

Lecture 18 objectives

- Embedded systems (Lab 8 decisions)
- Power
- Manufacturability

An embedded system is a system

- Microcontroller (9S12 or MSP430)
- Electrical circuits
- Mechanical devices (input/output)
- Power
- Package

Lab 8 Decisions

1) What should it do?

Game (graphics, sound, keys)
 Measure something
 Medical instrument (hearing aid, heart sounds, ekg)

2) Input devices

Switches (B3Fxxx.pdf)
 Keypad
 Microphone (Electretxxx.pdf)
 Accelerometer (ADXL202.pdf)

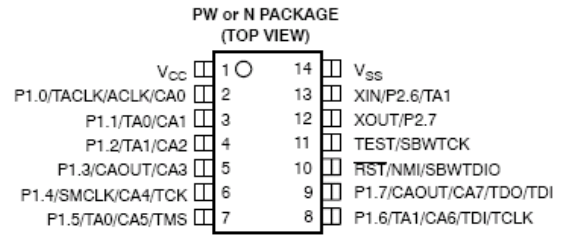
3) Output devices

LEDs
 1mA red, 2mA yellow, 2mA green
 20 mA orange, 20 mA blue
 LCD (16 by 1 or 20 by 4 line) from checkout
 Samtec BCS-114-L-S-TE
 LCD (16 by 2 line) from Valvano
 Samtec BCS-116-L-S-TE
 LCD 64 by 128 graphics, \$10 from BGMicro
 LCD1030.pdf, AGM1264_DP512.zip
 Samtec BCS-120-L-S-TE
 32 ohm speaker
 Solid state relay

4) Microcontroller

9S12C128 like Lab 6
 Free sample from Freescale
 9S12DP512 Tech Arts board
 Need 2 Samtec SMH-125-02-G-D

MSP430F2012 or MSP430F2013
 1.8V to 3.7V, very low power
 2 KiB EEPROM, 128 bytes RAM
 14-pin PDIP package
 10 I/O pins
 SCI, SPI, I²C, 10/16-bit ADC
 Debugger, assembler, compiler for free
 Samtec SLM-104-01-G-S
 TI MSP430F2012IN or MSP430F2013IN



5) Risk versus reward

Requirements Document (1 page)

1. Overview

- 1.1. Objectives: Why are we doing this project? What is the purpose?
- 1.2. Roles and Responsibilities: Who will do what? Who are the clients?
- 1.3. Interactions with Existing Systems:
 LCD, Tech Arts board

2. Function Description

- 2.1. Functionality: What will the system do precisely?
- 2.4. Performance: Define the measures and describe how they will be determined.
- 2.5. Usability: Describe the interfaces. Be quantitative if possible.

3. Deliverables

- 3.1. Reports: Simply state the reports for Labs 8 and 11 will be written
- 3.2. Outcomes: Simply copy/paste the Lab 8 and Lab 11 deliverables.

