Introduction to Microcontrollers

Tutorial: battery discharge monitoring

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Ultrasound and Non Destructive Testing Laboratory
http://www.uscndlab.dinfo.unifi.it/mdswitch.html

Summary

- Integrated Development Environment (microcontrollers)
- Programming languages
- Industrial electronics application
- Tutorial: monitoring battery discharge using micro

Integrated Development Environment

- Proprietary
  - (Studio 7->ATMEL, MPLab X ->MICROCHIP, Composer Studio->TEXAS
  - Zilog Developper Studio -> ZILOG, ….)
- Proteus (Lab Center)
  - (Environment to simulate some micro)
- IAR System
  - (11.071 devices)

Programming languages

Assembly

Language C

Language C

```
#include <avr/io.h>
#define uchar unsigned char
#define uint unsigned int

// Low level port/pin definitions
#define sbit(x,PORT) (PORT) |=
(1<<x)
#define pin(x,PIN) (PIN)&(1<<x)

int main(void)
 { SPL = 0x5f;
   SPH = 0x04;
……
OCR0 = 0x01;// Foc =
Fclk/2*(1+OCR0)
   // Configure the channel IN0
……
}
```

Language ASM

```
;--------------;
   ; MAIN ROUTINE ;
   ;--------------;
   BEEP: CLR I
   BLUPE:
     SER A              ;TURN SPKR ON
     OUT  PORTB,A
      RCALL PAUSE       ;WAIT
     CLR A              ;TURN IT OFF
     OUT PORTB,A
      RCALL PAUSE       ;WAIT AGAIN
     DEC I
      BRNE BLUPE
   LOOP: RJMP LOOP        ;STAY HERE
WHEN DONE
```

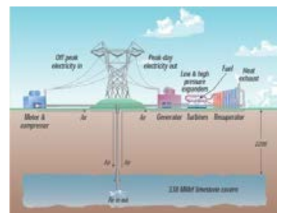
Applications of industrial electronic

- Digital Broadcast applications
- Medical Applications
- Automotive application
- Wireless Connectivity
- Smart Energy
- Drivers and Sensors

Tutorial: battery discharge monitoring

ENERGY STORAGE

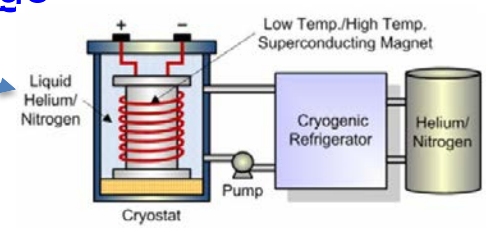
[compressed air energy storage](#)



[flywheel storage](#)

[pumped water storage](#)

[superconducting magnetic energy storage](#)



1 - 10 [W·h](#)/[kg](#)

SPECIFIC ENERGY

History

A battery is an energy storage device that uses a chemical reaction to do work on charge and produce a voltage between its output terminals. A battery is composed of one or more basic elements known as electrolytic cells (or electrochemical cells) and makes use of an oxidation-reduction reaction. These cells are enclosed in a container and electrically interconnected in an appropriate series/parallel arrangement to provide the required operating voltage and current levels.

