

HMI Lighting Testing for High-Speed Capture

SIRT Centre | Sheridan College

Pinewood Toronto Studios

225 Commissioners Street, Suite 200B
Toronto, Ontario, M4M 0A1



Investigators

Investigators: Bert Dunk (A.S.C., C.S.C.) and John Helliker

Collaborators: Michael Goencz, Jim Hagarty, Jordan Jancic, Mike Harwood, Chris Lew, Lucas Joseph.

Introduction

Since the first practical application of high-speed motion picture photography, our ability to capture images at high-speeds has evolved dramatically. This phase of motion pictures initially gathered interest in the form of research. As early as 1910, the Marey Institute of Paris captured as many as 2000 pictures in a single second. With current digital image capture, the interest and availability of high speed photography has had an impact not only in the scientific world, but in the entertainment industry as well.

In the late 1960's the first HMI lighting source was introduced in film capture. It was developed as a more efficient means of producing a daylight balanced light source. Initially, however, there was an issue with HMI lighting that caused a flicker to occur when filming at high speeds. Flicker occurs when the output of the light source is at a different "refresh rate" than the frame rate of the camera. As HMI light sources grew in popularity, it was realized there was a need to develop a new ballast that would allow them to be used with high frame rates. Using ballasts that have higher refresh rates solves this problem. Power Gems is one company that has developed and manufactures this type of ballast.

Objective

SIRT's objective was to test industry standard HMI lights coupled with Power Gems' high frequency electronic ballasts to determine whether or not they produce flicker when capturing images at high speed.

Procedures

Day One testing was the filming of a DSC Labs 18% matte gray card (See figure 1). This test was to determine whether flicker was visible on the gray card which was monitored by a Harris Videotech VTM 4150PKG waveform monitor/vector scope. The color

temperature (in degrees kelvin) of the DSC Labs gray card was measured with a Photo Research PR-680L SpectraDuo color meter. The camera was squared to the center of the gray card. The lights were positioned 45° on either side of the center line of the camera to produce an even exposure across the surface of the gray card. The 18K Power Gems ballasts were tested on both studio and generator power to compare the stability of both sources of power. It was determined that

the generator held the line frequency more precisely. The M18, M40 and M90 Power Gems ballast were tested on generator power.

Days two and three saw multiple live action sequences filmed to demonstrate the ballast's flicker free settings in real world situations. Day two (Figure 2.) had one setup with multiple shots of an actor with a variation of fabrics flowing in the wind created by a visual effects fan.

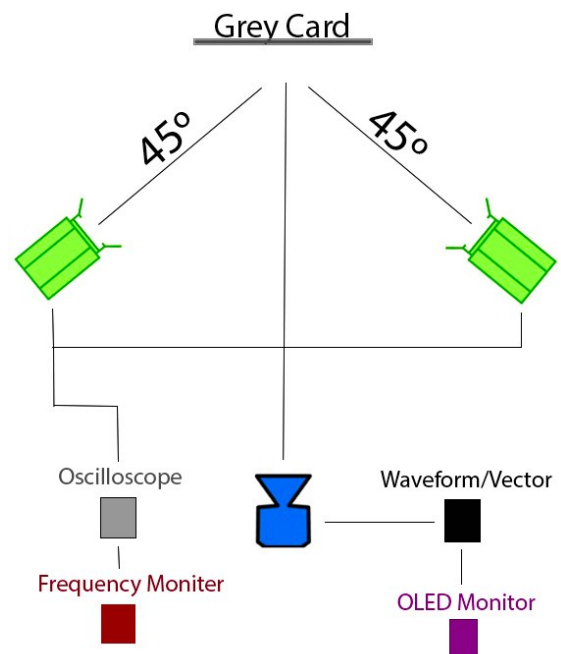


Figure 1.

