



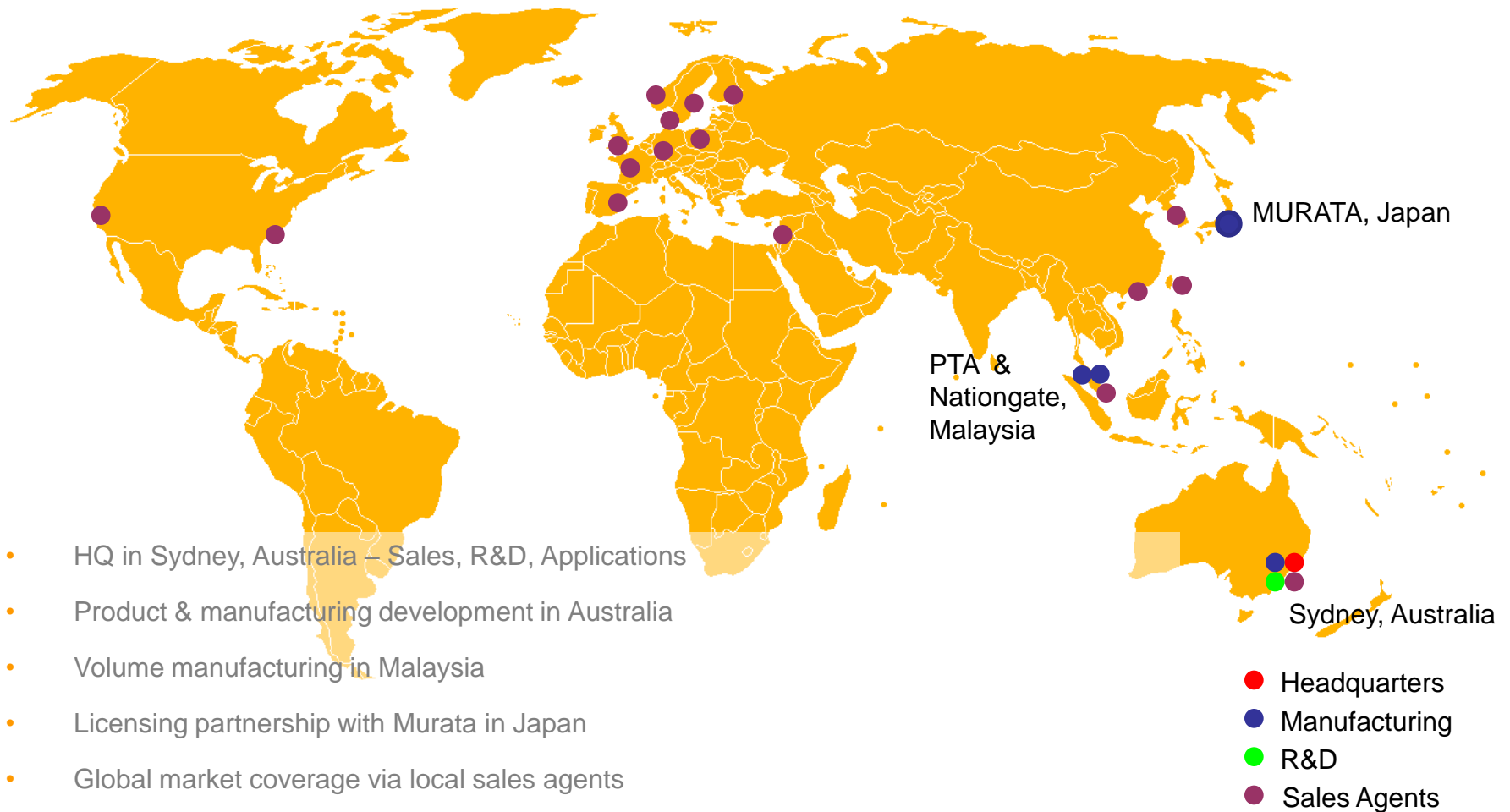
Prismatic Supercapacitor Applications

Anthony Kongats,
CEO, CAP-XX Ltd
17th April 2013

- About CAP-XX
- Prismatic Technology in General
- Small Laminate Prismatic supercapacitors
- Small SMD supercapacitors
- Large Laminate Prismatic supercapacitors

- World leader in high power energy storage devices (supercapacitors) for consumer and industrial electronics, cleantech and automotive markets
- More than 8m devices sold globally
- Unique technology, with 19+ patent families
- Technology validated by and licensed to Murata – Murata now in mass production
- Next generation of products - SMD and Large Format Supercapacitors for automotive and other markets - validated by test results and ready for licensing





- Proprietary Prismatic Construction
 - Low ESR / Highest Power
 - Ease & efficiency of packing /assembly for large cells
 - Better heat dissipation
 - Can be packaged with prismatic battery - Tier 1 auto suppliers have designed suitable racks for Li-Ion cells.
 - Ease of changing X-Y footprint in large cells
 - Ease of changing ESR, C, thickness to suit
 - Proprietary carbon & hybrid electrodes
 - Higher C, Higher Power, greater energy density, reduced size & weight
 - Deep Application knowledge and design skills
-

- Consumer Electronics

- ✓ Mobile phones
- ✓ Digital cameras & Digital video cameras
- ✓ Solid state drives
- ✓ e-Book readers & tablet PCs
- ✓ MP3 players & speakers

- Industrial Electronics

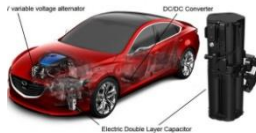
- ✓ Portable POS, PDAs & PCs
- ✓ Location trackers & RFID tags
- ✓ Condition monitoring & AMR
- ✓ Secure radios & security systems
- ✓ Medical & Military devices
- ✓ Electronic locks