BATTERIES

PRIMARY CELLS
or non-rechargeable batteries

alkaline battery

carbon zinc battery

SECONDARY CELLS
or rechargeable batteries

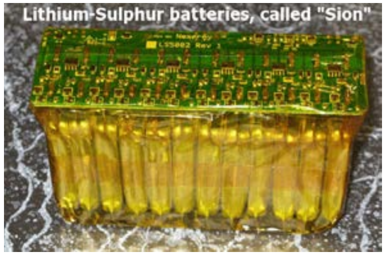
absorbed glass mat

fuel cell

gel-type battery

lead-acid battery

lithium-sulfur battery



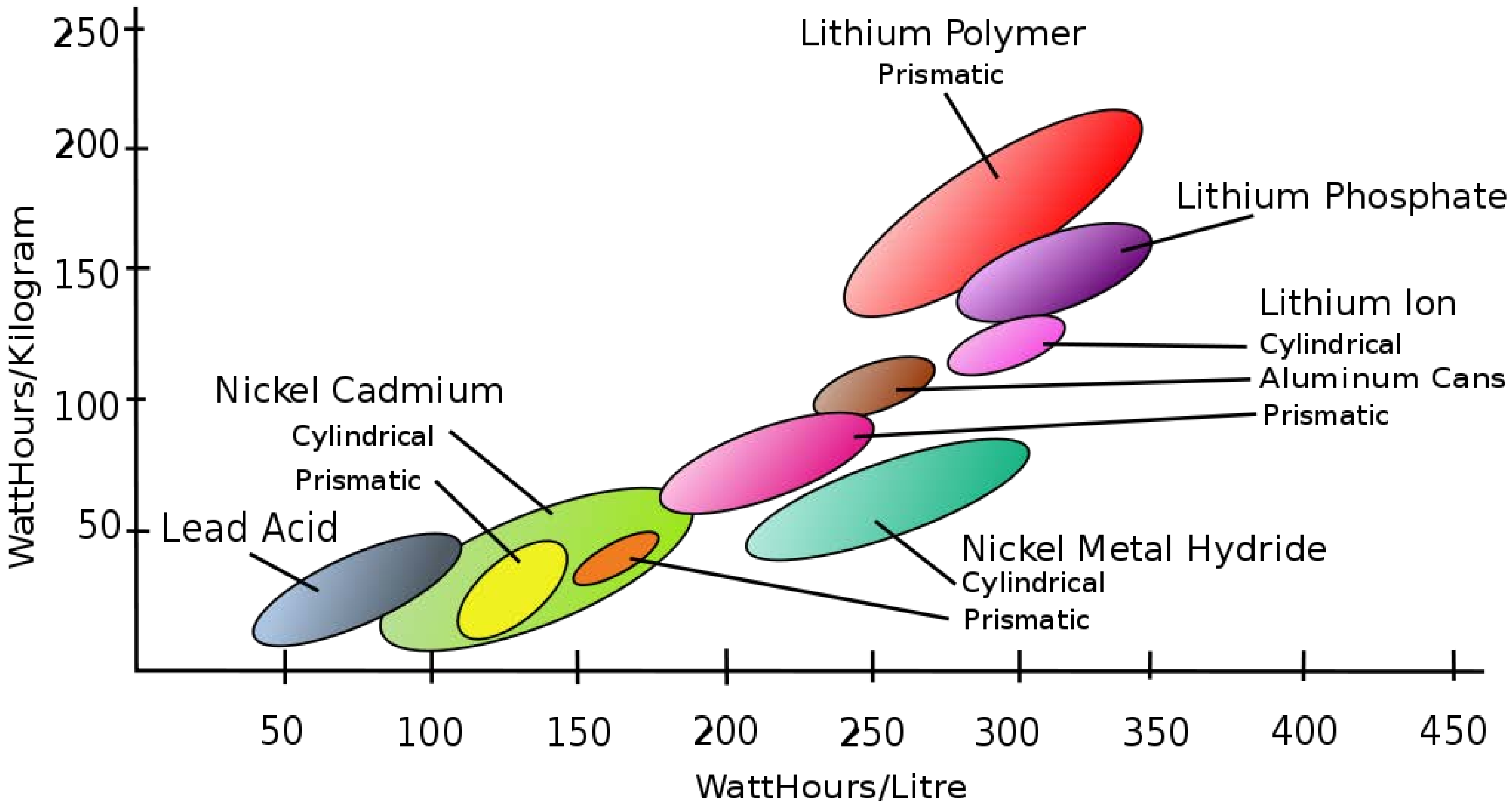
How is made: lead-acid battery

http://www.daviddarling.info/encyclopedia/L/AE_lead-acid_battery.html

The lead-acid battery was invented in 1859 by French phisicist Gaston Plantè and is oldest type of rechreargeable battery. An electrochemical battery that uses lead and lead oxide for electrodes and sulfuric acid for the electrolyte
Low energy-to-weight ratio
Low energy-to-volume ratio
Large power to weigth ratio

Specific energy	33–42 Wh/kg
Energy density	60–110 Wh/L
Specific power	180 W/kg
Cycle durability	500–800 cycles
Nominal cell voltage	2.0 V

Shallow cycle batteries, like the type used as starting batteries in automobiles, are designed to supply a large amount of current for a short time and stand mild overcharge without losing electrolyte. Unfortunately, they cannot tolerate being deeply discharged. If they are repeatedly discharged more than 20 percent, their life will be very short. These batteries are not a good choice for a PV system.


Lithium Polymer
Prismatic
Lithium Phosphate
Lithium Ion
Cylindrical
Aluminum Cans
Prismatic
Nickel Cadmium
Cylindrical
Prismatic
Lead Acid
Nickel Metal Hydride
Cylindrical
Prismatic
250
200
150
100
50
WattHours/Kilogram
50
100
150
200
250
300
350
400
450
WattHours/Litre