HMI Lighting Testing for High-Speed Capture

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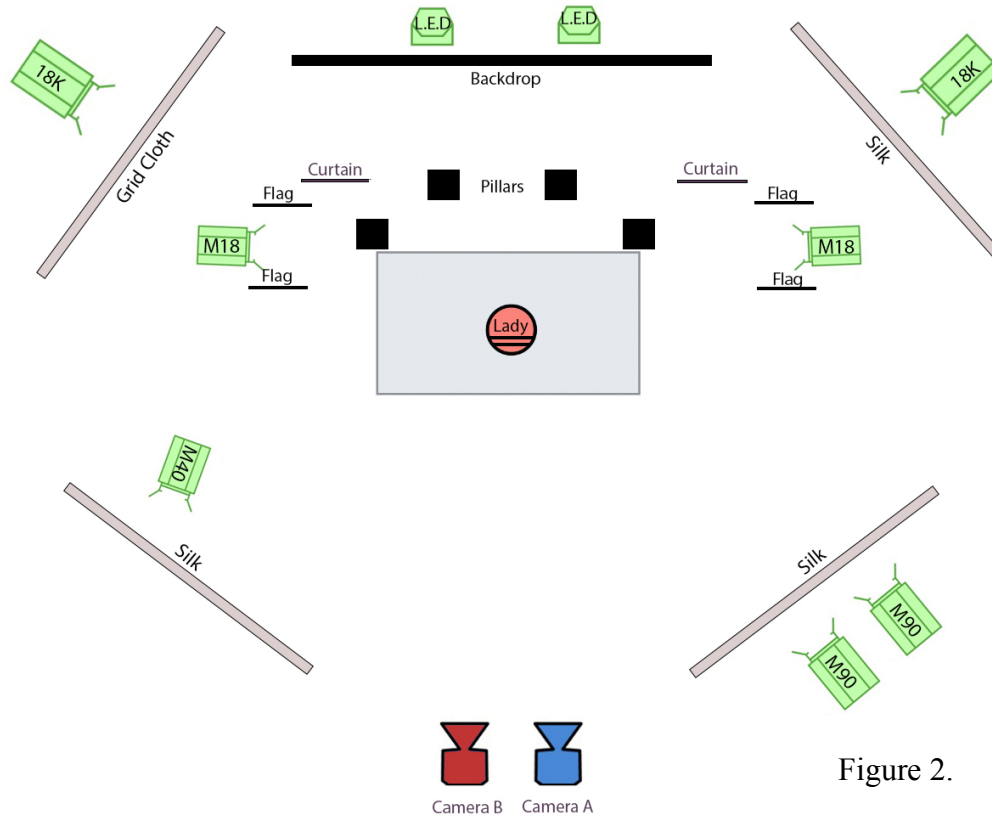


Figure 2.

The third day had multiple set ups with a variety of shots. The first shot (Figure 3.) was a shot of milk being poured into a glass bowl.

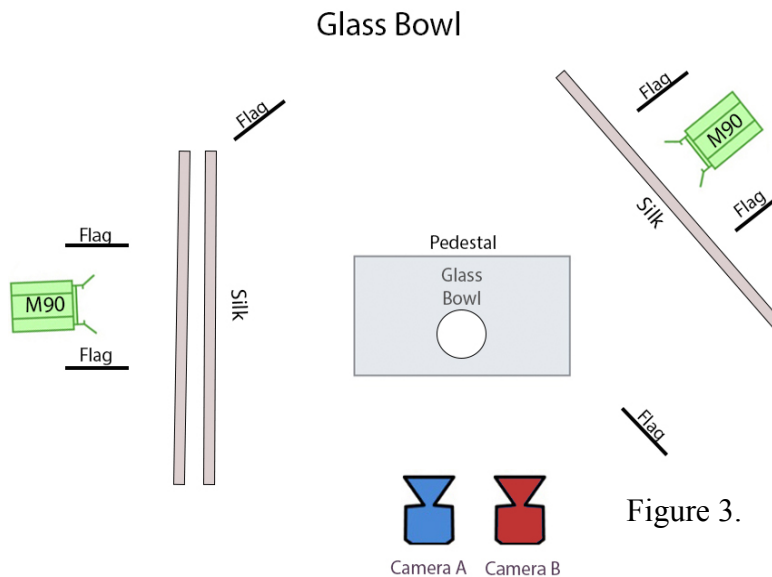


Figure 3.

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The second (Figure 4.) included different objects falling onto a granite counter top.