Bill of Materials

Collect example parts during the design
 3-D design

Power Budget

Average Current must be less than E/t_{life}

Strategies for low power design

- Choose E clock frequency
- Sleep mode
- Turn off power to op amps

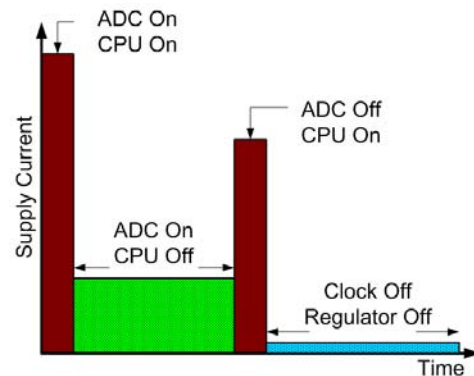


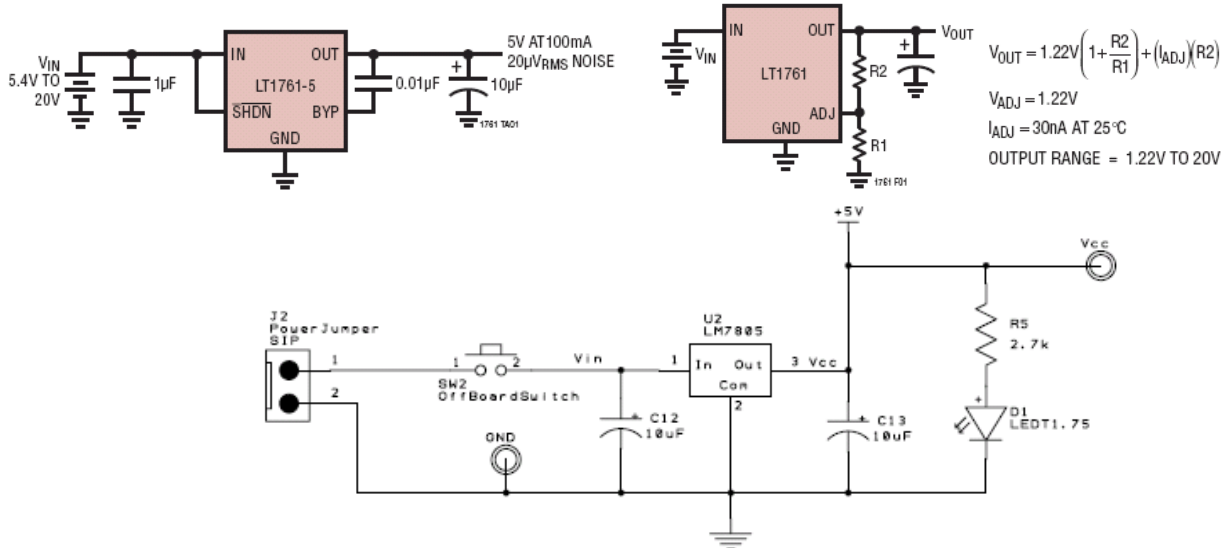
Table A-9. Supply Current Characteristics for Other Family Members

Num	C	Rating	Symbol	Min	Typ	Max	Unit
1	P	Run Supply Current Single Chip.	I_{DD5}	—	—	45	mA
2	P	Wait Supply current All modules enabled VDDR=4.9V, only RTI enabled ² VDDR=4.9V, only RTI enabled	I_{DDW}	—	—	33	mA
	C			—	2.5	8	
6	C	Pseudo Stop Current (RTI and COP disabled) ^{2,3}	$I_{DDPS}^{(1)}$	—	190	—	μ A
	P			—	200	250	
	C			—	300	—	
	C			—	400	1400	
	C			—	450	—	
	P			—	600	1900	
	P			—	650	—	
4	C	Pseudo Stop Current (RTI and COP enabled) ^{2) (3)}	I_{DDPS}^1	—	370	—	μ A
	C			—	500	—	
	C			—	590	—	
	C			—	780	—	
	C			—	1200	—	
5	C	Stop Current ³⁾	I_{DD5}^1	—	12	—	μ A
	P			—	25	100	
	C			—	130	—	
	C			—	160	1200	
	P			—	200	—	
	C			—	350	1700	
	P			—	400	—	

Regulator

- Fixed voltage, like 78M05
- Adjustable voltage, LT1761
- Low dropout voltage

5V Low Noise Regulator



LM341-5.0, LM78M05C

Unless otherwise specified: $V_{IN} = 10V$, $C_{IN} = 0.33 \mu F$, $C_O = 0.1 \mu F$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage	$I_L = 500 \text{ mA}$	4.8	5.0	5.2	V
		$5 \text{ mA} \leq I_L \leq 500 \text{ mA}$ $P_D \leq 7.5W, 7.5V \leq V_{IN} \leq 20V$	4.75	5.0	5.25	