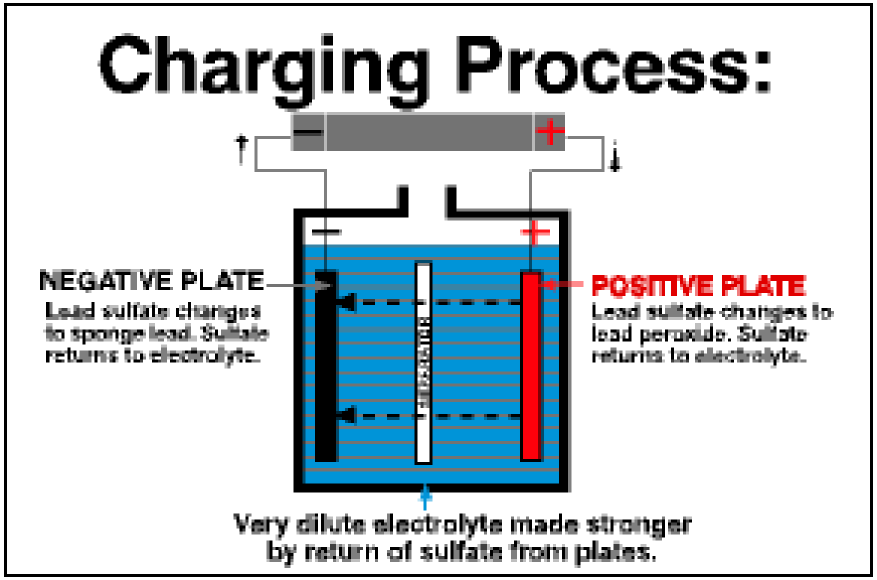
How it works

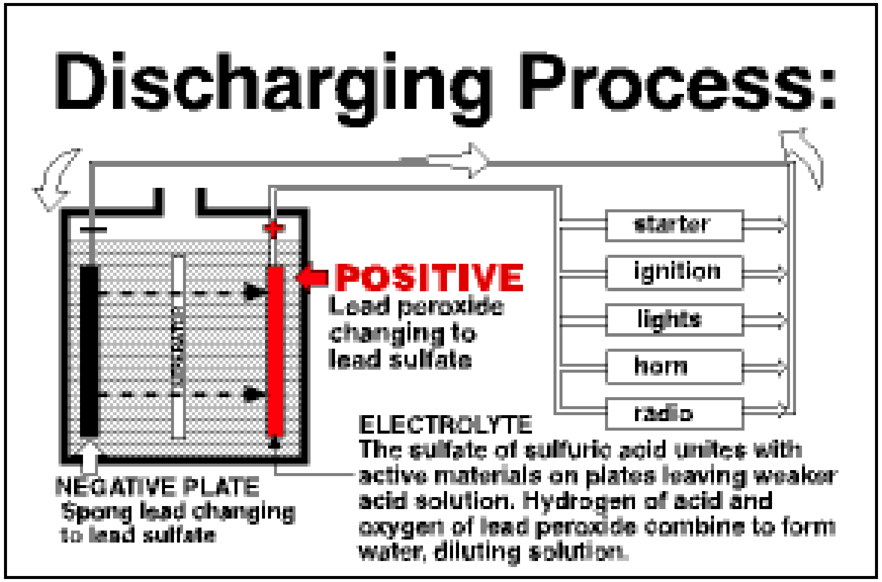
Negative plate reaction

$$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$$

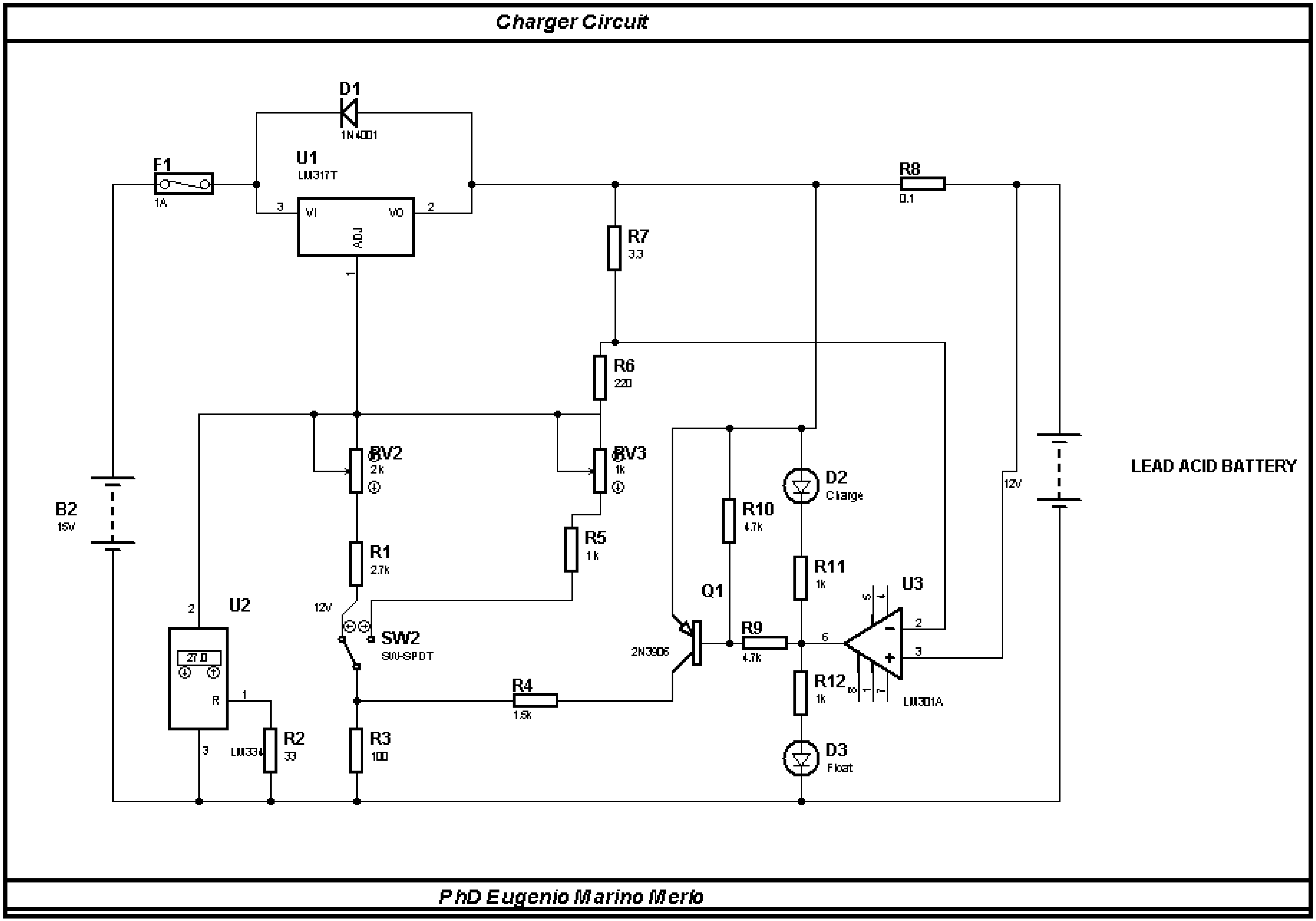
Positive plate reaction

$$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$



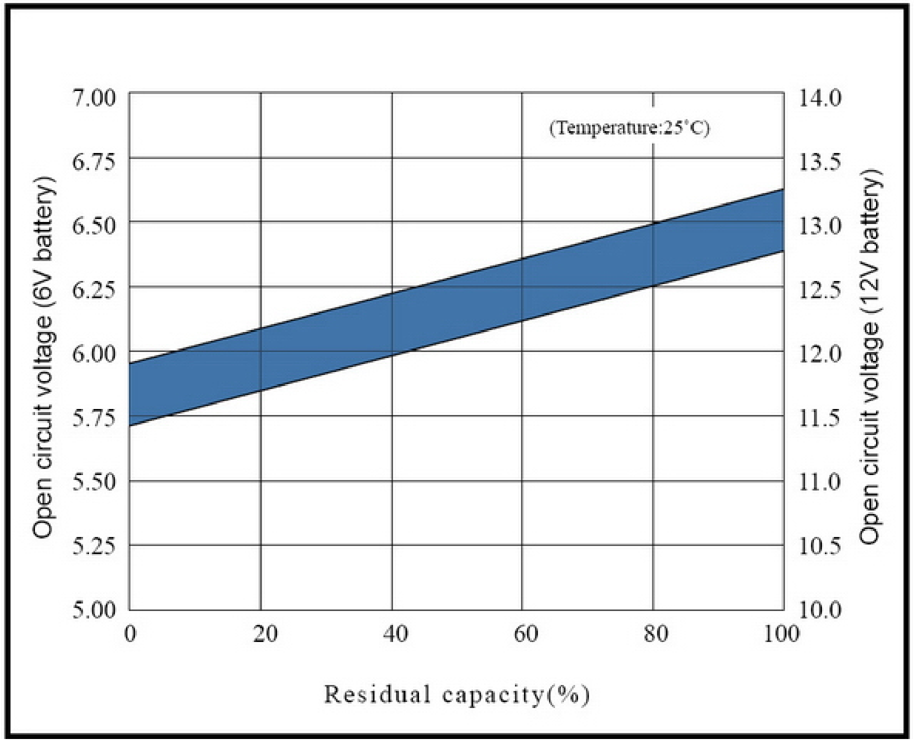


Attention: Risk of explosion for Excessive Charging


Charger Circuit
D1
1N4001
U1
LM317T
F1
1A
VI
VO
ADJ
R8
0.1
R7
3.3
R6
220
RV2
2k
RV3
1k
B2
15V
R5
1k
R1
2.7k
D2
Charge
R10
4.7k
R11
1k
U3
Q1
R9
4.7k
SW2
SW-SPDT
2N3906
U2
12V
R4
1.5k
R12
1k
LM301A
R2
33
R3
100
D3
Float
LM334
LEAD ACID BATTERY
12V
PhD Eugenio Marino Merlo

