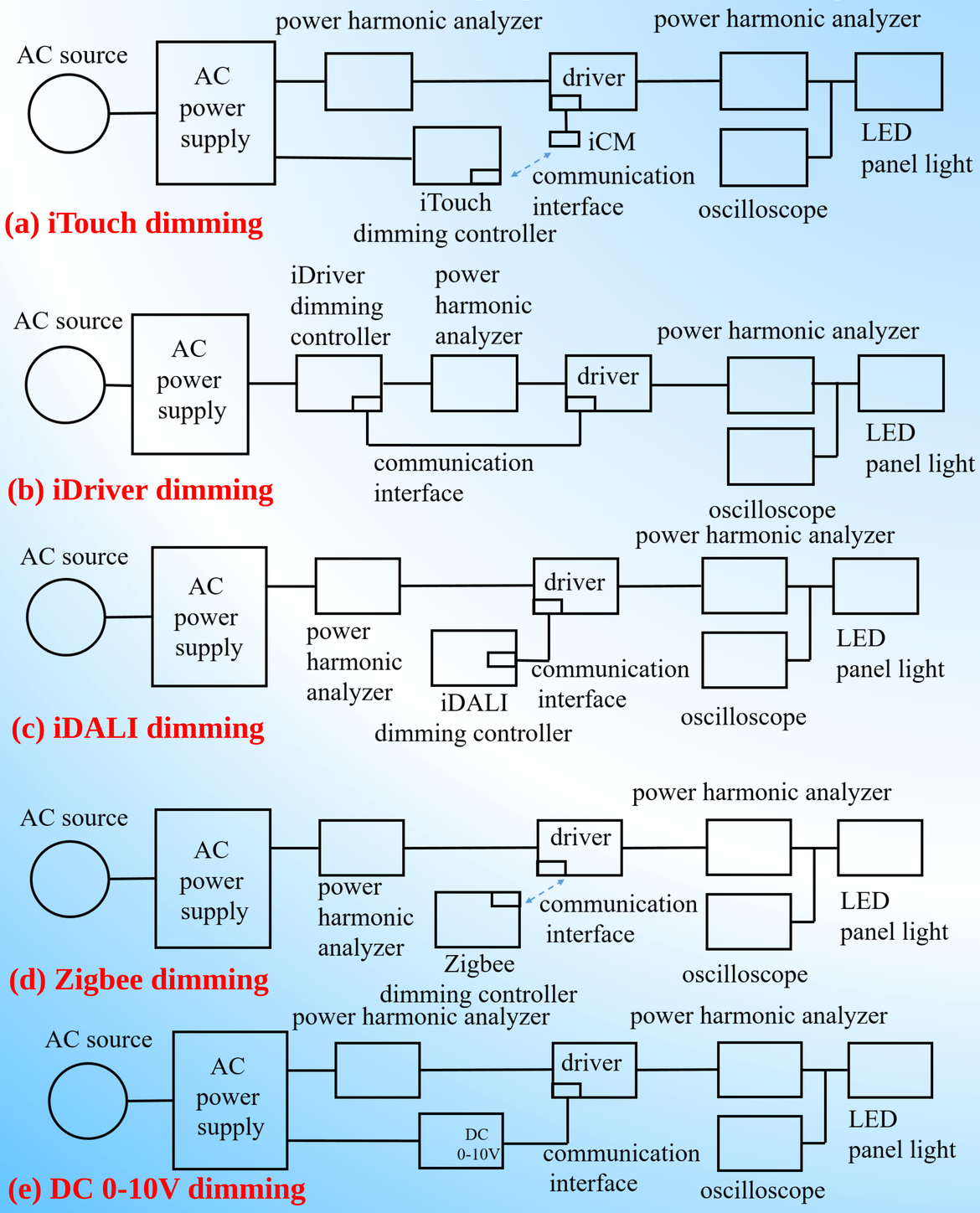

Figure 1 Five dimming modes and measurement structure

3. Results

Table 1 shows 10 groups of LED panel lights with the configuration architecture in Figure 1 setting the mains supply at 120V and 230V. Adjust the dimming controller so that the input power is at 100%, 75%, 50%, 25%, 10%, and 0% of the rated power respectively.

Table 1 Electrical characteristics of different Commoditys

Commodity-1, rated power 21W, iTouch dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	21.20	178.74	0.988	7.26	17.48	33.22	526.20	82.45
	75%	15.86	134.62	0.981	8.99	12.69	32.74	387.40	80.01
	50%	10.58	92.43	0.954	15.86	7.90	32.12	245.90	74.67
	25%	5.29	49.38	0.891	20.23	3.04	31.32	97.00	57.47
	10%	**	**	**	**	**	**	**	**
	0%	1.58	24.32	0.542	53.55	0	55.48	0	0
230	100%	21.52	100.89	0.928	11.00	17.47	32.18	525.80	81.18
	75%	15.52	75.51	0.894	16.08	12.09	32.62	370.50	77.90
	50%	10.56	55.60	0.826	15.97	7.58	32.05	236.40	71.78
	25%	5.33	38.55	0.601	20.88	3.06	31.30	97.66	57.41
	10%	**	**	**	**	**	**	**	**
	0%	1.42	21.66	0.284	33.39	0	55.13	0	0

