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Comparison of xenon flash and high current LEDs for photo flash in camera phones – a review and update

This article provides new information updating an Oct 2006 study comparing light sources for camera phones. The original report, "*Get enlightened about camera phone flash units -- compare xenon to high-current LEDs*," compared light power and light energy measured over time using camera phones ranging from 1.3 to 3.2-megapixel resolution. This new report includes data captured from higher resolution, 5-megapixel camera phones released in the last year, and also considers the technology advancements in camera sensors, xenon flash units, high power white LEDs (WLEDs) and LED flash drivers.

Camera phones have improved since 2006 – more megapixels (many now use 5-megapixel sensors), better lenses, improved image-processing software and image stabilization features.

However, what still lags behind is the power and energy of the flash for taking pictures in low-light conditions, such as in restaurants, bars or other places where people socialize. Many cell phones have compromised on size and/or cost by providing either a small xenon flash or a low-to-medium-current LED photo light, both of which provide insufficient light energy for an acceptable photo in low light (Fig 1).

Fig 1: Photo taken in very low ambient light using a small xenon flash (5MPx LG KU990 camera phone). The girl is only 2m from the camera, but only her silhouette is visible.

Two solutions are emerging to provide a good photo flash in low ambient light:

– High-current LEDs supported by a supercapacitor
– and xenon

This study will explore the limitations of existing LED flash implementations without a supercapacitor, and go on to compare supercapacitor-powered LED flash and xenon flash solutions. We will compare:

– light power and energy

- shutter requirements
- ease of circuit implementation
- safety
- size

Light Power vs Light Energy
The key to a good quality picture in low ambient light or backlit situations is to produce enough light energy from the flash during image-capture time to illuminate the subject adequately. Light energy is the *total* amount of light received by each pixel in the camera sensor. People often wrongly assume that light power, the brightness or intensity of the flash, is the key because it's what attracts our attention, but it's the light energy that counts.

Light energy is the area under the curve of light power over time. Assuming light power is constant during the flash pulse, as is the case for LED flash, then you calculate light energy by multiplying light power (measured in lux) by duration of the flash exposure (in seconds):

Light power (lux) x flash exposure time (secs) = light energy (lux.secs). A good picture ideally requires 10 – 15 lux.secs of light energy.

- Xenon flash has excellent light power, up to several hundred thousand lux, but a very short flash duration, typically 50 – 100μsec.
- LED flash delivers lower light power, but over a longer period of time to generate more light energy. Powered by a supercapacitor, LED flash can now generate up to several hundred lux with a flash pulse of up to ~100msecs.

Therefore, a xenon flash needs 1000 to 2000 times the power of the LED flash to deliver the same light energy. The light energy a xenon pulse can deliver depends on the size of the electrolytic 330V storage capacitor.

As camera resolution increases, so does the need for light
As camera sensors have increased in resolution and decreased in size, pixel area has shrunk, so the total light energy collected by each pixel has declined. As an example, a ¼" 1.3-megapixel sensor from 2006 had a pixel size of 3.18μm x 3.18μm = 10.1μm^2, while a ¼" 5-megapixel sensor from the same manufacturer released this year has a pixel size of 1.4μm x 1.4μm = 1.96μm^2 -- a fivefold reduction in area.

Improvements in pixel sensitivity since 2006 have offset this reduction in pixel size to some extent, but not enough to make up for the drop in area. The responsivity of the sensor, which gives the voltage generated per unit of light energy, captures both these conflicting trends. The responsivity of the two sensors mentioned above is 1.1V/lux.sec for the 1.3-megapixel sensor and 0.5V/lux.sec for the 5-megapixel sensor. Therefore, the 5-megapixel sensor needs more than twice the light energy of the 1.3-megapixel sensor to take an equally well-exposed photo.

Camera-phone solutions tested:
In this study, we measured light power over time for:

- Xenon: SonyEricsson K800i, LG KU990, Nokia N82 and Samsung G800, all with 5-megapixel cameras but with varying size storage capacitors
- Standard battery-powered LEDs: Nokia N73 (3.2-megapixel camera) and N96 (5-megapixel camera)

- Supercapacitor-powered LEDs: Using a power architecture called BriteFlash, developed by CAP-XX, which combines a LED flash driver IC, supercapacitor, battery and WLEDs.

Integration of the area under the curves of light power over time shows the light energy available to fill pixels in the camera sensor, enabling an objective comparison of the solutions.

Limitations of LED flash currently used in camera phones
There are many demands on cell-phone batteries, so designers want to avoid drawing more than 800 - 1000mA from the battery. The standard flash driver IC is a boost converter in current-control mode.

Assume the battery voltage is 3.6V, the LED forward voltage = 3.8V and the boost converter efficiency is 85%. For an 800mA battery current, the LED current = 0.8 x 3.6/3.8 x 0.85 = 650mA and LED power = 2.4W. At this current, a typical high-current LED will only provide 10 – 11 lux at a distance of 2m[1]. This compares with 7 – 8 lux 3 years ago.

If the camera sensor frame rate is 7.5 frames/sec, the light energy per pixel from such a solution = 10.5 lux x 0.133s = 1.4 lux.sec. Figs 8 and 9 illustrate this, plotting the light energy for a Nokia N73 with an image-exposure time of 90msecs and a low-current LED at 1W. The flash delivers just 1.7 lux.secs at 1m from the subject, and 0.4 lux.secs at 2m.

Most LED flash phones today drive LEDs at 1W – 2W and provide < 4 lux.secs at 1m and < 1 lux.secs at 2m. Examples are the N73 noted above, the N70 (which also drives the LED at 1W), and the Nokia N96 which drives a pair of LEDs at low current, but still only generates 3.5 lux.secs at 1m and 0.9 lux.secs at 2m (Figs 8 and 9).

As mentioned before, a good picture ideally requires 10 – 15 lux.secs of light energy. Before supercapacitors, a xenon flash tube was the only practical means of generating reasonable light energy, but this poses some problems for camera phones.

Xenon flash
In a xenon flash, an electrolytic capacitor is pre-charged to 330V, which then discharges across a xenon-gas-filled tube to produce an intensely bright flash (up to several hundred thousand lux at 1m) of very short duration (typically < 100μsec). A trigger circuit operating from 4000 – 8000V is required to precipitate the gas discharge.

The high energy stored at 330V is a safety concern, special care is required to prevent the high-voltage trigger circuit from arcing to other circuits, and the electrolytic capacitor is bulky for thin-form-factor camera phones and digital cameras.