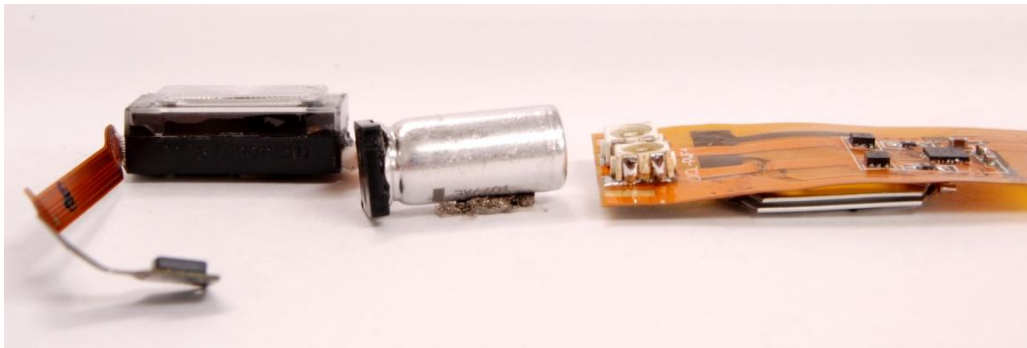
- Cleantech Automotive

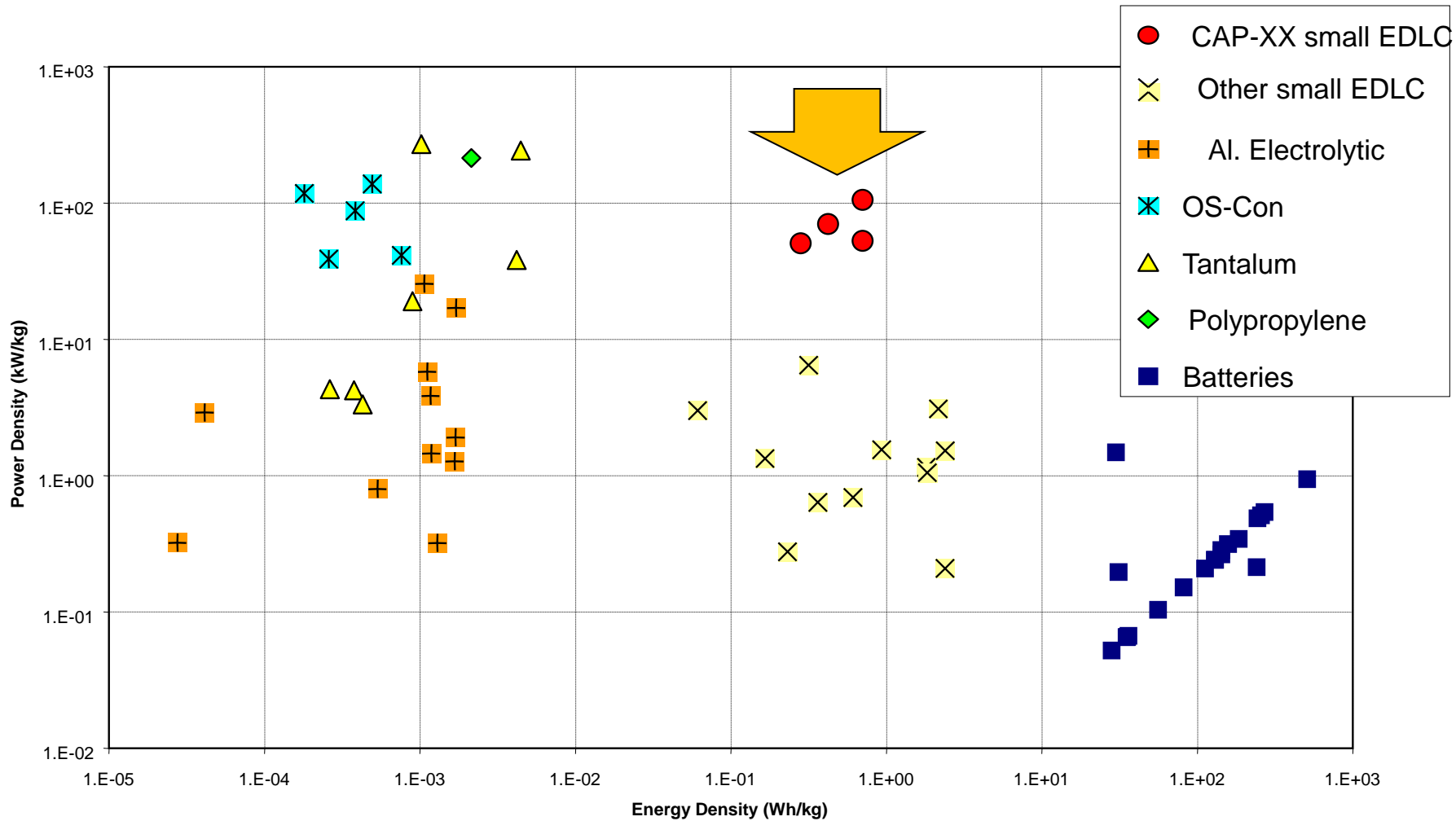
- ✓ Stop-Start (warm cranking); Cold cranking; Regenerative braking & Distributed power support in all vehicles
- ✓ Drive-train support in Hybrid Electric Vehicles, Electric Vehicles, Fuel Cell Vehicles & Electric Bikes

- Cleantech Other

- ✓ Energy harvesting systems: Solar, Vibration; Wind, Thermal, RF
- ✓ Smart grid & grid storage
- ✓ Fuel cell support