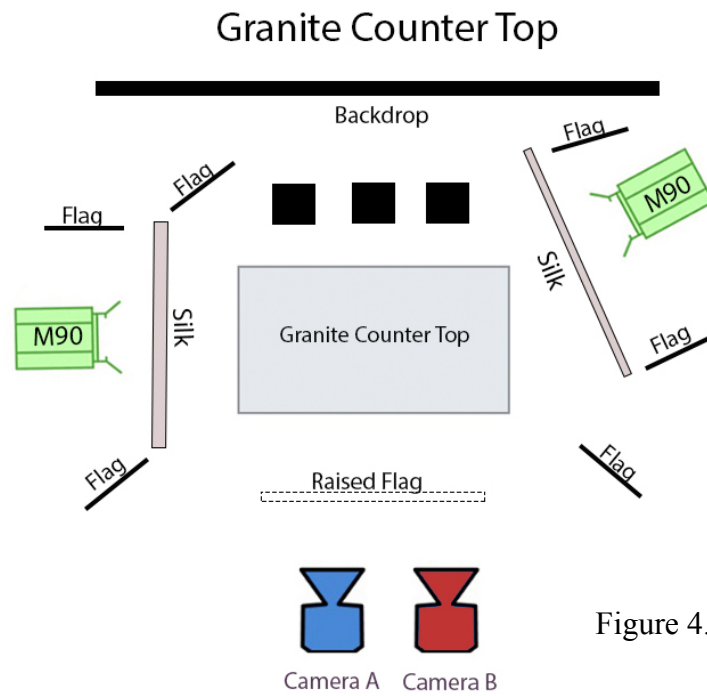


Figure 4.

The third (Figure 5.) was a metal spike dropping onto a mirror.

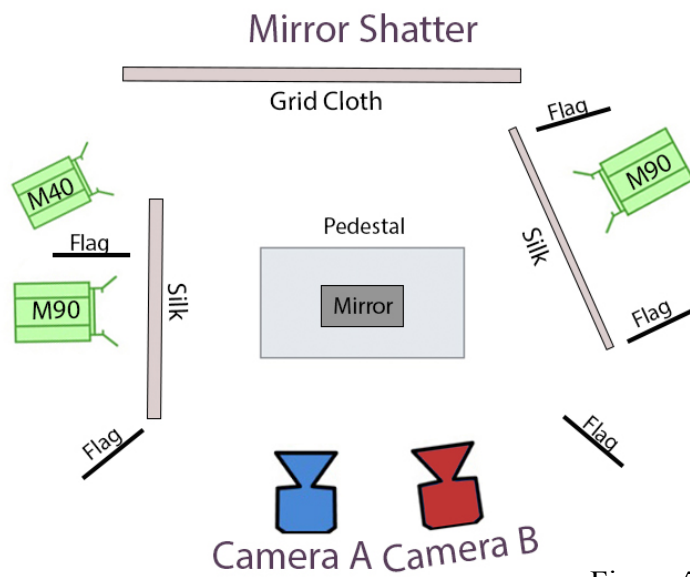


Figure 5.

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The fourth (Figure 6.) was a billiard ball falling into a large tank of water.

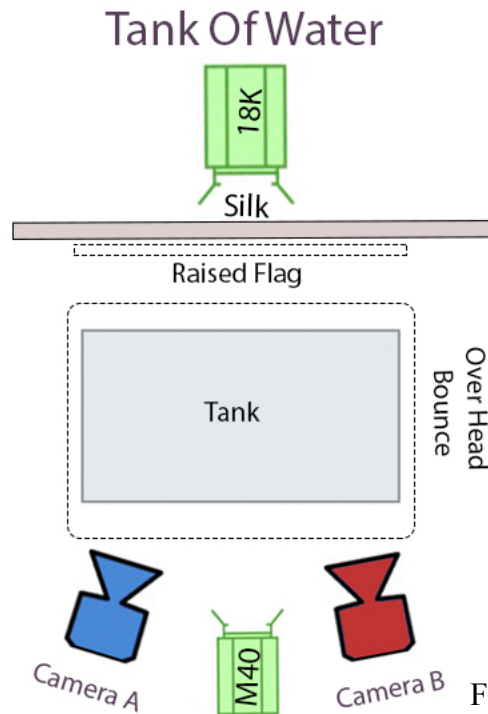


Figure 6.