Supercapacitor-based LED BriteFlash power architecture
A supercapacitor can power high-brightness WLEDs drawing > 1A at 5V. This overcomes the limitations of low-current LED solutions outlined above, and enables a thin-form LED flash solution which can deliver comparable light energy to a xenon flash. When using a supercapacitor to support LED flash, the battery only needs to supply average power and recharge the supercapacitor between flashes, while the supercapacitor provides the high-peak LED current (> 1A per LED) during the flash pulse. The flash driver's boost converter charges the supercapacitor to 5.5V, enabling it to drive the LED flash.

Fig 2 shows a block diagram of a typical flash driver using a supercapacitor.

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[1] Luxeon Flash PWM4

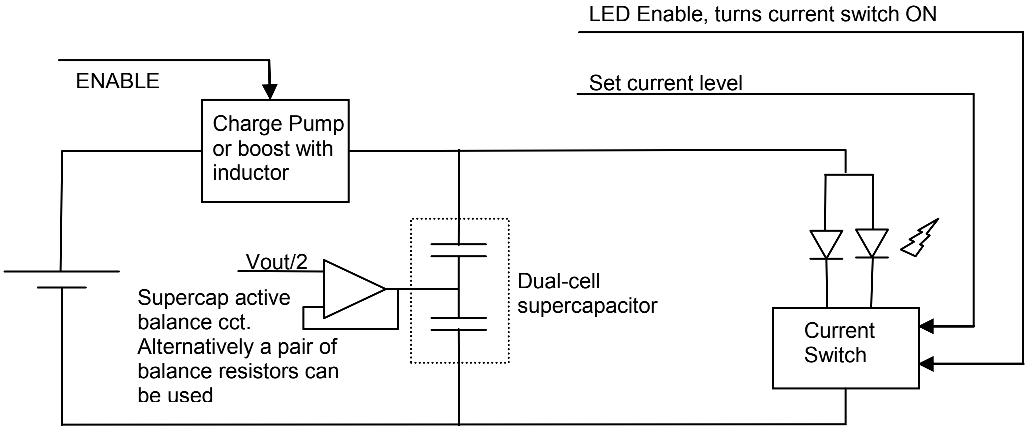


Fig 2: High Power LED Flash Supercapacitor Solution Block Diagram

Over the last 3 years, most major power IC vendors have released or are sampling supercapacitor-optimized LED flash drivers that integrate the functions in Fig 2, thus saving development time, board space and component cost.

Those already released include the AAT1282 from AnalogicTech, and the CAT3224 and NCP5680 from ON Semiconductor. An I2C interface allows users to set Flash and Torch currents. Depending on the IC, a total LED flash current of up to 10A is possible. The supercapacitor has sufficiently high energy (high C) and high power (low ESR) to supply the LED current for the duration of the flash pulse with little or no contribution from the battery. The battery charges the supercapacitor between flashes.

For example, if a 0.5F supercapacitor discharges 1V during the flash pulse, it only requires a 250mA recharge current for 2 seconds and it's ready to go again. Fig 3 shows flash and battery current for a flash pulse driving a four-LED array (Luxeon PWF1) at 1A each. Note that the battery current is limited to 300mA and the supercapacitor provides all the LED current during the flash pulse.

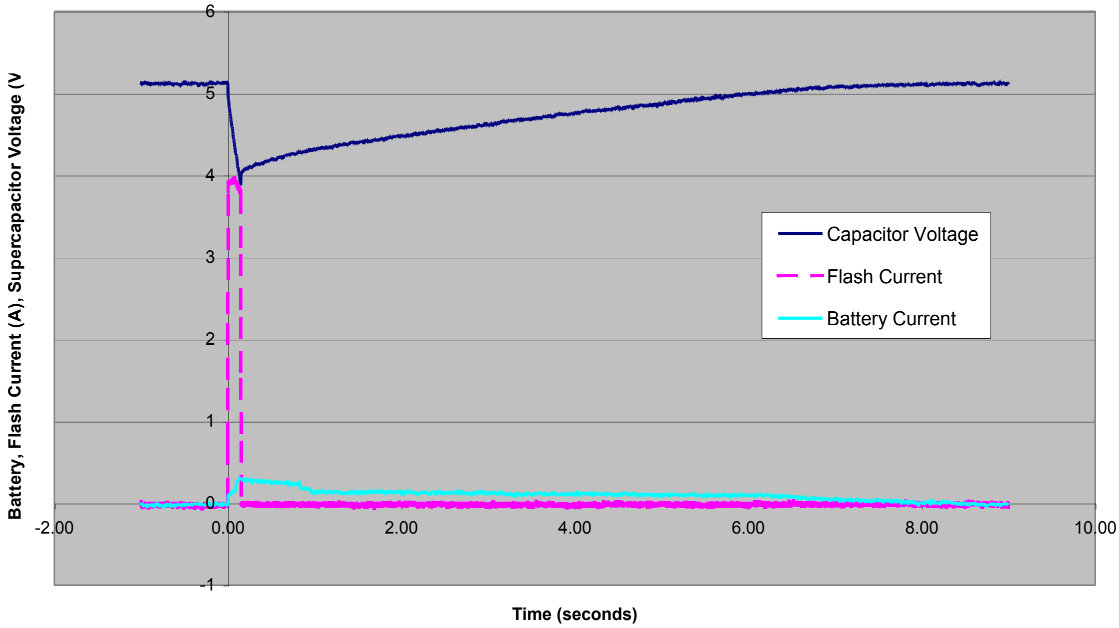


Fig 3: The supercapacitor provides 4A flash current while discharging from 5.2V to 4.0V; the battery provides 300mA recharge current to the supercap.

Comparison of light power and energy between xenon and LED flash

Measurement included several steps:
A photo detector measured on-axis illumination while a digital storage oscilloscope captured light power over time at 1 and 2 meters from the source. The areas under the power curves were integrated to measure the light energy at the detector as a function of time.

Fig 4 shows the test instrumentation set-up.

Fig 4: Dr Trevor Smith of CAP-XX setting up the light measurement equipment

Light power over time:
Fig 5 shows light power over time from the xenon sources at 1m and 2m respectively. The key points are:

- Light power from xenon flash is very intense, with the Samsung G800 delivering 300,000 lux peak power at 1m
- Light power measured at 2m is ≈¼ of the light power measured at 1m, as expected. For example, the Samsung G800 at 2m delivers 73,000 lux compared to 300,000 lux at 1m
- Flash power and pulsewidth are traded off against the size of the electrolytic storage capacitor, described below from largest to smallest:
  - The SonyEricsson K800 has 2 x 14μF, 330V electrolytic capacitors in parallel, for a total of 28μF, to produce ~220,000 lux peak power and a pulsewidth of ~100μsecs.
  - The Nokia N82 has a 20μF, 330V electrolytic capacitor and generates peak power of 160,000 lux with a similar pulsewidth. The ratio of light power between the two phones = 160,000lux/220,000lux is approximately the same as the ratio of capacitance = 20μF/28μF
  - The LG phone uses a very small 10μF electrolytic and only generates 50,000 lux with a pulsewidth of ~50μs.