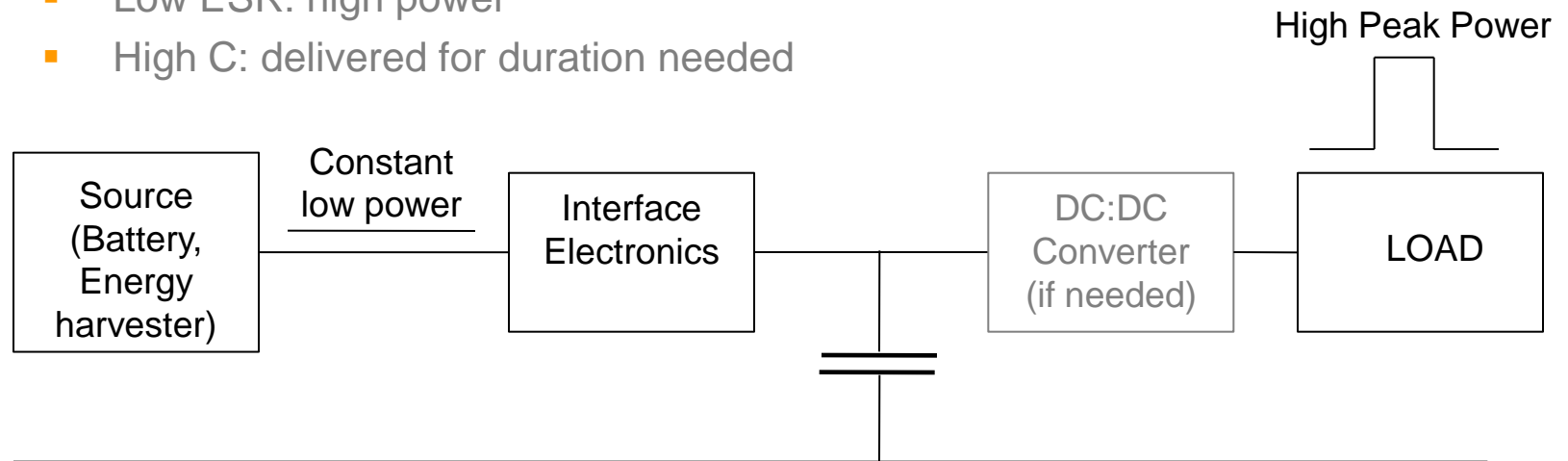




Ragone Plot: Gravimetric Power density vs Energy density

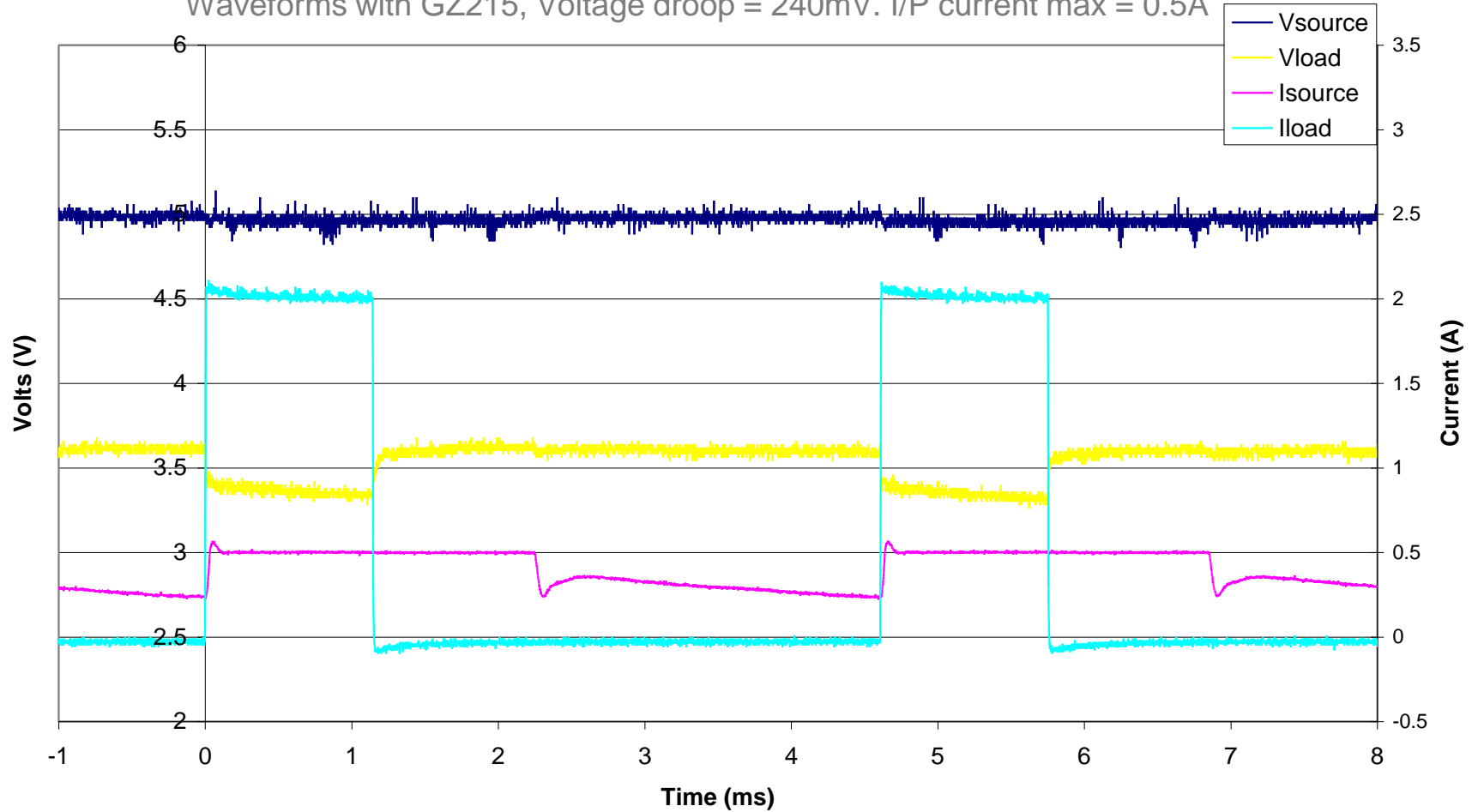
- Peak Power:
 - Wireless transmission (GPRS)
 - High Power LED Flash (Cameras and Video recorders)
 - Industrial Handheld Terminals (POS and PDAs)
 - AMR, RFID, location tracking (with long life, low power batteries)
 - Actuators, solenoids (e-Locks, Shut Off Valves)
 - Cold temps, battery cannot deliver the power
- Stored Power
 - Energy Harvesting / Wireless Sensor Networks
 - Industrial, Building Control, RFID, location tracking
- Backup Power
 - Solid State Drives (SSDs)
 - Industrial handheld terminals
 - Automatic Meter Reading