The fifth and final shot (Figure 7.) was of a hand grabbing a billiard ball out of the tank

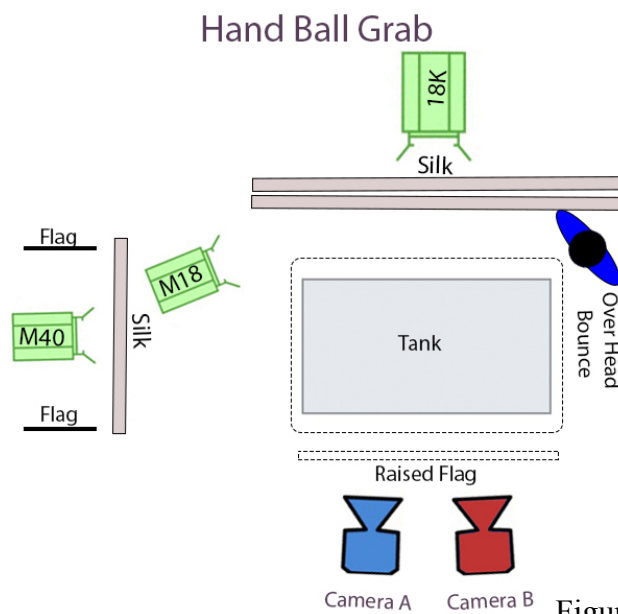


Figure 7.

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Technical Variables

The 18K Power Gem ballasts were tested on studio power and generator power. The M90, M40 and M18 Power Gem ballasts were tested on generator power. Both sources were captured with each camera.

Power Gems ballasts:

• **EB18126P 18000W**

- Serial: #71688, #71688

• **EB960P 9000W**

- Serial: #860045, #860046

• **EB425PL 4000W**

- Serial: #770298, #770299, #770300, #770301

• **EB180P 1800W**

- Serial: #760428, #76042

The lighting units tested included:

Arri HMI Lights

• **18K**

- Serial: #1311597, #1311598

• **M90**

- Serial: #B-583, #B-598

• **M40**

- Serial: #B-1490, #B-1493, #B-1494, #B-1500

• **M18**

- Serial: #B-1543, #B-3128

Cameras:

• **Weisscam HS2**

- Serial: #1041

• **Phantom Flex**

- Serial: #VR0411-11129

• **Phantom Gold**

- Serial: #VR0907-7050

• **Red Epic**

- Serial: #00470

• **Arri Alexa**

- Serial: #25486

• **Sony F65**

- Serial: #10096

• **Sony F5/F55**

- Serial: PMWF5-4

Other Equipment

• **PCO.dimax HD camera** was used to test the 10,000 frames per second speed.

- Serial: #9000000234

• **Harris Videotech VTM 4150PKG**
Waveform/Vector scope

- Serial: #0312M0081

• **DSC Labs 18% Gray Card**

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-
- Serial: #SXW14030701
 - **BK Precision Oscilloscope**
 - Serial: #2540B
 - **Burrell Generator**
 - Serial: #BG46466719
 - **Spectra Professional IV "A" Light Meter**
 - Serial: #073480
 - **Photo Research SpectraDuo PR680L**
 - Serial: #68110501
 - **Sony BVM-E250A OLED Monitor**
 - Serial: # 7000033

During testing the following variables were recorded: Light type, voltage, current (amps), frequency (hertz), colour temperature (degrees Kelvin), foot candles, t-stop, shutter angle, camera distance, take numbers, and duration of each take.

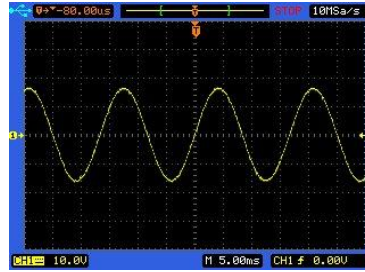
Based on the source of power (studio power or generator), disparities between the volts, amps and frequency were recorded on each day.