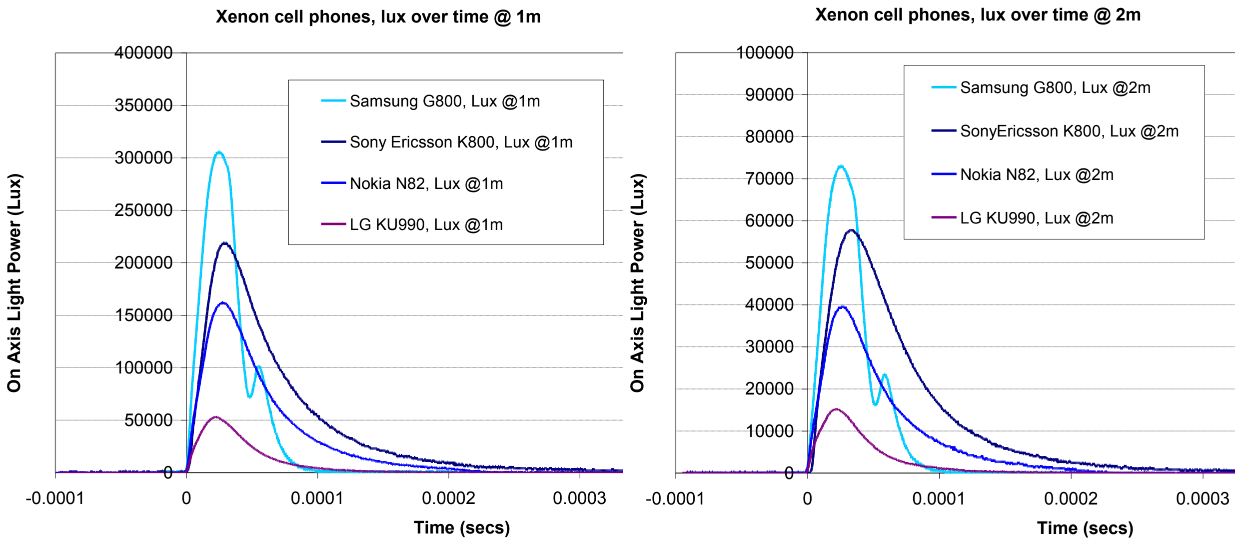


Fig 5: Light power over time for 4 xenon sources

Fig 6 shows the light power over time for the LED flash sources. To demonstrate the BriteFlash approach, we used the latest high-power LEDs from the Philips Luxeon range and a flash driver circuit. The graphs show results for two high-current LEDs with optic at 1m and 2m distance. The supercapacitor drives the LEDs at 1A and 2A each, i.e. 2A or 4A total for 2 LEDs.

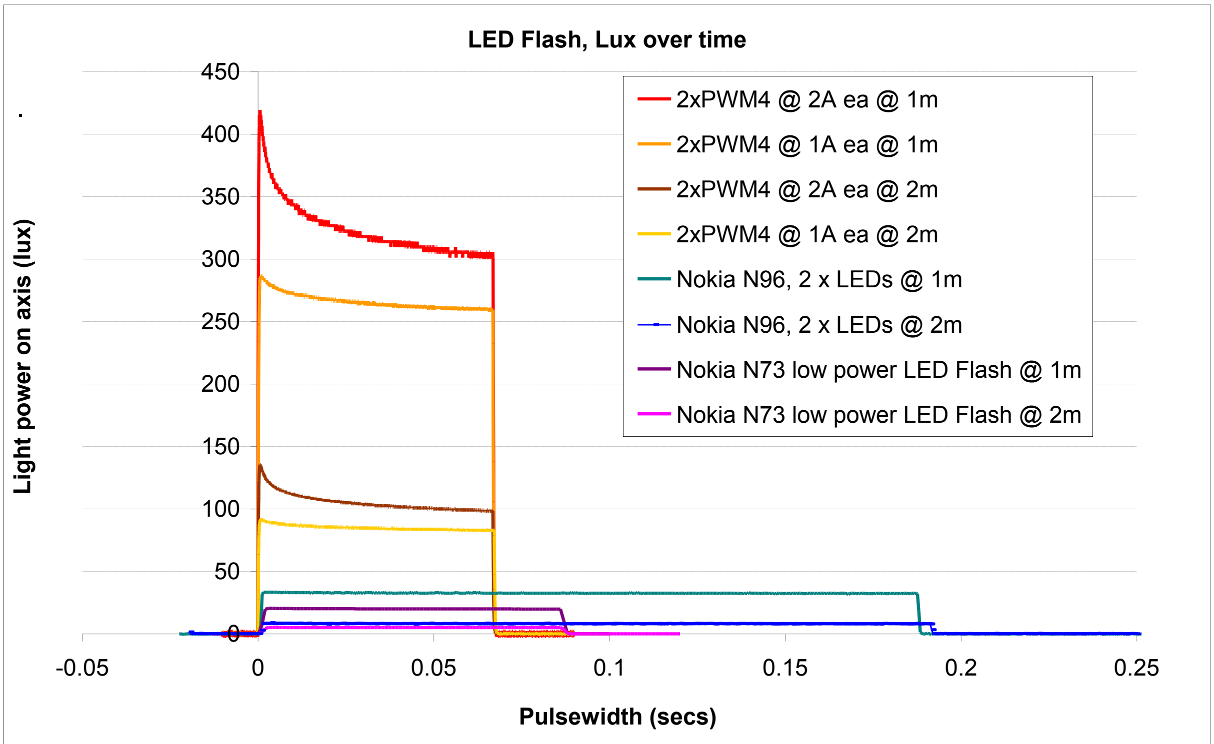


Fig 6: Light power over time for LED flash

The key points from Fig 6 are:

- As in the xenon light power graphs, the power measured at 2m is ~¼ of that measured at 1m.

- LEDs can deliver approximately constant light power for long flash pulses, allowing their use with a CMOS sensor rolling shutter and no mechanical shutter. The LED light power decreases slightly during the flash pulse due to heating. Starting with a slightly lower LED current and ramping up the current during the pulse can compensate for the heating effect.
- The supercapacitor-powered LED BriteFlash example delivered over 300 lux at 1m distance using 2 LEDs powered at 2A each.
- The Nokia N96 with standard LED flash delivered 32.5 lux at 1m, or approximately 1/10th of the supercapacitor solution with 2 LEDs @ 2A each.
- The Nokia N73, with a lower-power standard LED flash, barely registered on this scale. Its 1W of electrical power only delivered 16 lux at 1m, compared to >300 lux from the 2 high-power LEDs driven at 2A each.

Key parameter is light energy:
Figs 5 and 6 compared light power over time. However, as previously explained, the key parameter is light energy, not light power.

