

Rechnerarchitektur des NXT

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Prozesssteuerung und Robotik

Agenda

- Overview
- Micro Processors
- Sensors
- Actuators
- I²C

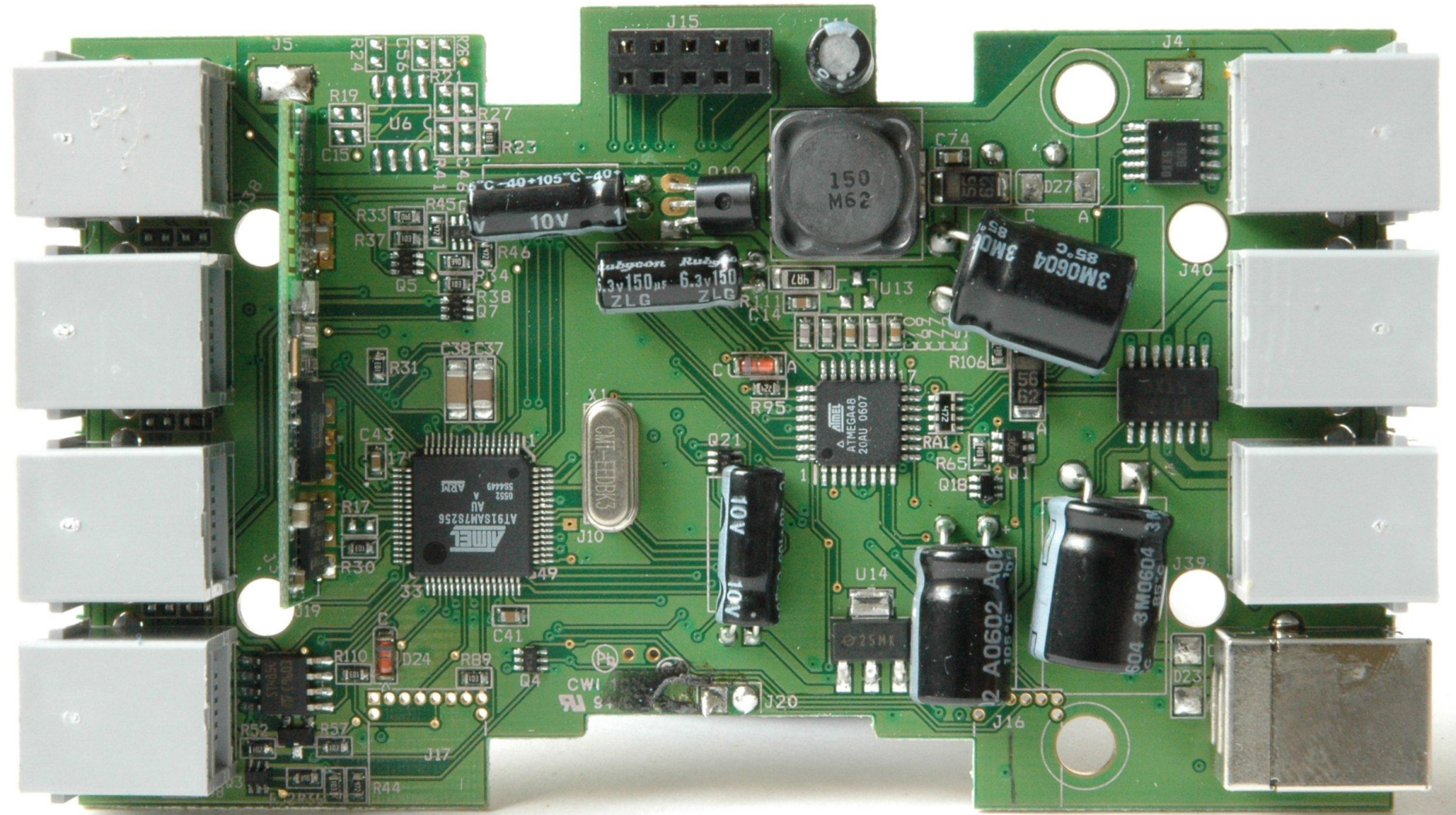


Central Micro Processors

	Atmel ARM7 main processor	Atmel ATmega48 co-processor
System Architecture	ARM – 32-bit RISC	AVR – 8-bit RISC
RAM	64 kilobytes	512 bytes
Flash RAM	256 kilobytes	4 kilobytes + 256 byte EEPROM
Throughput	Up to 49.5 MIPS (@ 55 MHz)	Up to 20 MIPS (@ 20 MHz)
Purpose	Running programs; communication via Bluetooth, USB; checking sensors; sound generation	Connects the motors and buttons



PCB (1)



Atmel AT91SAM7S256

Interrupt Controller

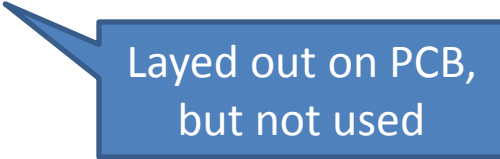
- 8 Level Priority, individually maskable