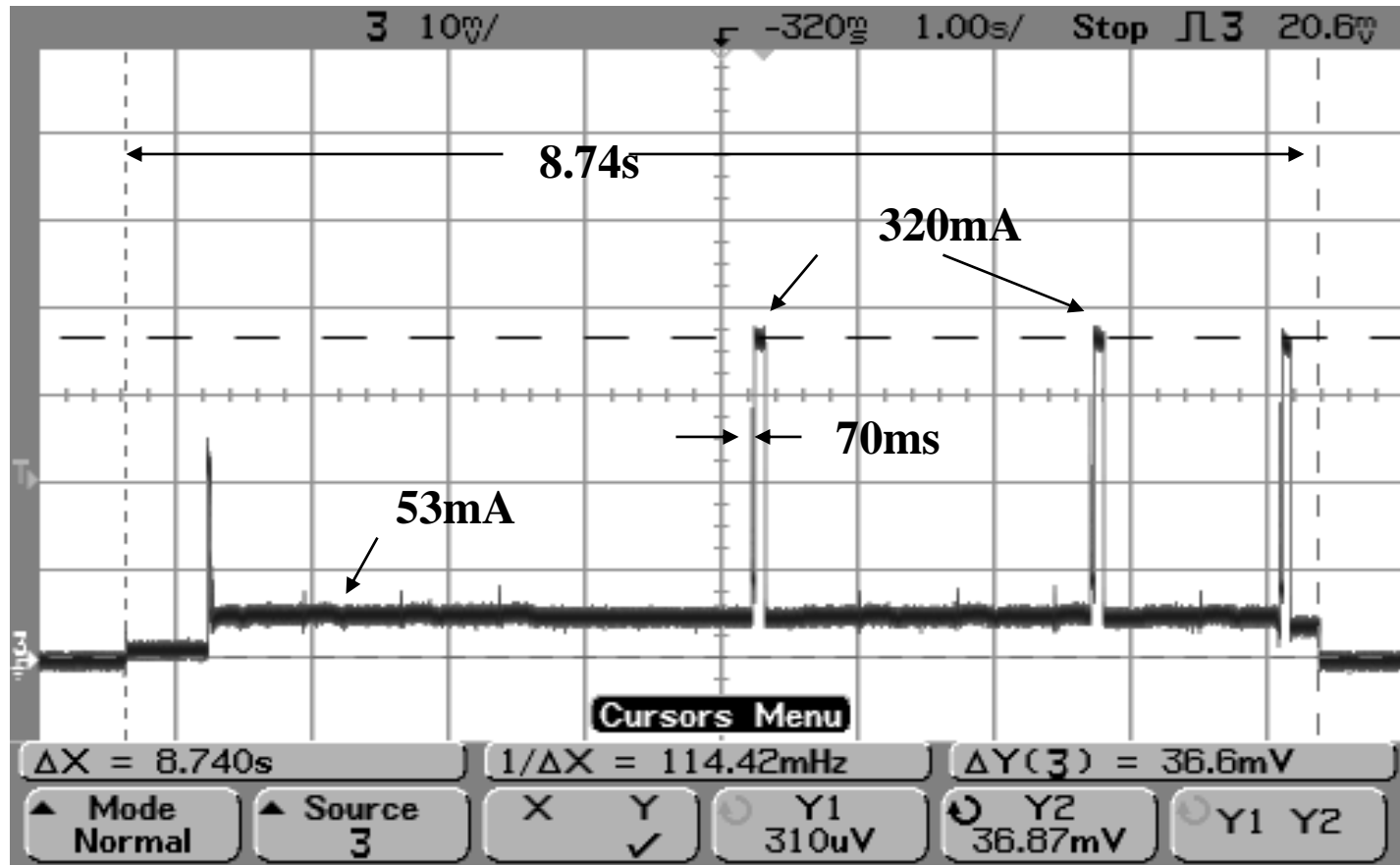
- A supercapacitor buffers the load from the source. Source provides low average power, supercapacitor provides peak power to the load.
- Average load power < Average source power
- Source sees constant power load, set at maximum power point
- Load sees a low impedance source that delivers high peak power for duration needed
 - Low ESR: high power
 - High C: delivered for duration needed



5V USB Class 10 0.5A limit with GZ215

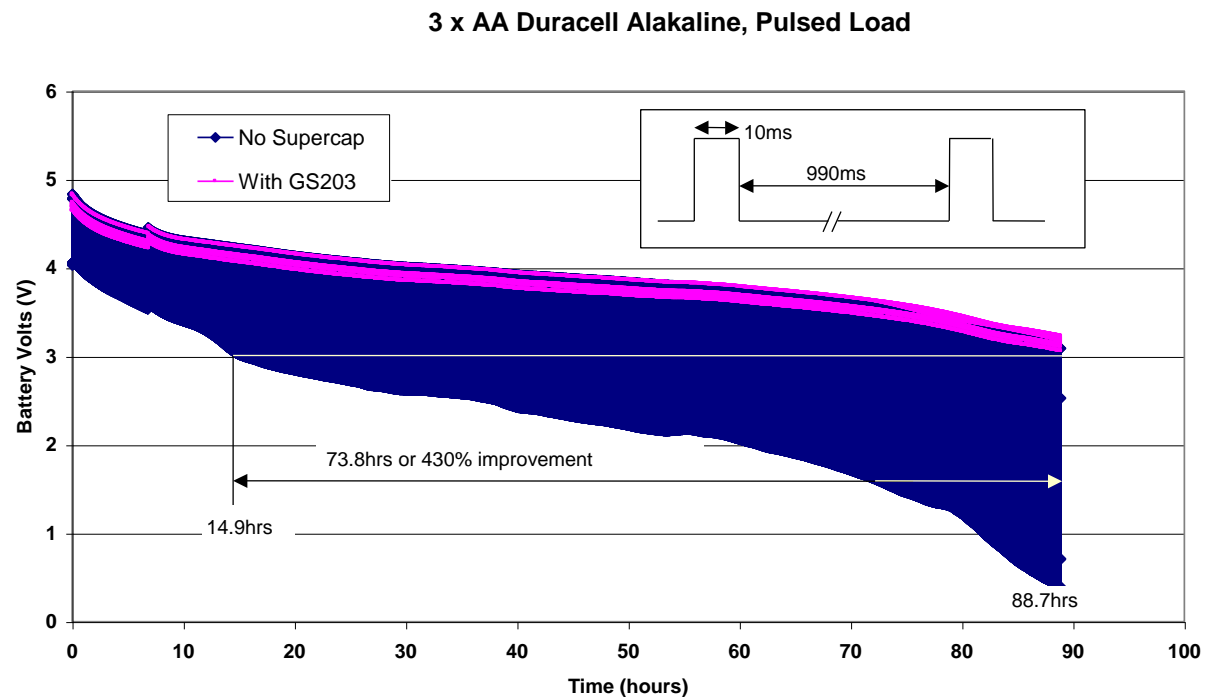
Waveforms with GZ215, Voltage droop = 240mV. I/P current max = 0.5A





- More current than a long life battery can deliver
- Longer pulses than a traditional capacitor can deliver