Commodity-2, rated power 21W, iTouch dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	21.06	177.08	0.990	6.61	18.52	42.68	434.00	87.94
	75%	15.56	130.07	0.996	5.97	13.65	42.21	323.50	87.72
	50%	10.47	87.46	0.997	5.40	9.03	41.73	216.30	86.25
	25%	5.17	44.00	0.978	5.87	4.13	41.03	100.69	79.88
	10%	2.27	21.26	0.888	8.86	1.36	39.62	30.14	59.91
	0%	0.58	13.08	0.371	39.22	0	50.41	0	0
230	100%	20.97	93.44	0.976	6.39	18.46	42.59	433.40	88.03
	75%	15.31	82.72	0.805	48.34	13.17	42.11	312.80	86.02
	50%	10.81	58.18	0.808	32.82	9.04	41.69	216.70	83.62
	25%	5.14	30.40	0.735	20.40	3.68	40.94	89.98	71.59
	10%	**	**	**	**	**	**	**	**
	0%	0.79	12.00	0.286	28.57	0	50.41	0	0

Commodity-3, rated power 18W, iTouch dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	18.10	151.47	0.995	8.70	15.88	41.92	378.70	87.73
	75%	13.49	113.11	0.993	8.12	11.76	41.57	282.90	87.18
	50%	9.09	77.23	0.980	7.26	7.76	41.16	188.40	85.37
	25%	4.59	42.36	0.902	10.35	3.57	40.59	87.98	77.78
	10%	**	**	**	**	**	**	**	**
	0%	0.57	13.40	0.356	51.81	0	50.10	0	0
230	100%	17.98	86.25	0.906	9.07	15.74	41.89	375.80	87.54
	75%	13.47	69.25	0.846	13.95	11.58	41.52	278.80	85.97
	50%	9.06	52.31	0.753	25.57	7.41	41.09	180.27	81.79
	25%	4.52	35.21	0.558	52.10	2.84	40.43	70.30	62.83
	10%	**	**	**	**	**	**	**	**
	0%	0.62	11.13	0.241	34.86	0	50.09	0	0

Commodity-4, rated power 30W, DC 0-10V dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	29.62	249.47	0.989	4.65	24.27	34.68	693.70	81.94
	75%	22.80	193.18	0.983	5.46	18.13	34.04	525.90	79.52
	50%	15.02	129.37	0.967	6.72	11.12	33.12	328.60	74.03
	25%	7.52	69.83	0.896	10.33	4.31	32.00	132.10	57.31
	10%	3.18	57.50	0.461	100.12	0.65	30.89	20.75	20.44
	0%	2.31	47.35	0.407	83.16	0	50.38	0	0
230	100%	30.00	143.67	0.908	8.31	24.30	34.68	694.20	81.00
	75%	22.52	113.30	0.864	11.19	17.43	33.95	506.70	77.40
	50%	14.92	85.25	0.761	15.97	10.42	33.02	308.50	69.84
	25%	7.48	59.12	0.550	25.69	3.57	31.86	110.13	47.73
	10%	**	**	**	**	**	**	**	**
	0%	2.57	39.12	0.285	34.01	0	50.28	0	0

Commodity-5, rated power 21W, iTouch dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	21.28	179.43	0.988	8.24	17.62	35.60	494.90	82.80
	75%	15.45	131.53	0.978	11.34	11.55	33.99	335.20	74.76
	50%	10.51	91.72	0.954	18.01	5.88	31.94	176.38	55.95
	25%	5.39	50.86	0.882	29.77	1.52	29.71	47.55	28.20
	10%	**	**	**	**	**	**	**	**
	0%	1.87	26.45	0.587	60.18	0	55.11	0	0
230	100%	21.17	99.59	0.924	14.62	17.61	35.62	494.40	83.18
	75%	15.67	77.50	0.879	20.64	12.64	33.80	357.70	80.66
	50%	10.41	55.80	0.811	25.73	7.88	33.06	235.20	75.70
	25%	5.26	36.03	0.635	30.45	3.18	31.27	99.01	60.46
	10%	**	**	**	**	**	**	**	**
	0%	1.96	24.29	0.351	34.56	0	55.49	0	0

Commodity-6, rated power 21W, iDriver dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	21.01	179.40	0.976	17.21	18.76	42.07	446.00	89.29
	75%	15.84	134.51	0.981	16.19	14.16	41.72	339.30	89.39
	50%	10.63	90.49	0.978	15.04	9.40	41.31	227.60	88.43
	25%	5.34	48.26	0.921	12.68	4.50	40.72	11.40	84.30
	10%	**	**	**	**	**	**	**	**
	0%	0.28	7.36	0.319	53.40	0	51.54	0	0
230	100%	20.74	96.50	0.934	16.53	18.57	42.08	441.30	89.54
	75%	15.52	76.77	0.879	15.40	13.81	41.70	331.20	88.98
	50%	10.48	57.98	0.786	16.47	9.05	41.27	219.20	86.35
	25%	5.80	39.59	0.637	40.61	4.50	40.72	110.37	77.59
	10%	**	**	**	**	**	**	**	**
	0%	0.39	9.68	0.174	27.11	0	51.14	0	0