CINEMILLS 12/18K

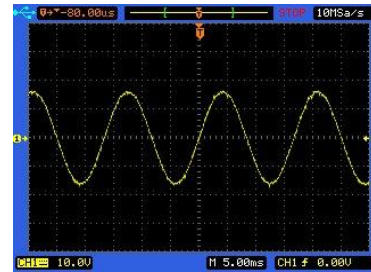


BALLAST	BALLAST SER.#	LIGHT SER.#	LIGHT
EB18126P	#71688	#1311597	18K
	#71689	#1311598	

HOUSE POWER



GENERATOR POWER



ARRI ALEXA

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 1	TAKE 1	120 FPS	RED LEG 116.6/99.9	BLUE LEG 117.2/97.9	BLACK LEG 116.0/169.6	60.1	300Hz	No

RED EPIC

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 2	TAKE 1	120 FPS	RED LEG 117.7/97.9	BLUE LEG 118.6/96.2	BLACK LEG 117.3/167.6	60	300Hz	No

SONY F65

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 3	TAKE 1	120 FPS	RED LEG 117.9/97.5	BLUE LEG 118.9/96.0	BLACK LEG 117.6/166.1	60	300Hz	No

SONY F55

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 4	TAKE 1	60 FPS	RED LEG 117.9/97.5	BLUE LEG 118.9/96.0	BLACK LEG 117.3/166.0	60	300Hz	No

PHANTOM FLEX

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 5	TAKE 1	1200 FPS	RED LEG 118.0/97.5	BLUE LEG 119.1/96.0	BLACK LEG 117.7/166.0	60	300Hz	Minimal

WEISSCAM									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 6	TAKE 1	1200 FPS	RED LEG 117.8/97.4	BLUE LEG 118.7/95.4	BLACK LEG 117.2/166.2	60	300Hz	No
		TAKE 2	2000 FPS				60	300Hz	Minimal

PHANTOM GOLD									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 7	TAKE 1	1000 FPS	RED LEG 117.5/97.8	BLUE LEG 118.8/96.0	BLACK LEG 117.6/166.5	60	300Hz	Minimal
		TAKE 2	600 FPS				60	300Hz	Minimal

ARRI ALEXA									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR POWER	SCENE 21	TAKE 1	120 FPS	RED LEG 119.6/98.0	BLUE LEG 126.1/91.5	BLACK LEG 120.8/160.0	60	300Hz	No

RED EPIC									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR POWER	SCENE 22	TAKE 1	120FPS	RED LEG 119.8/97.7	BLUE LEG 125.8/91.3	BLACK LEG 120.7/161.8	60	300Hz	No

SONY F65									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR POWER	SCENE 23	TAKE 1	120 FPS	RED LEG 119.8/98.0	BLUE LEG 126.1/91.5	BLACK LEG 120.8/162.0	60	300Hz	No

SONY F55									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR POWER	SCENE 24	TAKE 1	60 FPS	RED LEG 119.8/97.7	BLUE LEG 126.1/91.6	BLACK LEG 120.7/161.5	60	300Hz	No

PHANTOM FLEX									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR POWER	SCENE 25	TAKE 1	1200 FPS	RED LEG 119.8/97.1	BLUE LEG 126.1/91.1	BLACK LEG 120.7/161.7	60	300Hz	Minimal

PHANTOM GOLD									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR POWER	SCENE 26	TAKE 1	1000 FPS	RED LEG 119.8/97.5	BLUE LEG 126.1/91.4	BLACK LEG 120.8/161.7	60	300Hz	Minimal *1
		TAKE 2	600 FPS				60	300Hz	No

WEISSCAM									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR POWER	SCENE 27	TAKE 1	1200 FPS	RED LEG 119.8/97.3	BLUE LEG 126.1/91.3	BLACK LEG 120.7/161.2	60	300Hz	No
		TAKE 2	2000 FPS				60	300Hz	No
		TAKE 3	2000 FPS				60	300Hz	No

PHANTOM FLEX									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 44	TAKE 1	1200 FPS	RED LEG 118.1/98.9	BLUE LEG 117.3/97.0	BLACK LEG 117.2/168.8	60	300Hz	No

PHANTOM GOLD									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
HOUSE	SCENE 45	TAKE 1	1000 FPS	RED LEG 117.3/98.9	BLUE LEG 116.6/97.5	BLACK LEG 118.1/168.9	60	300Hz	Minimal *1
		TAKE 2	600 FPS				60	300Hz	No

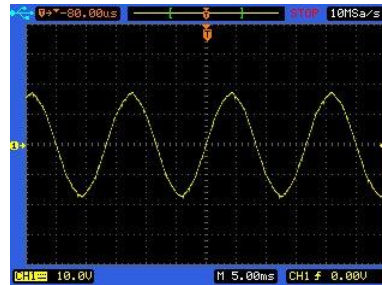
*1 (Although flicker was minimal on shots of the greycard, it was not noticeable on the live-action shots.)