Fig 7 shows how light is captured by a CMOS sensor with a rolling shutter. A frame is made of N lines, each with M pixels. Each pixel of a line is reset, and then sometime later is read. The voltage read from each pixel is proportional to the light energy that has accumulated from the time the pixel is reset to the time it is read. That light energy is the light power integrated over that time (Figs 8 and 9).

When all pixels in the N lines have accumulated light energy for the same period of time, a frame has been captured. As shown in Fig 7, this occurs in a period of twice the frame interval. If the frame rate is 15 frames/sec, then the image is captured in 2 x 1/15 = 2 x 66.7ms = 133ms. Each line has captured light energy (integrated light power) for 66.7ms.

A LED flash can provide constant illumination for the entire image-capture period and can therefore be used with a rolling shutter. To control the exposure, the LED current (and hence light intensity) can be set based on the ambient light measured. Alternatively, the line exposure time can be reduced. The frame rate will remain the same, but each line may only collect data for say 20msecs instead of ~67ms.

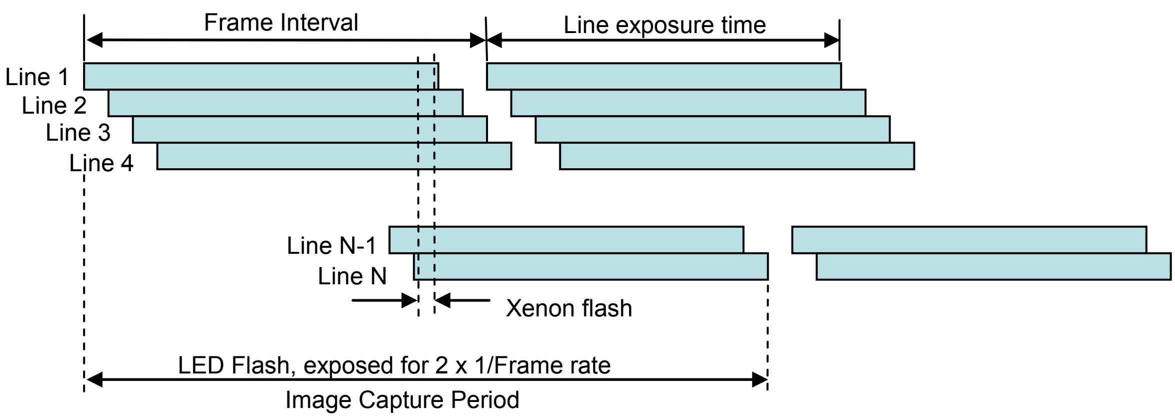


Fig 7: Light capture in a CMOS sensor

A xenon flash only lasts a fraction of a millisecond. Therefore it must strobe in the few millisecond period when all N lines are capturing light (Fig 7). The xenon circuit usually includes a photo detector that shuts the xenon down when sufficient light has been gathered to prevent overexposure. However, ambient light is still captured by each line in the period outside the xenon flash pulse. For Line 1, this period will be just less than 66.7ms before the xenon strobe and for Line N, a few ms less than 66.7ms after the strobe. To prevent this ambient light from overexposing the image, a mechanical shutter is necessary.

Figs 8 and 9 show light energy for the xenon and LED flashes at 1m and 2m from the detector respectively. The charts have a logarithmic timescale so the very short xenon pulses and longer LED flash pulses can be displayed on the same graph. They are the integral of the light power charts shown in Figs 5 and 6, and reflect the total light energy a CMOS sensor would capture.