- Alkaline batteries have many advantages
 - low cost; good energy density; convenient, available anywhere
- But they cannot support applications with hi pulse power due to internal battery impedance causing excessive voltage drop e.g. mobile phone call
- Supercapacitors overcome this handicap and make Alkalines viable where previously they were not



Non-life-support applications such as:

Pump or solenoid activation for drug delivery

Heating wire to vaporise a drug for inhalation

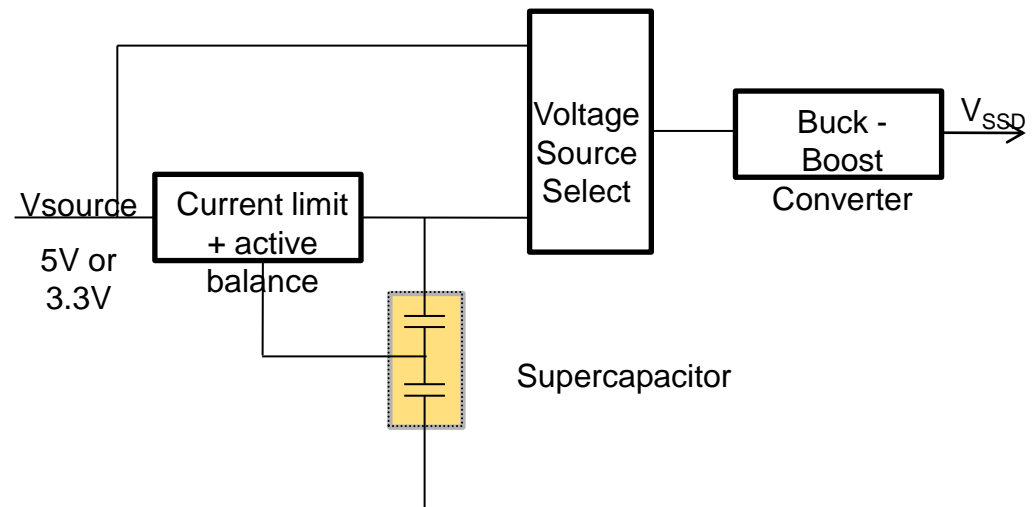
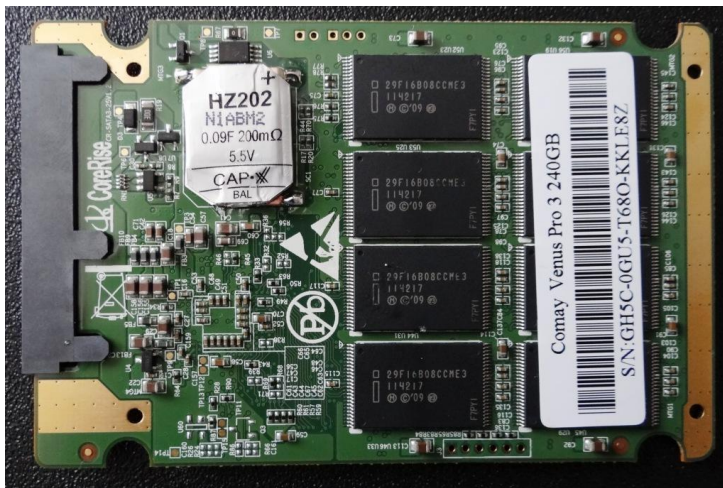


Semi disposable insulin device, with a CAP-XX supercapacitor

SSDs need Supercapacitors



- Writing to NAND Flash is slow
- Use cache RAM to improve performance
- But if power lost before cache flushed then lose data and SSD may be corrupted
- Use supercapacitor to power SSD while cache written to Flash in event of power fail
- Mini UPS





- Backup Power
 - Drop Test Protection
 - Graceful Shutdown
 - Last Gasp Transmission
- Cold temperature operation
 - -40C
- Battery Life Extension
- Peak Power
 - Thermal printer + GPRS

CAP-XX Energy harvesters need Supercapacitors

- Wireless sensors to control: HVAC; Lights (on/off/levels); Equipment condition monitoring
- Too expensive to wire power to the sensors
- Batteries need replacing every 2 – 3 years; expensive + problem of battery disposal
- Solution: environment has infinite ambient energy but at very low power – use a supercapacitor to provide peak power for data gathering and transmission.
- **Supercapacitor Requirements:**
 - Very low leakage current / low minimum charge current
 - Long life (5 – 20yr)
 - Wide operating temperature range
 - Very low source power, must provide peak load power

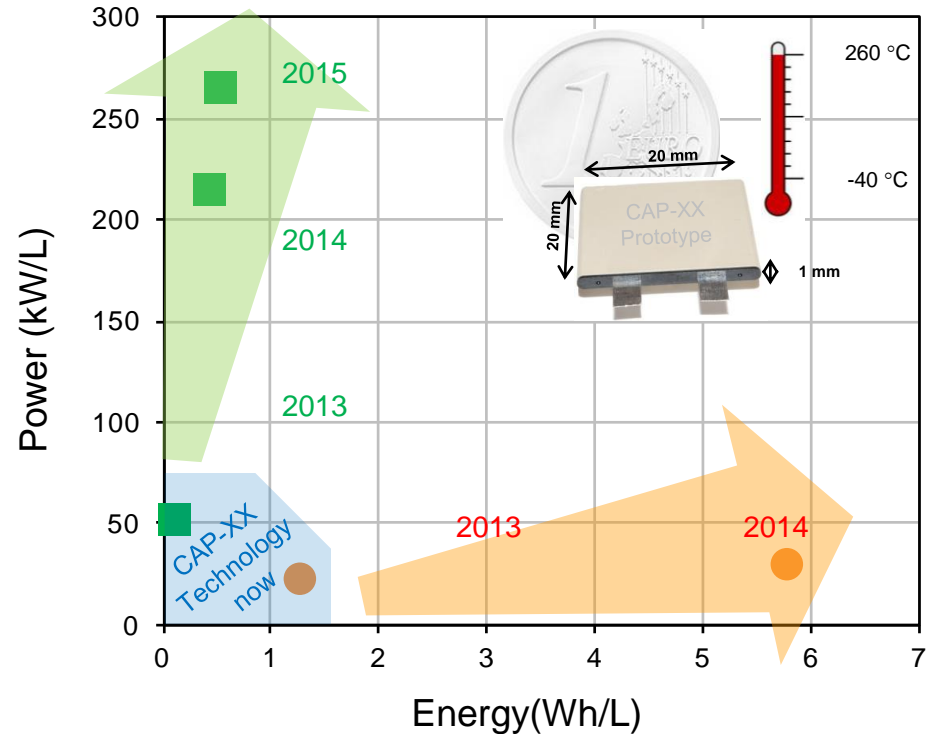
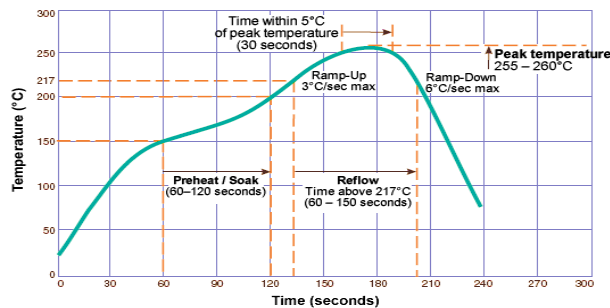