Commodity-7, rated power 30W, DC 0-10V dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	29.80	251.03	0.989	4.80	24.20	34.59	693.30	81.21
	75%	22.78	193.01	0.983	5.78	17.75	33.91	516.80	77.92
	50%	15.54	133.78	0.968	7.94	11.09	33.06	328.30	71.36
	25%	7.40	68.85	0.896	13.59	3.55	31.81	109.58	47.97
	10%	**	**	**	**	**	**	**	**
	0%	3.29	56.78	0.483	89.25	0	52.17	0	0
230	100%	29.85	142.74	0.909	8.63	23.83	34.54	683.60	79.83
	75%	22.13	111.72	0.861	11.75	16.61	33.79	485.00	75.06
	50%	15.08	85.22	0.769	16.37	9.97	32.90	296.50	66.11
	25%	7.53	58.43	0.560	26.44	2.88	31.67	89.64	38.25
	10%	**	**	**	**	**	**	**	**
	0%	3.39	428.4	0.344	35.75	0	50.52	0	0

Commodity-8, rated power 23W, iDriver dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	22.44	189.68	0.986	11.61	20.05	42.78	468.80	89.35
	75%	17.47	147.01	0.990	10.58	15.64	42.39	369.10	89.52
	50%	11.77	98.95	0.991	9.64	10.47	41.87	250.00	88.95
	25%	5.89	51.53	0.952	7.39	4.96	41.15	120.52	84.21
	10%	**	**	**	**	**	**	**	**
	0%	0.32	7.62	0.355	54.60	0	52.07	0	0
230	100%	22.29	102.71	0.944	11.67	20.06	42.78	469.00	90.00
	75%	17.49	88.20	0.862	36.70	15.56	42.38	367.10	88.97
	50%	11.74	75.72	0.674	48.98	10.00	41.82	239.10	85.18
	25%	5.97	40.37	0.643	43.54	4.48	41.07	108.96	75.04
	10%	**	**	**	**	**	**	**	**
	0%	0.50	9.93	0.218	33.53	0	52.10	0	0

Commodity-9, rated power 23W, iDALI dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	22.91	195.44	0.976	18.37	20.18	42.38	471.10	88.08
	75%	16.89	143.10	0.982	17.32	14.42	42.30	340.70	85.38
	50%	11.35	96.02	0.985	17.00	9.41	41.77	225.20	82.91
	25%	5.39	47.62	0.943	16.56	3.57	40.59	87.98	66.23
	10%	**	**	**	**	**	**	**	**
	0%	1.05	20.44	0.429	51.35	0	50.27	0	0
230	100%	22.73	103.88	0.951	14.55	20.16	42.84	470.50	88.69
	75%	17.38	83.16	0.909	15.25	14.84	42.36	350.40	85.39
	50%	8.34	50.57	0.717	36.07	6.25	41.37	150.95	74.94
	25%	**	**	**	**	**	**	**	**
	10%	**	**	**	**	**	**	**	**
	0%	1.26	14.27	0.383	71.15	0	50.26	0	0

Commodity-10, rated power 40W, ZigBee dimming

Vi(rms) (V)	Pi (W)		Ii(rms) (mA)	PF	iTHD (%)	Po (W)	Vo(dc) (V)	Io(dc) (mA)	η (%)
120	100%	37.64	316.92	0.989	11.30	32.40	50.82	637.50	86.08
	75%	29.50	249.36	0.985	12.77	25.37	50.15	505.90	86.00
	50%	21.25	181.01	0.978	14.72	17.85	49.36	361.60	84.00
	25%	10.50	92.61	0.944	21.29	7.93	48.00	165.13	75.52
	10%	4.19	45.57	0.765	51.27	2.03	46.64	43.42	48.45
	0%	1.68	24.33	0.577	95.92	0	67.16	0	0
230	100%	37.22	171.63	0.943	16.42	32.36	50.84	636.70	86.94
	75%	30.22	142.57	0.922	19.58	26.03	50.20	518.50	86.14
	50%	18.90	96.63	0.850	30.26	15.48	49.10	315.20	81.90
	25%	9.25	67.81	0.593	68.83	6.29	47.74	131.79	68.00
	10%	**	**	**	**	**	**	**	**
	0%	1.51	18.14	0.361	81.37	0	67.06	0	0

4. Conclusion

The maturity of semiconductor technology has caused the luminous efficiency (lm/W) of LED products to continue to grow, causing the electrical specifications of LED lamps of different brands to vary greatly. If the electrical conditions of LED light sources and drivers can be standardized and the two can be separated, LED light sources and drivers produced by different manufacturers are interchangeable, allowing users to easily replace them, which will help the development of LED lamps.

5. Acknowledgements

This work was supported by a project grant from the Industrial Technology Research Institute, R.O.C., project name: Development and application promotion project of energy-saving lighting and driving power technology.