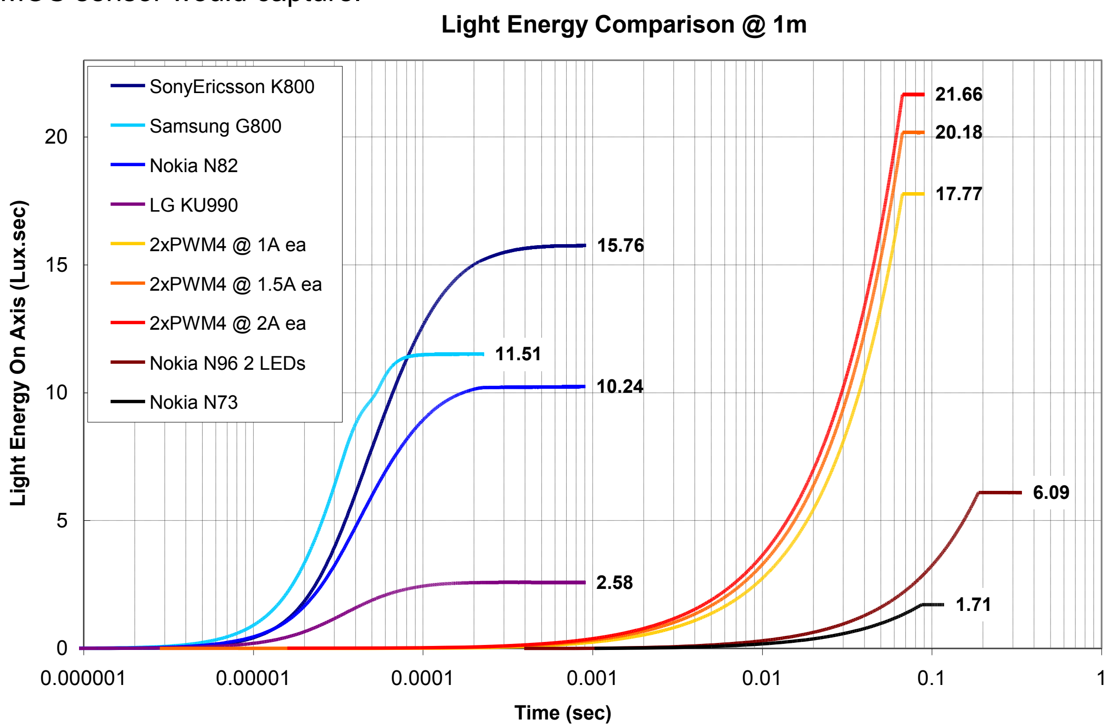


Fig 8: Light energy @ 1m for xenon and LED flash

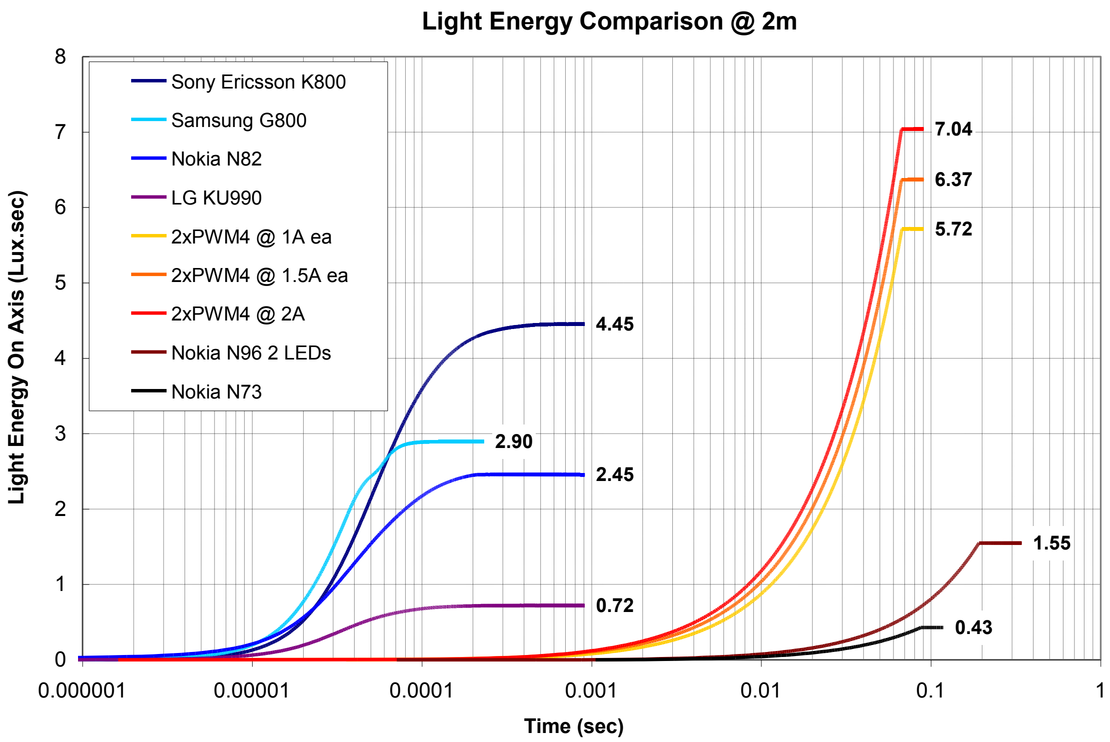


Fig 9: Light energy @ 2m for xenon and LED flash

The light energy for the xenon flashes can be read from the final value shown on the charts. For the xenon flash solutions, this ranged from ~3 – 16 lux.secs at 1m, all of which will be captured by the CMOS sensor within the period labelled "Xenon flash" in Fig 7.

Light energy for the LED flashes can be read from the charts for a given exposure time of a line in a CMOS sensor. For example, at 1m, the 2 LEDs @ 2A BriteFlash case delivered 10.5 lux.secs over 30ms and 22 lux.secs over 67ms exposure. Table 1 below tabulates light energy and power for the various cases.

Table 1: Comparison of light energy between xenon, BriteFlash and low-power LED Flash

Source	Storage Capacitor	Distance (m)	Peak Light Power (lux)	Exposure Time (msecs)	Light Energy (lux.secs)
Xenon, Samsung G800	Unknown	1	303,000	<1	11.5
Xenon, SonyEricsson K800	2 x 14μF	1	217,000	<1	15.8
Xenon, Nokia N82	20μF	1	161,000	<1	10.2
Xenon, LG KU990 (Viewty)	10μF	1	52,000	<1	2.6
BriteFlash example (2 x LEDs @ 2A each)	0.55F	1	425	17	6.0
				33	11.2
				67	21.7
1 x LED @ 1A	0.55F	1	135	67	8.9
2 x LEDs, Nokia N96	NA	1	30	67	2.15
				100	3.45
1 x LED, Nokia N73	NA	1	20	90	1.71
Xenon, Samsung G800	Unknown	2	72,000	<1	2.90
Xenon, SonyEricsson K800	2 x 14μF	2	57,000	<1	4.45
Xenon, Nokia N82	20μF	2	40,000	<1	2.45
Xenon, LG KU990 (Viewty)	10μF	2	15,000	<1	0.72
BriteFlash example (2 x LEDs @ 2A each)	0.55F	2	130	17	1.9
				33	3.6
				67	7.0
2 x LEDs, Nokia N96	NA	2	8.2	67	0.55
				100	0.86
1 x LED, Nokia N73	NA	2	5.0	90	0.43

Points to note from Table 1 are:

- The supercapacitor-powered LED BriteFlash example (2 LEDs powered at 2A each):
  1. Delivers 37% more light energy over 67ms (CMOS sensor frame rate of 15/sec) than the SonyEricsson K800, the xenon phone with the highest light energy which includes a 28μF storage capacitance.
  2. Delivers 110% more light energy with a rolling shutter over 67ms (CMOS sensor frame rate of 15/sec) than the Nokia N82 xenon flash with a 20μF storage capacitance.

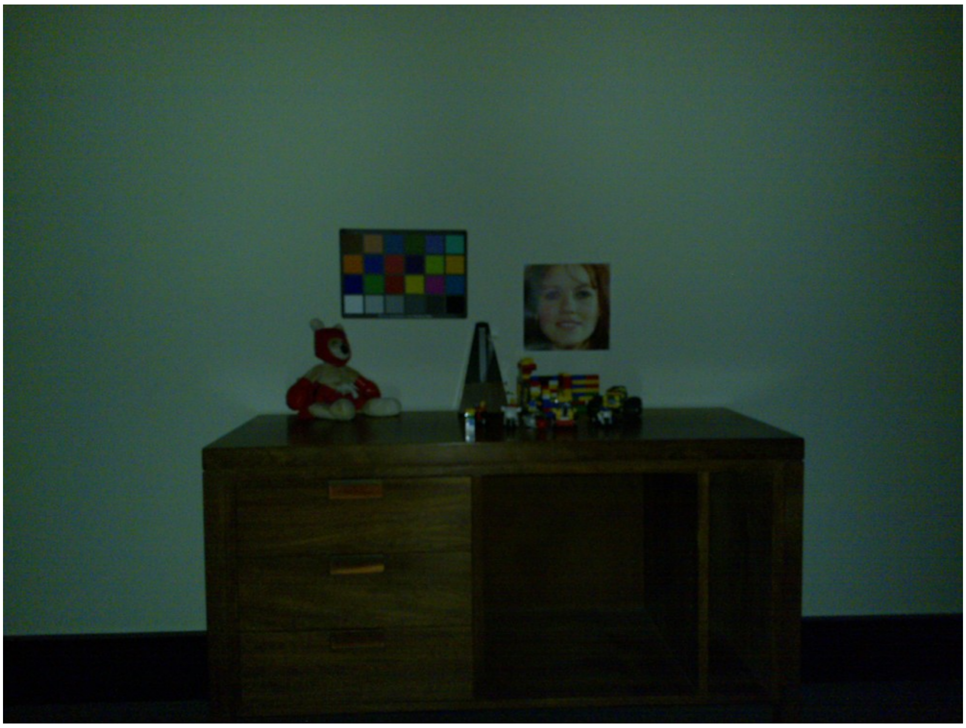
3. Over only 17ms, delivers 2.3 x the light energy delivered by the LG xenon flash with a 10µF storage capacitor – i.e. enough light for a photo of much higher quality. Some CMOS sensors have a frame extension capability, where the line exposure time is extended and the following frame is dropped. The period labelled as "Xenon flash" in Fig 7 can then be expanded, enabling an image-capture time of 17ms. This is short enough (1/60th of a second) to eliminate blurry photos if the photographer's hand shakes. Like xenon, this solution would also require a mechanical shutter.
4. Similarly, over 33ms, delivers approximately the same light energy as the Nokia N82 xenon flash, and 70% of the light energy from the SonyEricsson K800 phone, enabling high quality photos with a short exposure time and a mechanical shutter.