Real-time Timer

- 32 Bit free running timer
- Programmable counter + interval counter

I/O

- USB 2.0 Interface
- 32 programmable I/O lines
- 8-channel ADC
- Serial Peripheral Interface (for display and sensors)
- JTAG Interface (for debugging)



Layed out on PCB,
but not used

Display

- 100 x 64 Pixel monochrome LCD display
- Each pixel individually addressable
- Even allows space invaders to be played on NXT



Sound

- Simple tone generation using sine-wave tones
- Also plays standard PCM files
 - Mono, 8 bit, 2kHz – 16kHz sampling frequency
 - Decoded using the ARM7

Communication

- USB 2.0 Full-Speed (12 Mbit/s)
 - Included in ARM7 CPU
- Bluetooth 2.0 +EDR using Serial Port Profile
 - Class II – ca. 10 meters range
 - External controller connected to ARM7

Motors







- New motor specifically for the NXT

Weight	80 g
Stalled torque	50 Ncm
Stalled current	2 A
Rotation speed (free running)	170 rpm
No-load current	60 mA

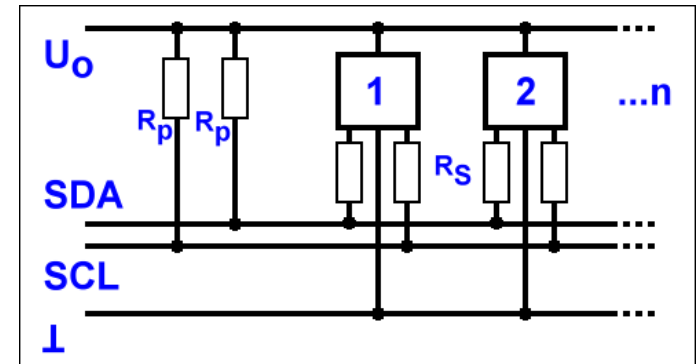
Overheats the motor after a few secs

- Built-in optical rotation sensor (1 degree resolution)
 - Allows to synchronize motors in pairs
- Each NXT brick can control up to 3 individual motors

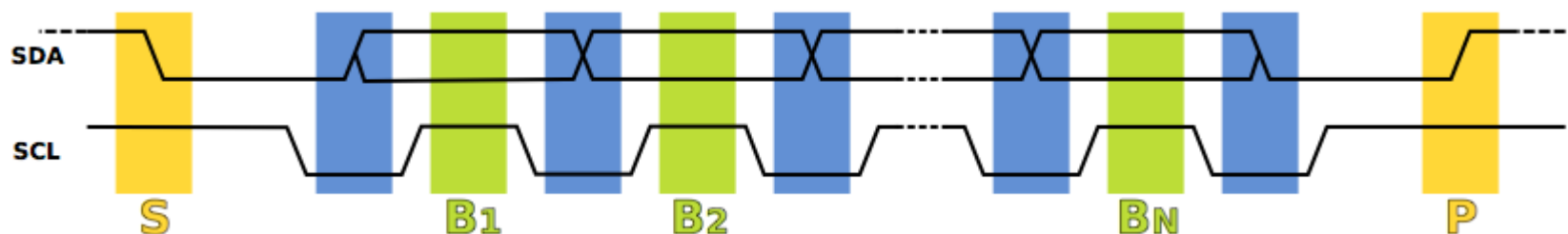
Standard NXT Sensors

- Touch sensor 
 - Measures linear pressure against the sensor
- Sound sensor 
 - Measures acoustic pressure in selectable frequency ranges
- Light sensor 
 - Measures the amount of light reflected by nearby objects
- Ultrasonic sensor 
 - Measures the distance to nearby objects using high frequency sound waves
 - Uses the I²C protocol (low-speed mode)

I²C (4)



- Simple and cheap (multi-)master serial bus
- Allows a single controller to access a whole network of other controllers
- 7-bit address space (max. 112 nodes)
- Master sets clock and addresses slaves



I²C by NXT

- NXT uses the low-speed mode only (10 kbit/s)
- Brick's CPU only supports master mode
- Main use case: additional sensors
 - Sensors not provided by Lego
 - Air Pressure,
 - Compass, ...
 - Allows more than 4 sensors per Brick

Conclusion

- Common ARM processor
 - Powerful enough for most usage scenarios
- Communicative hardware
 - 4 sensors (and many more using I²C)
 - 3 actuators
 - B&W display, sound
 - Bluetooth, USB

References

1. <http://www.jstuber.net/lego/nxt-programming/nxt-hardware.html>
2. <http://nxtasy.org/2007/11/18/taito-space-invaders/>
3. <http://www.philohome.com/nxtmotor/nxtmotor.htm>
4. [http://{de, en}.wikipedia.org/wiki/I²C](http://{de, en}.wikipedia.org/wiki/I%C2%B2C)
5. John C. Hansen, “Lego Mindstorms NXT Power Programming: Robotics in C”, Variant Press, 2007