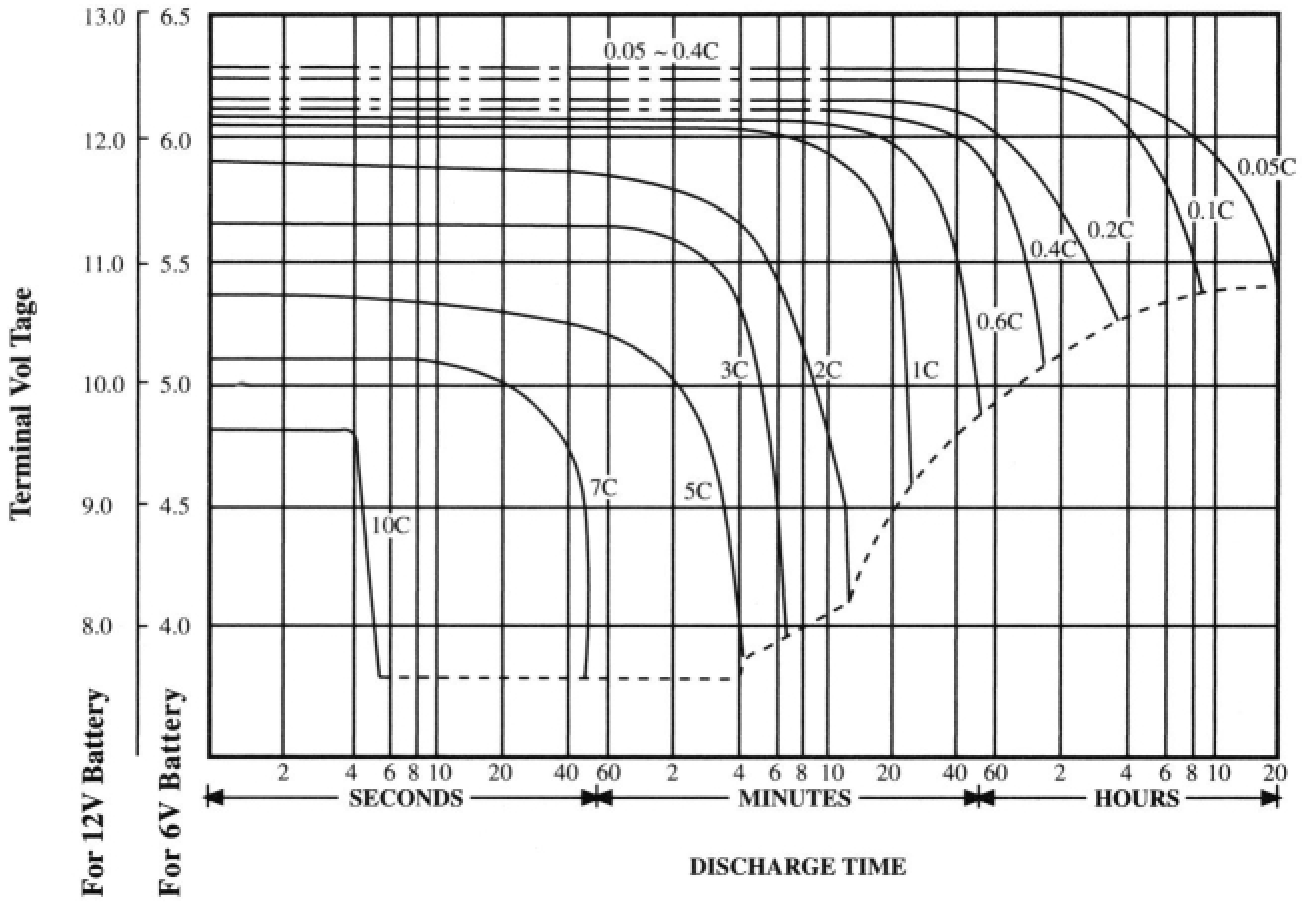
Charge Monitoring

Open circuit voltage vs. Residual capacity 77°F (25°C)



Battery State of Charge Determination
Circuit Voltage and the Remaining Capacity at constant temperature

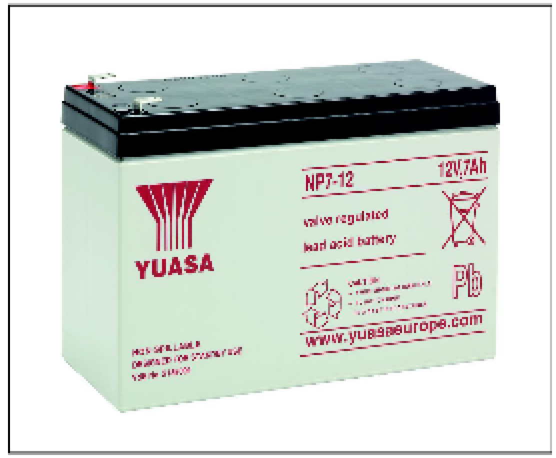
DISCHARGE Monitoring



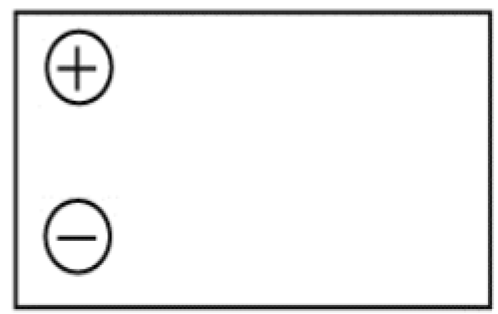
C = 7Ah in our battery

NP7-12

SPECIFICATIONS		
Nominal voltage	12	V
20-hr rate Capacity to 1.75VPC at 20°C	7	Ah
10-hr rate Capacity to 1.75VPC at 20°C	6.4	Ah
DIMENSIONS		
Length	151 (±1)	mm
Width	65 (±1)	mm
Height		mm
(height over terminals)	97.5 (±2)	mm
Mass (typical)	2.2	kg
TERMINAL TYPE		
FASTON (Quickfit / release)	4.75	mm
OPERATING TEMPERATURE RANGE		
Storage	-20°C to +60°C	
Charge	-15°C to +50°C	
Discharge	-20°C to +60°C	
STORAGE		
Capacity loss per month at 20°C (approx)	3	%
CASE MATERIAL		
Standard Option	ABS (UL94:HB)	
Flame retardant option (FR)	ABS (UL94:V0)	
CHARGE VOLTAGE		
Float charge voltage at 20°C	13.65 (±1%)	V
	2.275 (±1%)	V/cell
Float Charge voltage temperature correction factor (for variations from the standard 20°C)	-3	mV/cell/°C
Cyclic (or Boost) charge at 20°C	14.5 (±3%)	V
	2.42 (±3%)	V/cell
Cyclic Charge voltage temperature correction factor (for variations from the standard 20°C)	-4	mV/cell/°C
CHARGE CURRENT		
Float charge current limit	No limit	A
Cyclic (or Boost) charge current limit	1.75	A
MAXIMUM DISCHARGE CURRENT		
1 second	210	A
1 minute	48	A



LAYOUT



Bibliography

- http://www.daviddarling.info/encyclopedia/B/AE_battery.html
- http://www.atmel.com/
- Wikipedia