ABB Solar Powered Flowmeter



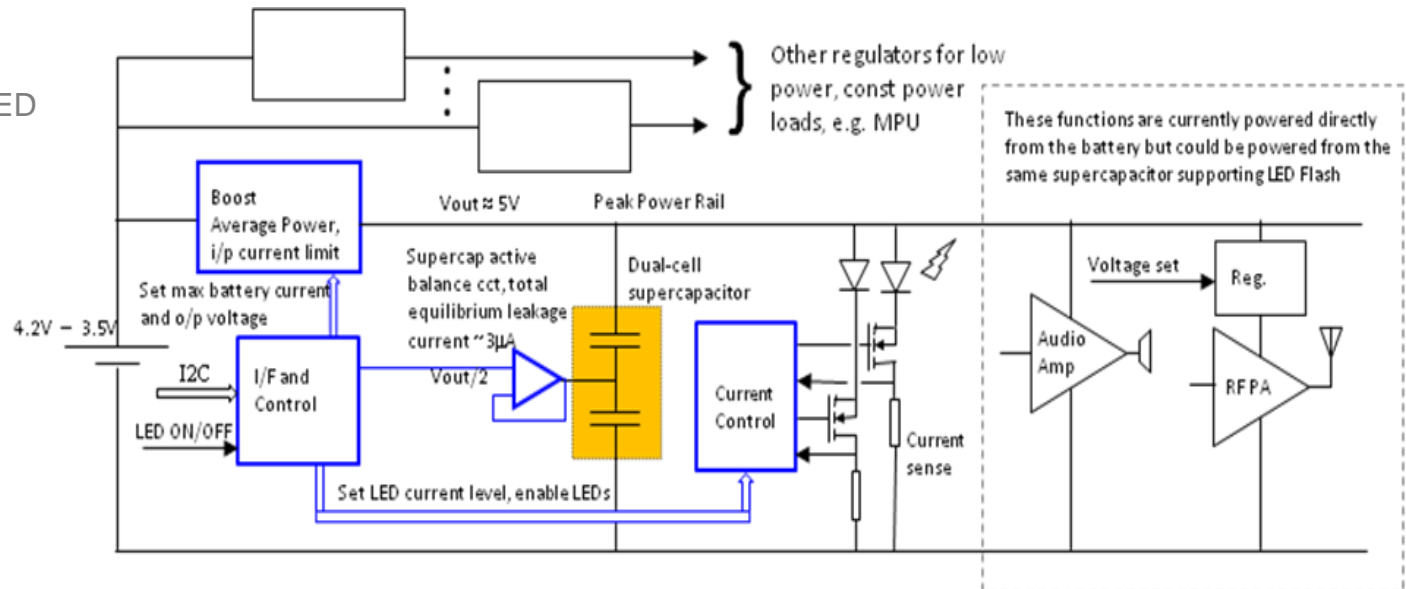
Vibration Transducer

- World's highest power supercapacitor is now surface mountable - a world first
- Multi-pass lead-free reflow (<10% change in performance)
- Smaller and higher energy than current technology
- Environmentally friendly
- Long life and high reliability
- Low Bill of Material Cost
- Improvements planned to increase frequency response and energy density



Functions in blue have been integrated into a LED Flash Driver IC targeted for mobile phones:

- NCP5680
- CATS3224
- AAT1282
- LM3550
- TPS61325



Possible power architecture for mobile phone with a Supercapacitor:

- Peak power rail for high current loads
- Boost converter supplies Supercapacitor with average power, high power loads can draw the power they need from the Supercapacitor without straining the battery
- Where appropriate, another regulator can control the voltage or current at input to the peak power load, e.g. LED current, voltage to RF PA, etc.
- Low or constant power loads, where the Supercapacitor does not help, can be driven separately from the battery

- L3 and Sony Ericsson launched first phones with a supercapacitor, new phones from several manufacturers expected shortly
- Many semiconductor companies have designed ICs around CAP-XX's supercapacitor, recent announcement of new supercapacitor enabled IC from ST Micro and that they are working with Murata
- Supercapacitor phone enhancements include:
 - ✓ Better photos through high power LED flash
 - ✓ Battery life enhancement
 - ✓ Audio quality enhancement
 - ✓ Support for high definition screens



Standard Nokia N73



CAP-XX Nokia N73



SonyEricsson K800i (xenon strobe)

Companies which have released supercapacitor ICs

Company	Part No	Function
Analogue Devices	AD1658	High current flash LED driver
AnalogicTech	AAT1282	High current flash LED driver
Exar	XRP6840	High current flash LED driver
Linear Technology	LTC3225	General charger
ON Semiconductor	NCP5680	High current flash LED driver
ON Semiconductor	CAT3224	High current flash LED driver
National Semiconductor	LM3550	High current flash LED driver
Texas Instruments	TPS61325	High current flash LED driver



LTC3225

150mA Supercapacitor
Charger

FEATURES

- Low Noise Constant Frequency Charging of Two Series Supercapacitors
- Automatic Cell Balancing Prevents Capacitor Overvoltage During Charging
- Programmable Charging Current (Up to 150mA)
- Selectable 2.4V or 2.65V Regulation per Cell
- Automatic Recharge

DESCRIPTION

The LTC[®]3225 is a programmable supercapacitor charger designed to charge two supercapacitors in series to a fixed output voltage (4.8V/5.3V selectable) from a 2.8V/3V to 5.5V input supply. Automatic cell balancing prevents overvoltage damage to either supercapacitor. No balancing resistors are required.