Think about the lost power

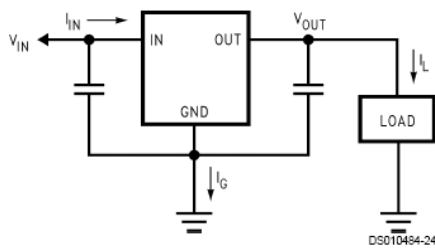
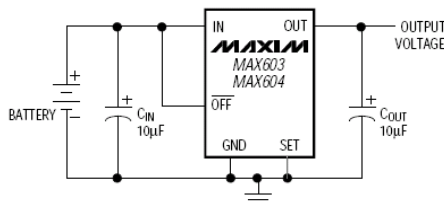


FIGURE 2. Power Dissipation Diagram

$$I_{IN} = I_L + I_Q$$

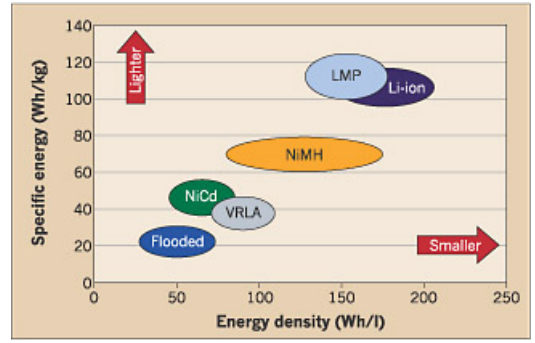
$$P_D = (V_{IN} - V_{OUT}) I_L + V_{IN} I_Q$$



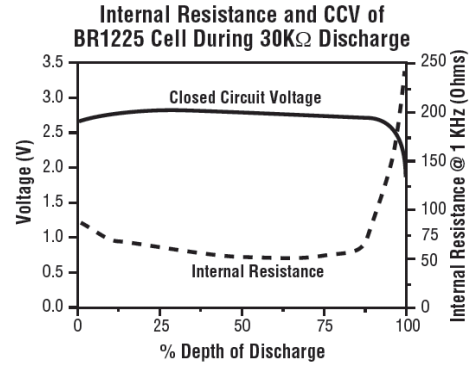
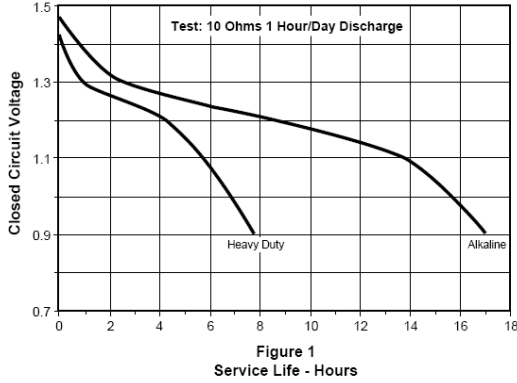
Output Voltage (Note 2)	V_{OUT}	$I_{OUT} = 20\mu A \text{ to } 500mA, 6.0V < V_{IN} < 11.5V$	MAX603	4.75	5.00	5.25	V
		$I_{OUT} = 20\mu A \text{ to } 300mA, 4.3V < V_{IN} < 11.5V$	MAX604	3.15	3.30	3.45	

Batteries

However, embedded systems that use these types of battery will require a voltage regulator to maintain a constant voltage for the electronics. For example, a +5V 9S12DP512 will operate with a power supply voltage from 4.5 to 5.25 V. The curve on the left is a BR1225 Lithium battery, which maintains a constant voltage until 85-90% of the energy is discharged.