- 1 LED driven at 1A with a rolling shutter running at 15 frames/sec would deliver 240% more light energy than the LG KU990 xenon flash with a 10µF storage capacitance.
- The N96 standard LED solution only delivers 1/10th of the light energy over 67ms of 2 supercapacitor-powered LEDs @ 2A each. For the N96 to capture sufficient light energy, when it is set to automatic exposure, its exposure time is 100ms, which may result in image blur, and only gives 0.86 lux.secs at 2m (Figs 11a and 11b).
- The standard low-current LED flash, using the Nokia N73 with a 90ms flash pulse as the example, generates much less light energy than the other solutions, only 8% of that produced by 2 high-current LEDs with a 67ms flash pulse, and 11% of that generated by the SonyEricsson K800.

While an image capture time of 67 – 133ms for a rolling shutter is relatively long, and may cause blurring if the photographer's hand shakes, image-processing software can correct this. A xenon strobe, with its very short exposure time, will always be superior for taking action shots in low light. Keep in mind that many camera-phone shots in low light are of friends posing at parties, nightclubs, etc. where movement is not an issue.

Fig 10 shows a photo taken under the same conditions as Fig 1. Fig 10 used a Nokia N73 modified by CAP-XX with a supercapacitor to drive 3 x LEDs at 1A each for a total flash power of 12W. We can now see the model, instead of her silhouette.

Fig 10: Photo taken in the same conditions as Fig 1, but this time using a Nokia N73 modified with a supercapacitor to drive 3 x LEDs at 1A each for a total flash power of 12W. We can now see the girl clearly instead of her silhouette.



Nokia N96

2592 x 1944 pixels

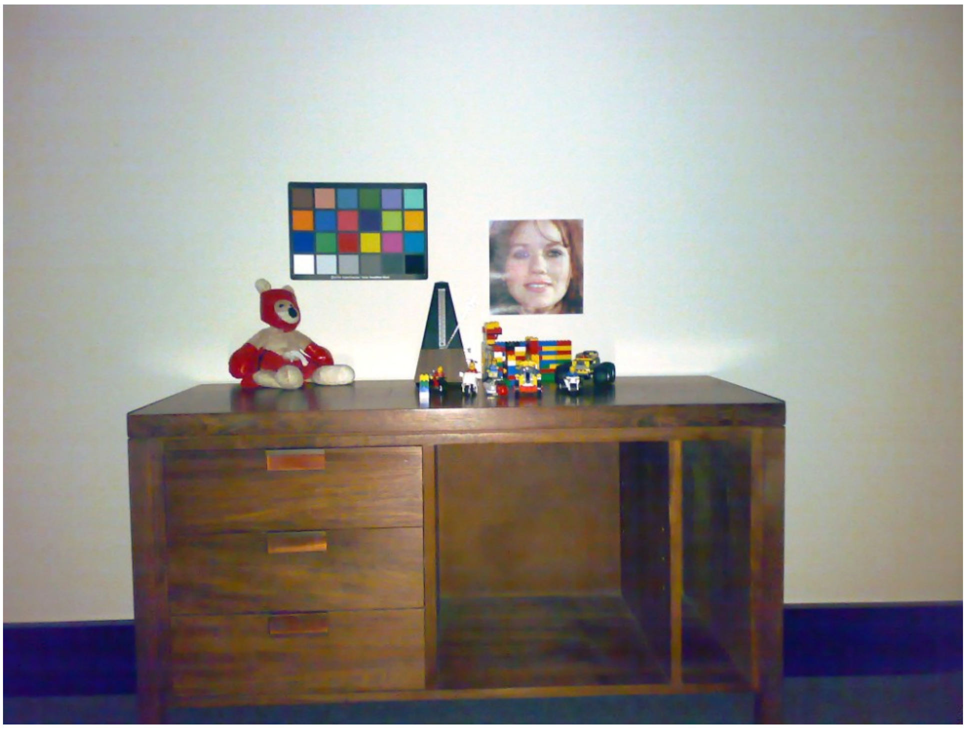
300dpi resolution

Fstop f/2.8

Exposure time 1/10s

Focal length 5mm

Fig 11a: Test scene shot from 2m in a dark room, using a standard Nokia N96 with 2 LEDs with no supercapacitor support. Note the poor color reproduction from the color chart. There is also a metronome ticking at 1Hz to show blurring due to exposure time.



Nokia N73

2048 x 1536 pixels

300dpi resolution

Fstop f/2.8

Exposure time 1/15s

Focal length 6mm

Fig 11b: The same scene as Fig 11a shot with a Nokia N73 modified with a supercapacitor to drive 3 x LEDs at 1A each for a total flash power of 12W. The color chart shows much better color rendition than Fig 11a, and the metronome arm shows less blur from a faster exposure.

Comparison of solution size and energy density

The key advantage of LED flash over xenon in camera phones is size. Fig 12 compares the xenon solution size in the SonyEricsson K800 with the supercapacitor used for LED flash. The SonyEricsson K800 uses two cylindrical electrolytic capacitors, each measuring 7mm dia. x 18mm long.