5A Super-Capacitor WLED Flash Driver
And AUDIO Power Supply Controller

Preliminary Specification –Internal v6

ADP1658

FEATURES

- Integrated Super Capacitor Manager and Push Driver
- High peak current Audio supply rail
- 24 Bump WL CSP
- PC interface
- Super Capacitor Manager:
 - 2.8V to 5.5V Input Voltage

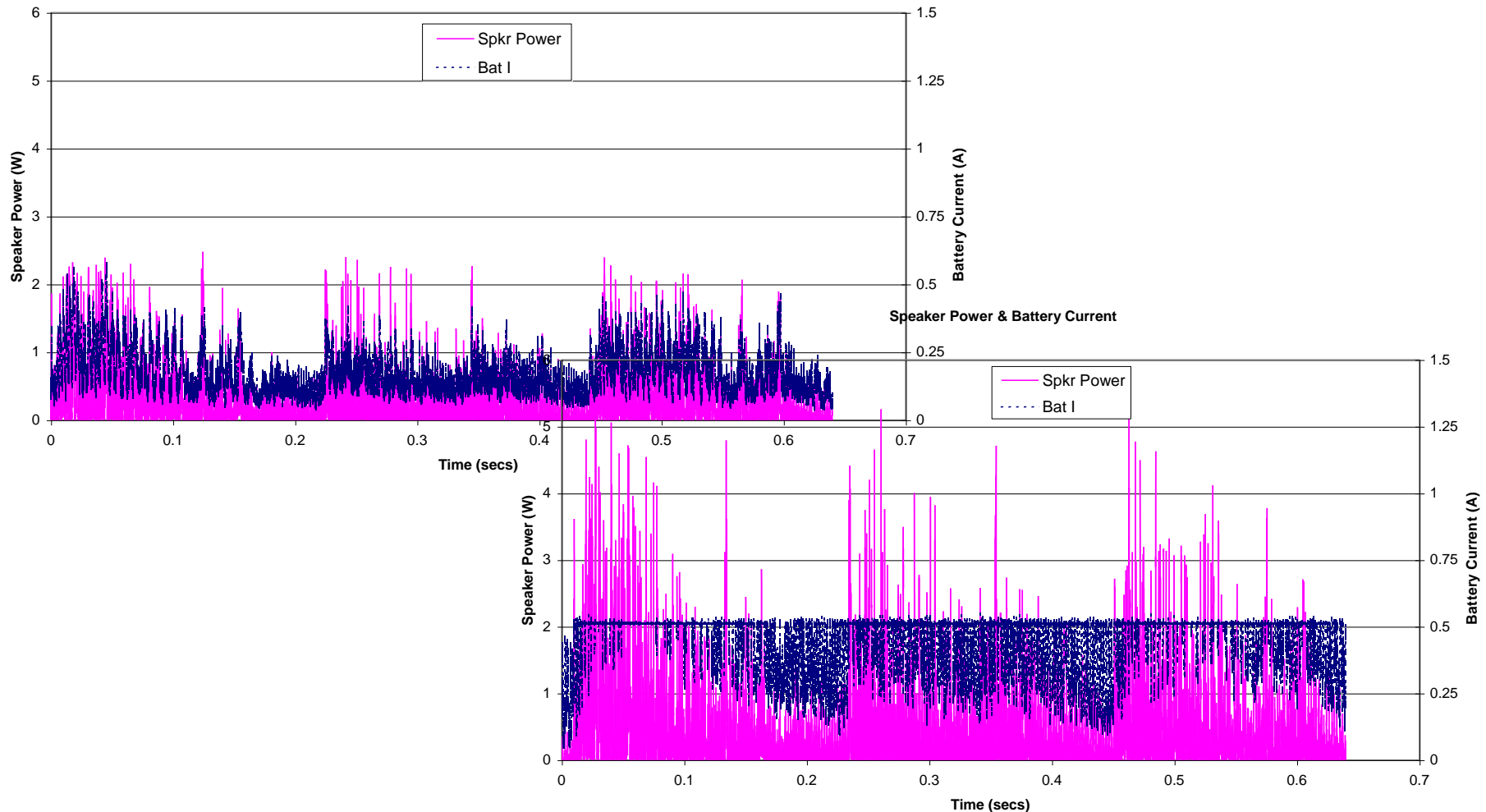
GENERAL DESCRIPTION

The ADP1658 is a high current LED camera-flash IC which enables the use of super capacitors to enhance LED flash brightness in cellular phones and digital still cameras.

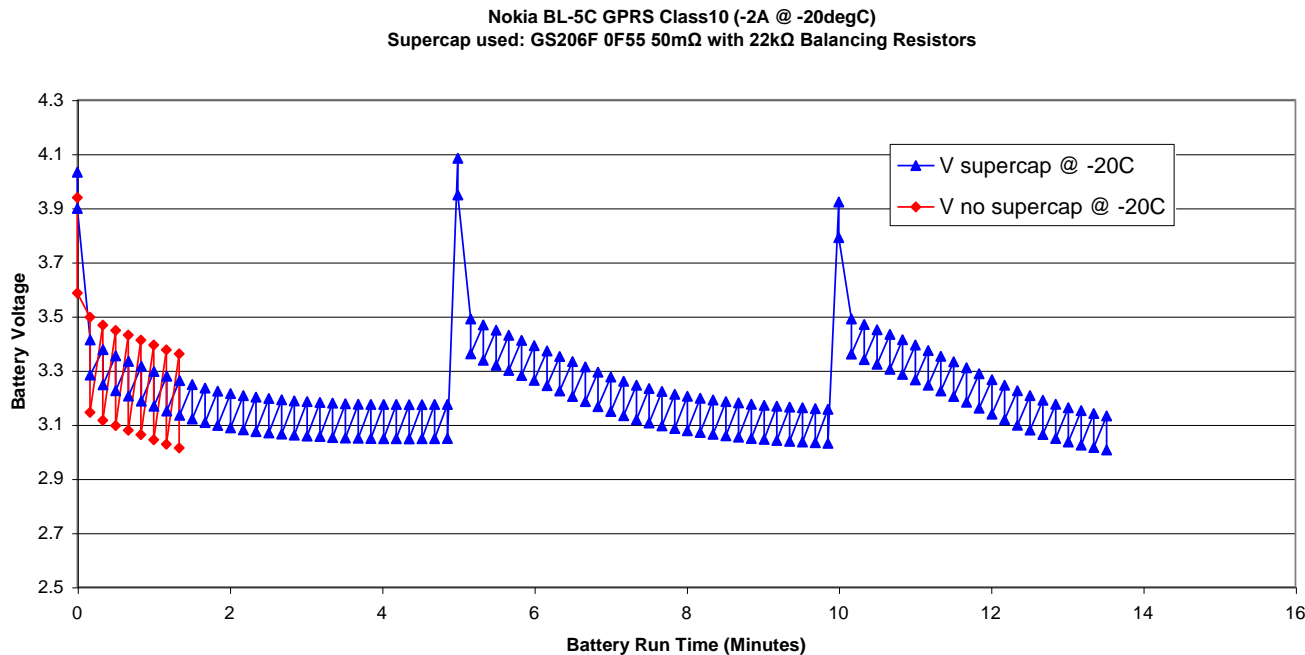
The super capacitor's large capacity and low ESR allows LED peak currents up to 5A for flash, improving picture quality of high resolution cameras to low light environments.