Introduction to Microcontrollers

architecture

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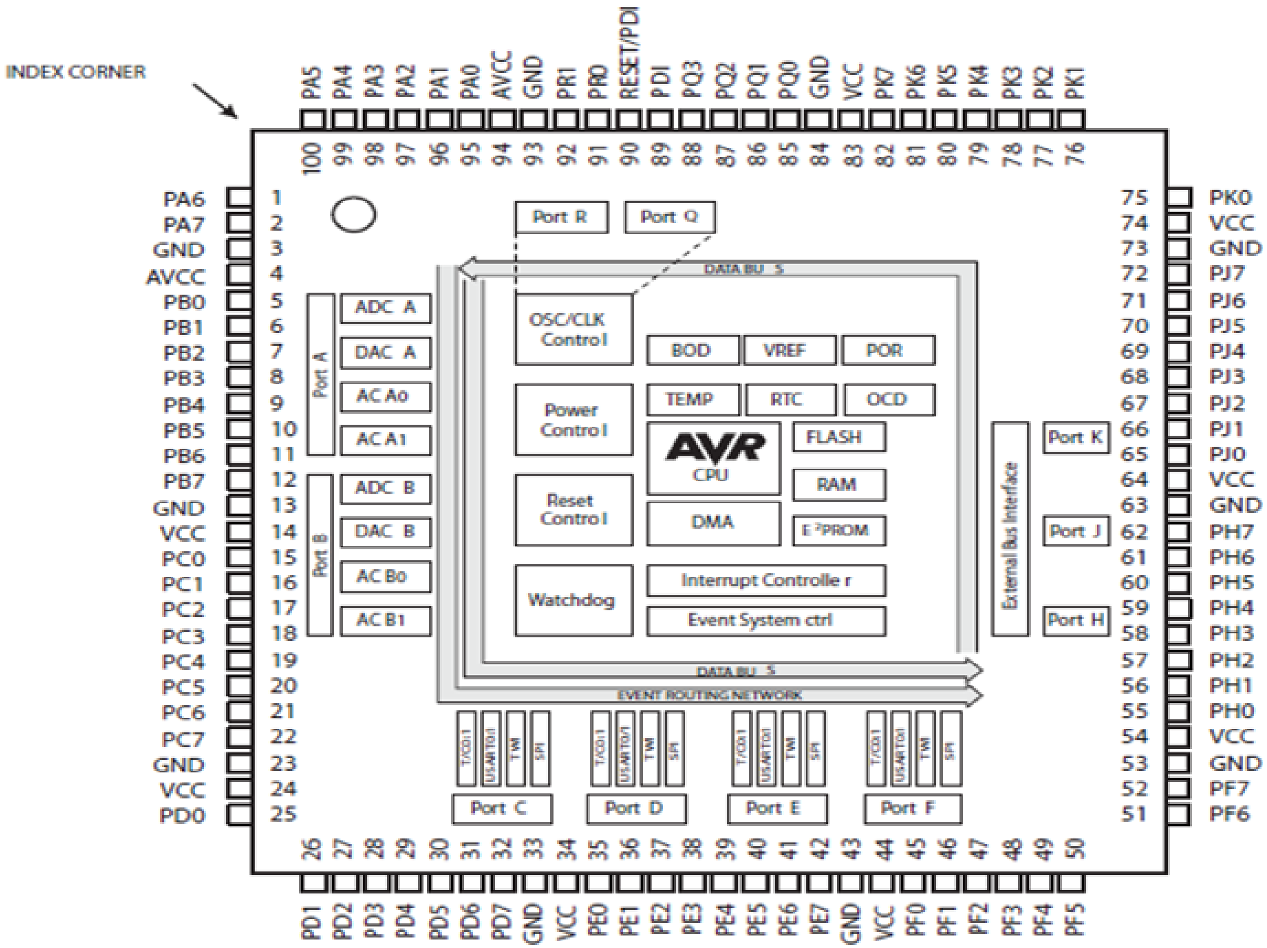
Summary

Microcontrollers:

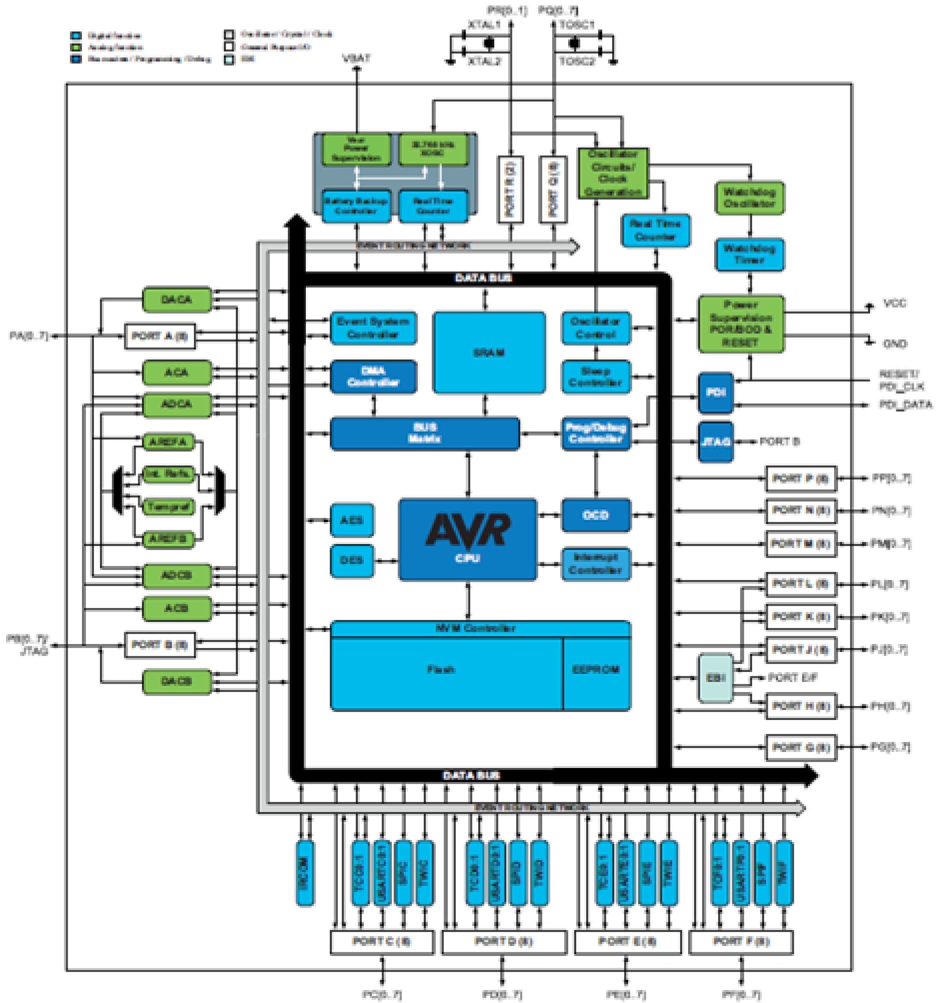
- Pinout
- Block diagram
- Features
- Demo board Xplained
- Examples and simulation with Proteus

PINOUT



Notes: 1. For full details on pinout and pin functions refer to "Pinout and Pin Functions" on page 55.
2. VCC/GND on pin 83/84 are swapped compared to other VCC/GND to allow easier routing of GND to 32kHz crystal.

Block Diagram



Microcontroller features

Low-power Atmel® AVR® XMEGA® 8/16-bit Microcontroller
Non volatile program and data memories
64K - 128KBytes of in-system self-programmable flash
4K - 8KBytes boot section
2 KBytes EEPROM
4 KB - 8 KBytes internal SRAM
Eight 16-bit timer/counters
Four timer/counters with 4 output compare or input capture channels
Eight USARTs with IrDA support for one USART
Four two-wire interfaces with dual address match (I2C and SMBus compatible)
16-bit real time counter (RTC) with separate oscillator
Two sixteen channel, 12-bit, 2msps Analog to Digital Converters
Two two-channel, 12-bit, 1msps Digital to Analog Converters
Four Analog Comparators (ACs) with window compare function, and current sources

•Microcontroller features

- External interrupts on all general purpose I/O pins
- Programmable watchdog timer with separate on-chip ultra low power
- QTouch® library support
- Internal and external clock options with PLL and prescaler
- Programmable multilevel interrupt controller
- Executing instructions in a single clock cycle
- 32 general purpose working registers directly connected to the arithmetic logic unit (ALU)
- Two independent registers to be accessed in a single Instruction
- 78 general purpose I/O lines
- 16-bit real-time counter (RTC);
- Eight flexible, 16-bit timer/counters with compare and PWM channels
- Two 16-channel, 12-bit ADCs with programmable gain

XMEGA-A1 Xplained

Matching buttons

PD0 <- Button 1
PD1 <- Button 2
PD2 <- Button 3
PD3 <- Button 4
PD4 <- Button 5
PD5 <- Button 6
PR0 <- Button 7
PR1 <- Button 8

Mappatura Led

LED1 <- PE0
LED2 <- PE1
LED3 <- PE2
LED4 <- PE3
LED5 <- PE4
LED6 <- PE5
LED7 <- PE6
LED8 <- PE7

Sensore NTC	-> PB0	->	Conv. Analogico Digitale
Sensore Luminosità	-> PB1	->	Conv. Analogico Digitale
DAC	-> PB2	->	Speaker