ARRI M90



BALLAST	BALLAST SER.#	LIGHT SER.#	LIGHTS
EB960P	#860045	#B-583	M90
	#860046	#B-598	

GENERATOR POWER



ARRI ALEXA

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 12	TAKE 1	120 FPS	121.4/46.2	124.5/44.7	121.6/77.8	60	300Hz	No

RED EPIC

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 13	TAKE 1	120FPS	121.4/45.7	124.5/44.4	121.7/77.5	60	300Hz	No

SONY F65

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 14	TAKE 1	120 FPS	121.4/46.0	124.5/44.5	121.6/77.5	60	300Hz	No

SONY F55

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 15	TAKE 1	60 FPS	121.4/46.1	124.4/44.7	121.7/78.0	60	300Hz	No

PHANTOM FLEX

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 16	TAKE 1	1200 FPS	121.4/45.9	124.5/44.6	121.7/77.8	60	300Hz	Minimal *1

PHANTOM GOLD									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 17	TAKE 1	1000 FPS	RED LEG 121.3/45.9	BLUE LEG 124.7/44.6	BLACK LEG 121.6/77.8	60	300Hz	No
		TAKE 2	600 FPS				60	300Hz	No

WEISSCAM									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 19	TAKE 1	1200 FPS	RED LEG 121.3/45.9	BLUE LEG 124.6/44.8	BLACK LEG 121.7/77.8	60	300Hz	No
		TAKE 2	2000 FPS				60	300Hz	No

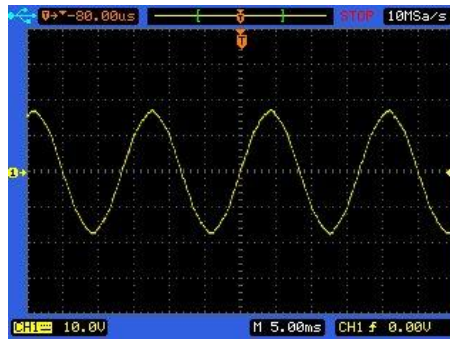
*1 (Although flicker was minimal on shots of the greycard, it was not noticeable on the live-action shots.)

ARRI M40



BALLAST	BALLAST SER.#	LIGHT SER.#	LIGHTS
EB425PL	#770299	#B-1494	M40
	#770300	#B-1495	

GENERATOR POWER



ARRI ALEXA

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 29	TAKE 1	120 FPS	122.1/35.1	124.4/0.5	122.3/34.9	60	300Hz	No
		TAKE 2	120 FPS				60	1000Hz	No

RED EPIC

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 30	TAKE 1	120FPS	122.1/34.8	124.4/1.1	122.3/34.9	60	300Hz	No
		TAKE 2	120FPS				60	1000Hz	No

SONY F65

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 31	TAKE 1	120 FPS	122.1/35.0	124.4/1.5	122.3/34.9	60	300Hz	No
		TAKE 2	120 FPS				60	1000Hz	No

SONY F55

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 32	TAKE 1	60 FPS	122.1/35.1	124.4/1.1	122.3/34.9	60	300Hz	No
		TAKE 2	60 FPS				60	1000Hz	No
		TAKE 3	60 FPS				60	300Hz	No

PHANTOM FLEX									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 33	TAKE 1	1200 FPS	RED LEG 122.1/35.0	BLUE LEG 124.4/2.1	BLACK LEG 122.3/35.0	60	300Hz	Minimal *1
		TAKE 2	1200 FPS				60	1000Hz	Minimal *1

PHANTOM GOLD									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 34	TAKE 1	N/A	RED LEG 122.1/34.9	BLUE LEG 124.4/0.5	BLACK LEG 122.3/34.9	N/A	N/A	N/A
		TAKE 2	1000 FPS				60	300Hz	Minimal *1
		TAKE 3	600 FPS				60	1000Hz	Minimal *1
		TAKE 4	1000 FPS				60	300Hz	Minimal *1
		TAKE 5	600 FPS				60	1000Hz	No