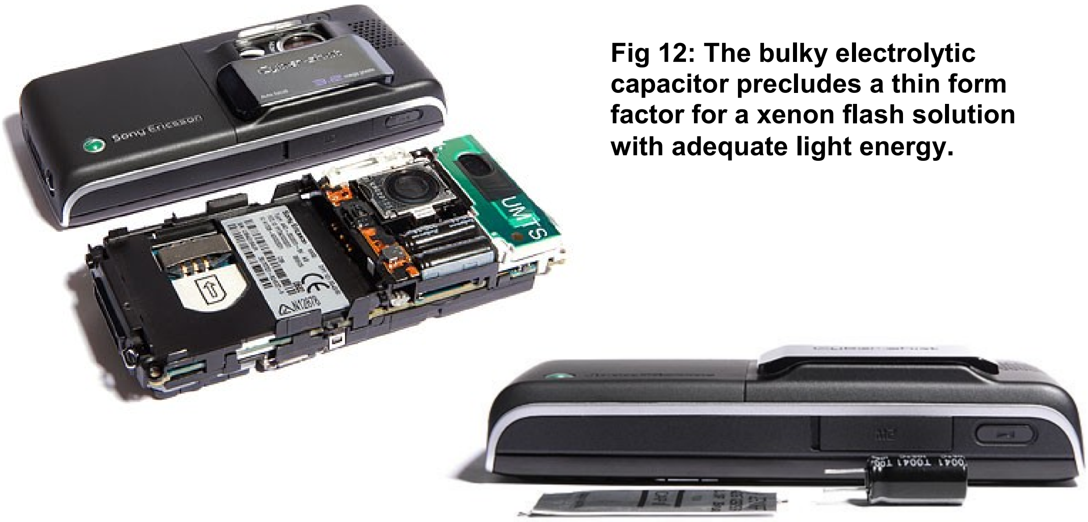


Fig 12: The bulky electrolytic capacitor precludes a thin form factor for a xenon flash solution with adequate light energy.

Fig 13: Size comparison between prismatic supercapacitor and cylindrical electrolytic storage capacitor used for xenon flash. The SonyEricsson K800 uses two of these electrolytics; the Nokia N82 uses one of the same size.

Electrolytic capacitors prevent slimline camera phones. Demonstrated in Fig 13, an electrolytic capacitor the same size as used in the SonyEricsson and Nokia phones is much bulkier than an HA230 supercapacitor designed for LED flash applications.

Fig 14 contrasts the Nokia N82's xenon flash module + electrolytic capacitor (left) with a LED flash module with driver (right), including 2 high-power LEDs with integrated optic, and an HA230 supercapacitor.

This LED flash solution can deliver 4A for 133ms, or a 67ms line exposure for a camera running at 15 frames/second with a rolling shutter. Fig 8 shows this solution delivers 7 lux.secs at 2m from the subject compared to 4.5 lux.secs for the K800 and 2.5 lux.secs for the N82. Xenon solutions with smaller electrolytic storage capacitors, such as the 10μF in the LG phone, compromise light energy delivered. In this case, the LG KU990 delivers only 1/5 the light energy of the SonyEricsson K800 and only 1/8 the light energy delivered by 2 high-power LEDs at 2A LED current with a line exposure of 67ms.

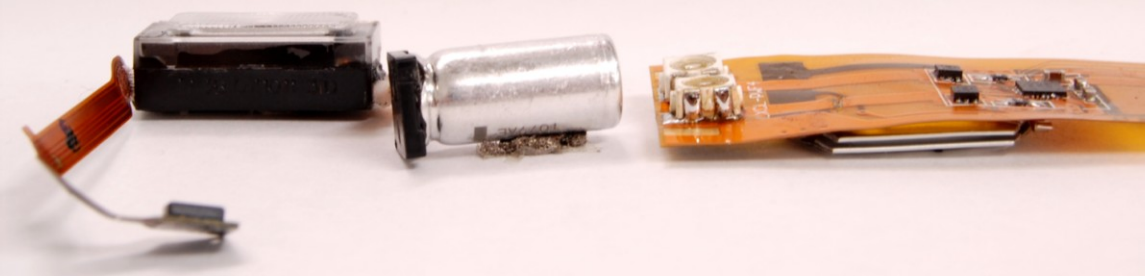


Fig 14: The Nokia N82 phone's electrolytic capacitor + xenon flash module (left) compared to a LED flash module (right) which uses an HA230 supercapacitor (on the underside) and the ON Semiconductor NCP5680 flash driver to drive high-current Philips Lumileds LEDs.

Table 2 compares energy density of the electrolytic capacitors in the SonyEricsson K800 and Nokia N82 with the CAP-XX HA230 supercapacitors. These provide high C (0.425F) and low ESR (110mΩ) in a small 18mm x 20mm x 3.4mm package.

Table 2:

	Electrolytic Capacitor Sony Ericsson K800	Electrolytic Capacitor Nokia N82	CAP-XX HA230 Supercapacitor
Capacitance	2 x 14µF = 28µF	20µF	0.425F
Energy storage	½ x 28µF x ($330V^2$ – $100V^2$) = 1.4J	½ x 20µF x ($330V^2$ – $100V^2$) = 1.0J	½ x 0.425F x ($5.5V^2$ – $4.5V^2$) = 2.0J
Dimensions	(2) x 7mm dia. x 18mm long	7.7mm dia x 18mm long	18mm x 20mm x 3.4mm
Volume	1.76cc (effective)[2]	1.07cc (effective)[2]	1.22cc
Energy density	0.785J/cc	0.927J/cc	1.634J/cc

Of key concern to handset designers is total solution volume. Table 3 makes this comparison for the xenon and LED flash solutions shown in Fig 13.

Table 3:

	Xenon	**LED Flash**	
Capacitor/Supercapacitor	1.067	1.224	
Electronics & xenon tube	1.558	0.143	
2 LEDs		0.137	
Connector	0.071	0.071	
Total Volume (cc)	**2.697**	**1.575**	42% Less

Comparing energy storage and voltage

For xenon flash, the storage capacitor is charged to 330V and discharges to ~100V at the end of the strobe. In LED flash, the supercapacitor is charged to 5.5V and discharges to ~4.5V at the end of the flash pulse. The electrolytic capacitor has high energy storage by virtue of its high voltage, which poses some safety issues. The supercapacitor, on the other hand, has high energy storage due to its enormous capacitance and operates at low voltage with no safety issues.

The key messages from Tables 2 and 3 are:

- The supercapacitor provides 75% better energy density (energy stored per unit volume) than the electrolytic capacitor, and
- The total LED flash solution is 40% smaller than a good-quality compact xenon flash, such as that in the Nokia N82.

[2] The gap between a circle of dia 7mm and square with 7mm side is not usable volume, so the effective area is calculated as 7mm x 7mm x 18mm

Comparison of other attributes between xenon and LED flash

Table 4 compares all attributes of xenon and LED flash.