AA Cell Discharge Relative Service Moderate Current

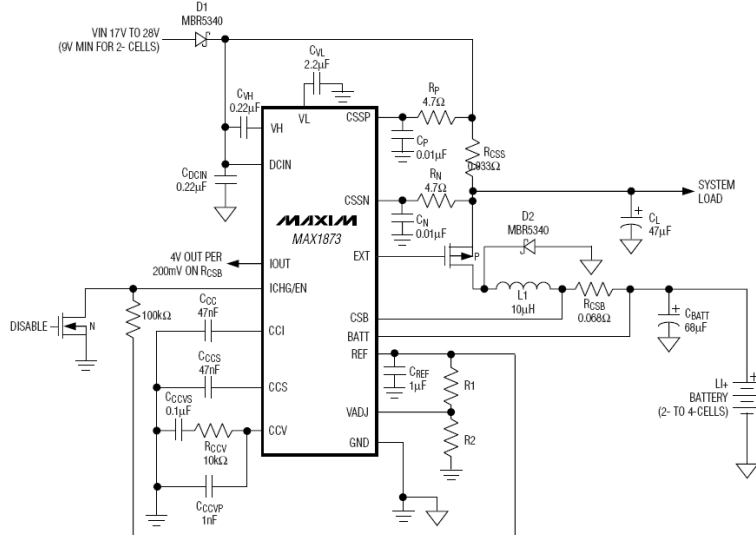


AA-sized batteries are 50 mm tall by 14 mm diameter.

Battery	Voltage (V)	Energy (mAh)	Type
Alkaline	1.5	2000	Primary
Lithium	1.5	3000	Primary
NiCad	1.2	1200	Secondary
NiMH	1.2	1800	Secondary
Li-ion	3.6	1900	Secondary

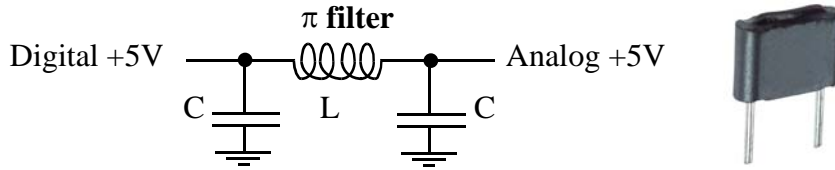
Energy storage for different battery types of AA size.

If you use a rechargeable battery, how will it be charged? If you use a disposable battery, how easy is it to change?

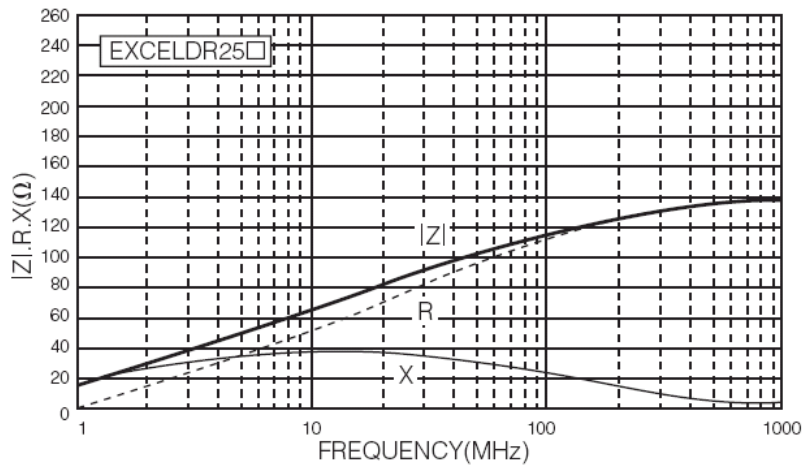


http://www.engineersedge.com/battery/battery_knowledge_menu.shtml

A **CLC filter** can be used to create a blocking filter to separate current spikes generated by digital logic from becoming voltage noise on analog power lines. This filter is also called a π filter.



For the inductor, one can use a ferrite bead. At DC the bead is essentially a short circuit. The ferrite bead increases both its real and reactive impedance at high frequencies. The bead should be selected to have a large impedance at the digital clock frequency. Panasonic makes a series of ferrite beads. In the following figure, X is the reactance (in Ω), determined by the magnitude $|j\omega L|$. R is the real part of the resistance (also in Ω), which also increase with frequency. $|Z|$ is the overall impedance. The Panasonic EXC-ELDR25C has a DC resistance of 0.08Ω , can conduct 7A DC, but has an $80\text{-}\Omega$ impedance at 24 MHz.



Testing

- Debugging interface, BDM, JTAG, Spy-Bi-Wire
- Test points (big clip for ground)
- Heart beats (LEDs or scope test points)