Peak power = 5.25W, 110% ↑ ; RMS Power = 0.66W, 65%↑; Peak battery current = 0.52A



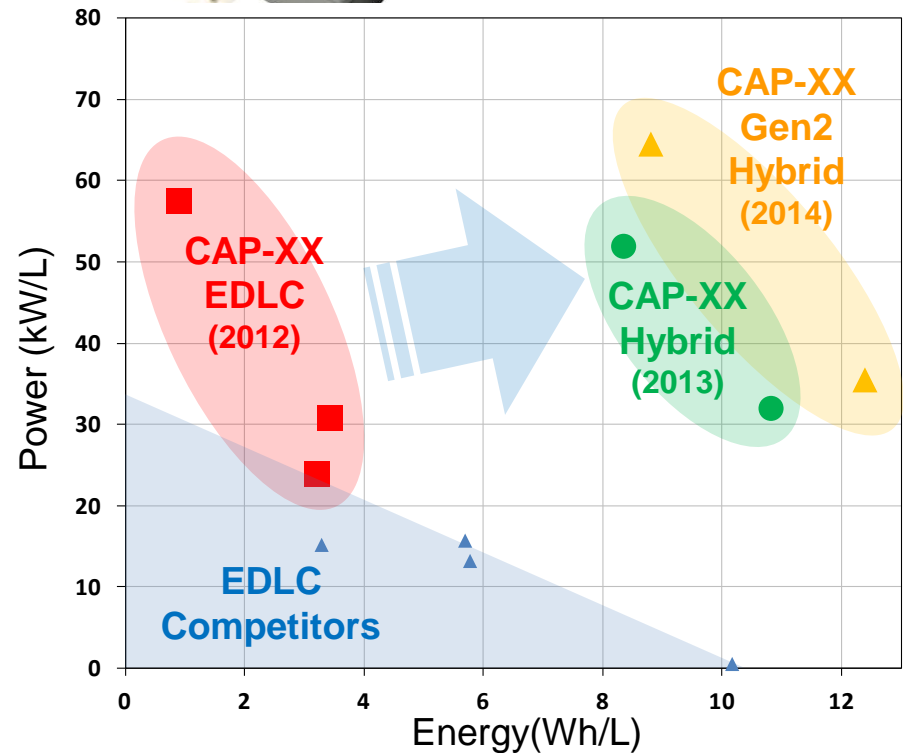
- Li-Ion Battery performance is hampered by low temperatures (below 0°C)
- The supercapacitor extends run time and battery life (much more so than at room temp)





- Automotive batteries have limitations in terms of life, sudden failure, limited power delivery and small temperature range
- Supercapacitors use physical charge storage, not rate-limited by chemistry:
 - Have “unlimited” cycle life
 - Have excellent Dynamic Charge Acceptance
 - Deliver / accept energy at very high power
 - Useful over a wide temperature range (-40C to +70C or more)
- Supercapacitors resolve the limitations of Lead-Acid, Lead-Carbon, Ultrabatteries & Lithium-ion batteries in many uses:
 - ✓ Warm cranking for fuel efficient Stop-Start systems
 - ✓ Cold cranking (ESR @ -40°C is $\approx 2 \times$ room temp ESR)
 - ✓ Regenerative energy capture during braking/coasting
 - ✓ Safety backup for electrically driven brakes and steering
 - ✓ Drive-train support in Hybrid Electric and Electric Vehicles
 - ✓ Distributed power systems to reduce wiring loom size/weight/cost

- World's highest power large supercapacitors for automotive
 - Low ESR, high voltage, 1400 F
- Next generation: High energy, high power, long life hybrid cells
 - 3400 F per cell
 - Low BoM of US\$0.002 per Farad
 - Over 1 million cycles
- Prismatic soft-packaging for easy, low cost cell manufacture
 - Thin, compact cells
 - Layered electrodes for modularity and high performance
- Environmentally friendly
- Established development pipeline



- In all tests, end of battery life is defined as system voltage falling below 7.2V during cold cranking or 10V during a Stop-Start cycle
- 1. New European Drive Cycle (ADR79) at 23°C:
 - Battery alone - Failed after 44,000 starts
 - Battery + Supercapacitor – Ran for 120,000 starts
- 2. Japanese Battery Charge Acceptance Test at 23°C:
 - Battery alone - Failed after 981 starts
 - Battery + Supercapacitor - Ran for 9,553 starts
- 3. Modified New European Drive Cycle (ADR79) at -18°C:
 - Battery alone - Failed after 1 Stop-Start cycle at 10V/ failed after 4th cold start
 - Battery + Supercapacitor – Failed after 4500 Stop-Start cycle at 10V/ failed after 17th cold start
- 4. NEDC (ADR79) Light Commercial Diesel Vehicle at 23°C:
 - 3.4% fuel saving; 21% faster starting; battery voltage > 12V



CAP-XX

For more information, please contact

Peter Buckle

VP Sales & Marketing

Email: peter.buckle@cap-xx.com

Web: www.cap-xx.com