WEISSCAM									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 35	TAKE 1	1200 FPS	RED LEG 122.1/34.9	BLUE LEG 124.4/0.4	BLACK LEG 122.3/34.9	60	300Hz	No
		TAKE 2	1200FPS				60	1000Hz	No
		TAKE 3	2000 FPS				60	300Hz	Minimal *1
		TAKE 4	2000 FPS				60	1000Hz	No

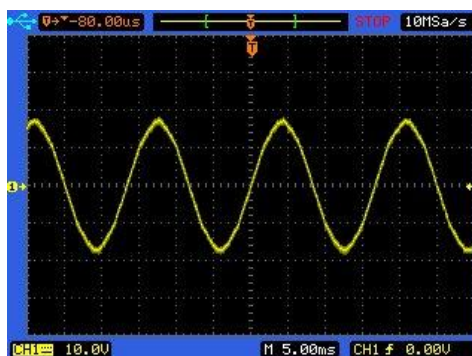
*1 (Although flicker was minimal on shots of the greycard, it was not noticeable on the live-action shots.)

ARRI M18



BALLAST	BALLAST SER.#	LIGHT SER.#	LIGHTS
EB180P	#760428	#B-1543	M18
	#760429	#B-3128	

GENERATOR POWER



ARRI ALEXA

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 37	TAKE 1	120 FPS	123.1/0.2	122.9/16.4	122.1/16.9	60	300Hz	No
		TAKE 2	120 FPS				60	1000Hz	No

RED EPIC

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 38	TAKE 1	120FPS	123.1/0.2	122.9/16.4	122.1/16.8	60	300Hz	No
		TAKE 2	120FPS				60	1000Hz	No

SONY F65

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 39	TAKE 1	120 FPS	123.1/0.2	122.9/16.5	122.2/17.0	60	300Hz	No
		TAKE 2	120 FPS				60	1000Hz	No

SONY F55

Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
				RED LEG	BLUE LEG	BLACK LEG			
GENERATOR	SCENE 40	TAKE 1	60 FPS	123.1/0.2	122.9/16.5	122.1/16.9	60	300Hz	No
		TAKE 2	60 FPS				60	1000Hz	No

PHANTOM FLEX									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 41	TAKE 1	1200 FPS	RED LEG 123.1/0.2	BLUE LEG 122.9/16.4	BLACK LEG 122.1/17.0	60	300Hz	Minimal *1
		TAKE 2	1200 FPS				60	1000Hz	No

PHANTOM GOLD									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 42	TAKE 1	1000 FPS	RED LEG 123.1/0.2	BLUE LEG 122.9/16.6	BLACK LEG 122.1/17.1	60	300Hz	No
		TAKE 2	600 FPS				60	1000Hz	No
		TAKE 3	1000 FPS				60	300Hz	No
		TAKE 4	600 FPS				60	1000Hz	No

WEISSCAM									
Power Source	Scene	Take	Frame Rate	Volts/Amps			Freq.	Ballast Freq.	Flicker
GENERATOR	SCENE 43	TAKE 1	1200FPS	RED LEG 123.1/0.2	BLUE LEG 122.9/16.5	BLACK LEG 122.1/17.1	60	300Hz	No
		TAKE 2	1200FPS				60	1000Hz	No
		TAKE 3	2000 FPS				60	300Hz	No
		TAKE 4	2000 FPS				60	1000Hz	No

*1 (Although flicker was minimal on shots of the greycard, it was not noticeable on the live-action shots.)

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Conclusions

Throughout the tests we have determined that the Power Gems ballasts are flicker free under most circumstances. On day one, minimal flicker was seen on the Harris waveform monitor as well as the Sony OLED colour-grading monitor. The Phantom Flex had minimal flicker at speeds of 1200fps with the M18, M90 and M40 Power Gems ballasts. The Phantom Gold also saw minimal flicker at speeds of 1000fps on the M40 and the 18K Power Gem ballasts. All other cameras were flicker free.

Day's two and three saw flicker only in isolated situations. The metal spike that was dropped onto the mirror was shot at 2500 fps on the Phantom Flex. The flicker was only visible before the action had taken place, once the action started; the flicker was unnoticeable. The second time flicker was visible was during the shot that had a hand grabbing a billiard ball from an aquarium. This was due to the positioning of the light directly at the camera. By raising the light the flicker was then minimized.