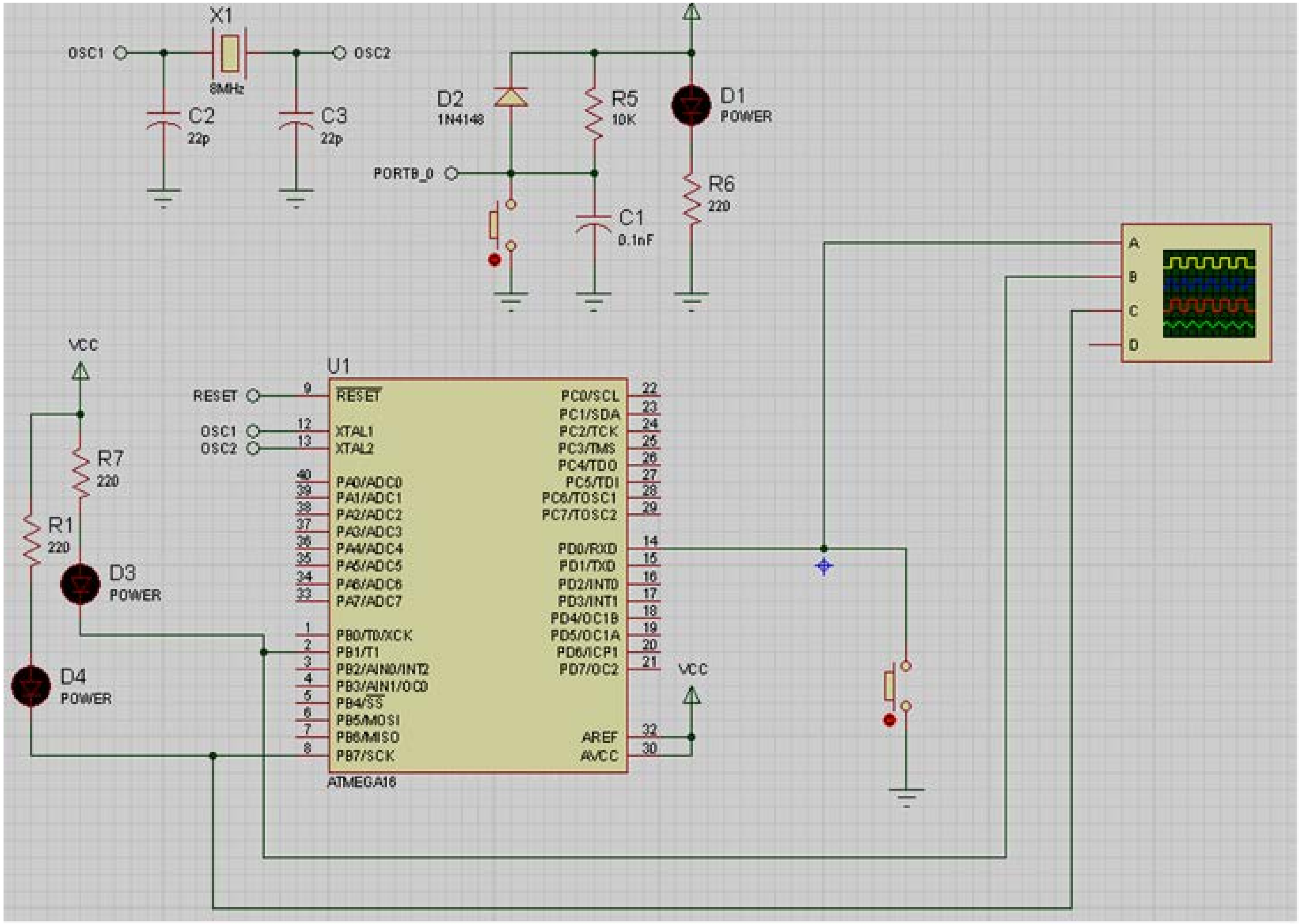
JTAG

Pin	JTAG Mode	
	Signal Name	Description
1	TCK	Clock signal
2	GND	Signal ground
3	TDO	Data from device
4	VCC(TRGT)	Target power supply
5	TMS	JTAG state machine control
6	—	No connect
7	—	No connect
8	—	No connect
9	TDI	Data to device
10	GND	Signal ground

The **Joint Test Action Group** (**JTAG**) is an electronics industry association formed in 1985

Example 1: LEDs turn on with push button

```
/********************************
FILE NAME:        io.c
CHIP TYPE:        ATMEGA16
CLOCK FREQUENCY:  8MHZ
IDE:              VSMStudio
COMPILER:         PhD Eugenio Marino Merlo
TIME:             30/5/2016
********************************/
#include <avr/io.h>
#include <util/delay.h>



/********** Main Program ******************/


int main(void)
 {

  DDRD =0x00; PORTD=0xff;  // pins portd as input pull-up
  DDRB=0xff; PORTB=0x00;   // portb as outputs
  int a=0x00;


  while(1) // forever
                    {
                                    //if (PIND !=0xff) a=~a;
                                    if (PIND ==0xff) a=0x01;
                                    if (PIND ==0xfe) a=0xfe;
                                    PORTB=a;
                     }
 }
```


X1
OSC1
OSC2
8MHz
C2
22p
C3
22p
D2
1N4148
R5
10K
D1
POWER
PORTB_0
R6
220
C1
0.1nF
A
B
C
D
VCC
U1
RESET
XTAL1
XTAL2
PA0/ADC0
PA1/ADC1
PA2/ADC2
PA3/ADC3
PA4/ADC4
PA5/ADC5
PA6/ADC6
PA7/ADC7
PB0/T0/XCK
PB1/T1
PB2/AIN0/INT2
PB3/AIN1/OC0
PB4/SS
PB5/MOSI
PB6/MISO
PB7/SCK
PC0/SCL
PC1/SDA
PC2/TCK
PC3/TMS
PC4/TDO
PC5/TDI
PC6/TOSC1
PC7/TOSC2
PD0/RXD
PD1/TXD
PD2/INT0
PD3/INT1
PD4/OC1B
PD5/OC1A
PD6/ICP1
PD7/OC2
AREF
AVCC
ATMEGA16
R7
220
R1
220
D3
POWER
D4
POWER

Bibliography

- http://www.daviddarling.info/encyclopedia/B/AE_battery.html
- Wikipedia