Table 4:

Xenon	BriteFlash LED Flash with Supercapacitor
Bulky: – Large electrolytic storage capacitor – Total volume of xenon solution in SonyEricsson K800 ~3.8cc and 7mm thick	Small and thin: – Prismatic supercapacitor and LEDs – Typically < 2cc and 2 – 4mm thick[3]
Fragile (Drop test): – Xenon tube – Electrolytic connection to flex PCB prone to fracture due to large mass of capacitors and flimsiness of PCB	Rugged (no difficulties with drop test) : – No large mass – No fragile parts
Safety: 1.5J of energy stored at 330V can give a nasty shock, particularly near the ear	Safe: Low voltage, no safety issues
High Voltage (HV) trigger circuit needed for xenon flash tube, > 4000V. Special measures and/or clearance is required to prevent arcing to other circuits	No HV, no special steps to prevent arcing to other circuits
Mechanical shutter required to prevent overexposure: extra cost, size & power	Works with a rolling shutter. No mechanical shutter required
High voltage and current pulse for xenon strobe causes Electro Magnetic Interference (EMI)	High current delivered from supercap, EMI easier to manage
Still need a separate LED for video/torch mode	Same LEDs used for flash and video/torch
Long time to re-charge electrolytic capacitor between photos (~8s for SonyEricsson K800)	Short time to re-charge supercapacitor between photos (~2s)
Electrolytic capacitor cannot be used for any other peak-power needs	Supercapacitor can be used to meet all peak power needs in the cell phone including: – Flash pulse – GPS readings – RF Transmission for GPRS – Audio
Very high-powered light delivered in < 200µsec: – No photo blur – Can take an action shots in low light	Light energy delivered over longer time: – Capable of high-quality still shots, but cannot take action shot in low light – Image stabilization software can correct for hand movement

[3] Thickness will depend on implementation: two single-cell supercapacitors side by side (double the footprint and half the thickness), or a dual-cell supercapacitor with the two cells stacked on top of each other (half the footprint and double the thickness).

Supercapacitor can meet all peak-power needs in the mobile phone
A key point in Table 4 is that the supercapacitor can meet all the peak-power needs of a portable device such as a cell phone, not just the LED flash. Fig 15 shows a camera-phone power architecture which illustrates this.

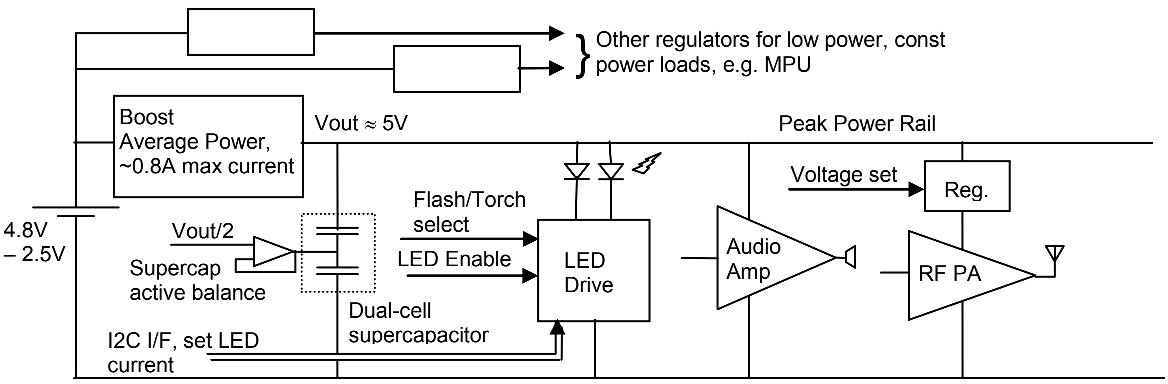


Fig 15: Possible power architecture for a camera phone with a supercapacitor

The boost converter supplies average power to the supercapacitor. The supercapacitor then supplies peak-power needs simultaneously to all the high-power loads. The phone software can set the flash and torch currents via an I2C interface.

Several supercapacitor-optimized flash driver ICs have been released over the last year that implement this architecture, including the AAT1282 from AnalogicTech and the CAT3224 and NCP5680 from ON Semiconductor. These ICs integrate the boost converter, supercapacitor balancing, I2C interface and LED current control.

RF Amplifier
The supercapacitor can supply the 2A peak current for 0.577ms to the RF PA to respond to a network poll during a 2A 133ms LED flash pulse. The RF pulse would only discharge a 0.5F supercapacitor by 2.3mV. The supercapacitor also prevents excessive battery-voltage droop during the RF pulse. This extends talk time and enables operation in sub 0°C temperatures outdoors.

Audio Amplifier
Similarly, the supercapacitor could support the audio amp to drive high-power audio (>5W) without requiring that the audio power supply be gated by the RF transmit pulse to ease the strain on the battery. The supercapacitor will “stiffen” the audio power rail to eliminate any noise from fluctuations in the audio amp power supply. Similarly, the supercapacitor will eliminate audio noise from power transients from the RF amplifier, in particular any 217Hz buzz from the GPRS frame frequency during phone conversations.

Conclusions
This study has compared the performance and other key attributes of xenon and supercapacitor-based high-power LED flash, or BriteFlash, for use in mobile phones. With a rolling shutter, the light energy generated by the LED BriteFlash power architecture exceeds most xenon flashes. Furthermore, LED flash is now approaching brightness levels which enable the use of frame extension mode to capture an image in 1/60 sec.

In light energy (lux.secs) comparisons:

- From 1m, the supercapacitor-powered two-LED array driven at 2A per LED, with a 15 frames/sec rolling shutter, delivered the best of all cases with 21.7 lux.secs, 37% more than the best-performing xenon, the SonyEricsson K800 with 15.8 lux.secs.

- From 2m, the same two-LED array delivered 7.0 lux.secs over 67msecs (15 frames/sec rolling shutter), ~60% more light energy than the 4.45 lux.secs from the best-performing xenon, the SonyEricsson K800.
- Over 33msecs, short enough to avoid blur from hand shake, the same two-LED array delivered 3.6 lux.secs, or nearly 50% more light energy than the Nokia N82 xenon phone with 2.45 lux.secs.
- The standard battery-powered LED flash unit in the Nokia N73 delivered only 0.43 lux.sec.

With supercapacitor-based LED BriteFlash comparable to xenon in light energy, other attributes of the supercapacitor solution make it more attractive. Supercapacitors:

1) Are thinner (enabling flash units 2 - 4mm thick) than the xenon solution. For example, the K800 xenon flash unit, including its electrolytic storage capacitor, occupies 3.8cm^3 and is 7mm thick
2) Use a lower voltage (5V compared to a 330-V electrolytic storage capacitor)
3) Take only ~2 seconds to recharge between flashes compared to ~8 seconds for the xenon in the K800
4) Can handle all the peak-power needs of the mobile phone including flash, the RF power amplifier and audio amplifier.

About the Author

Pierre Mars is the VP of Applications Engineering for CAP-XX Ltd. He jointly holds three patents on supercapacitor applications. Mr. Mars has a BE electrical (1st class hons) and an MEng Sc from the University of NSW, Australia, in addition to an MBA from INSEAD, France. He is also a member of the IEEE. Based in Sydney, Australia; the company can be reached at sales@cap-xx.com. Design tools, application notes and other details are available at http://www.cap-xx.com.