What is an embedded system?

"A subsystem integrated into a larger overall system that interacts directly with the

environment via sensors and actuators. In addition, embedded systems often have

application-specific hardware. In the case of embedded systems, non-functional

requirements such as real-time capability, reliability... are important."

Okay. We have, after all, looked at the I&C, or measurement, control, loop. What does the

of?

"The MSR loop is used to illustrate what an embedded system consists of and how it works.

and how it works. In order to influence a process, you first need to have

of the system, which are converted into other physical quantities in the non-electrical transducer.

variables in the non-electrical transducer. Then comes the transducer, i.e. the actual sensor, which converts

electrical quantities are created from non-electrical quantities. Then comes the

sensor electronics, which is important for amplification and demodulation. Since sensors normally

analog signals, but digital signals are used in digital processing,

then comes the A/D conversion. In the digital processing afterwards, a human can still intervene in the process via an

MMS interface can still intervene in the process. After that, there's another D/A converter,

to get the analog signal for the actuators. Then comes the power electronics, which amplifies the

amplifies the signal. Then a converter, e.g. an electric motor, which converts an electrical signal into a non-electrical signal.

non-electrical signal. Then comes a gearbox, which again accesses the process."

With the transducer, yes, we looked at the accelerometer. How does that one work?

Here, I first recorded the ground on the spring rod. Afterwards I have drawn the mass into the

plate capacitors and gave the formula for C (C=epsilon0 *A/d) and explained,

why C1 and C2 change. After that I drew the circuit (measuring bridge) and explained,

that the capacitors behave like a complex resistor.

How do you get the acceleration from that?

I derived a by the formulas F=m*a and F=c*z (deflection) and explained that this is a non-electrical transformation of the measured quantity.

The right part of the circuit, what is that?

"A voltage divider"

What voltage is applied here in the middle?

He wanted to get at the formula U2=Ue*R2/(R1+R2). But I did not understand this directly and I pressed around for quite a long time. He helped me then, however, until I came on the formula.

And on the left side, how is it there?

"Exactly, because the capacitors are like complex resistors

How do you calculate them?

I didn't know the formula for complex resistors. He told it to me again again (R=j*omega*C) and explained why it is so easy (j*omega is shortened).

Let's move on to the A/D converter. How does it work?

I mentioned and explained the 3 phases (low pass filter, S&H element and actual converter), why you need the filter and the S&H element and the parallel and the weighing method. are mentioned.

For the weighing method, how does it work and what does the circuit look like?

I was able to explain how the method works, but could not draw a circuit. (Input voltage is always compared with reference voltage (half, quarter, eighth) and thereby coded).

What are the problems with this?

I didn't know directly what he meant, but after a few hints I came to the conclusion that the resistors, which are used in doubt are also not exact and therefore the comparisons become comparisons become more inaccurate.

How does the procedure work in the other direction?

He just meant as a D/A converter. I did not know that at all, he explained it to me then.

Let's continue with the regulation. There we got to know the classical regulation and another one and another, the fuzzy control. How does it work?

"The fuzzy control turns sharp values into fuzzy values. So it consists of 3 phases, the fuzzification, the fuzzy inference and the defuzzification. In fuzzification, linguistic variables are

variables are created. In the lecture, we looked at a pendulum that is supposed to be straight. There

are e.g. the linguistic variables deflection or velocity. For this one creates then

linguistic terms, e.g. small positive, large positive or so. For the variables and terms one

functions for the variables and terms, which can look like this (triangle drawn) or like this (trapezoid drawn).

drawn).

For these, one then sets up rules, i.e. if...then statements."

Are the membership functions then next to each other like this?

"No, they are on top of each other like this."

Exactly, otherwise you wouldn't have to do that at all. What do you do then?

"Then comes fuzzy inference, where the membership functions are evaluated for sharp input values.

membership functions are evaluated for sharp input values. So then you have e.g. 75% this and 25% that (graphic

(graphic), depending on the t- or s-norm (I confused the t- and s-norm at that moment, so he

and then corrected me, but I mixed it up again when I asked a question afterwards.

mixed up again. Nervousness and all). After that comes the defuzzification, in which you have to find out from the fuzzy

from the fuzzy quantities by the centroid method or the maximum method or by an approximation.

to get a sharp initial value."

If one determines the sharp input value by the center of gravity method or by the left or right

maximum method, it looks as if one would come to different values.

different values. Does that not matter?

"There one also comes to different values, that is also not indifferent. But that's why you need

several iterations until you arrive at the correct value."

Exactly, that still remains a regulation, which regulates itself first. Why does one

not always done?

"The number of statements is no longer trivial in complex real systems, so it is difficult to set up such a system.

difficult to set up such a system."

Exactly, in the normal case one says, the expert knows that, but unfortunately he knows that in the reality then

in reality. Above all the question is, how many terms one uses, with 5 it goes yes,

but do you get 5 or 7 or 100? Why does one do that then at all?

"The fuzzy control is relatively easy to extend and also quite intuitive with its statements."

Yes, everyone knows the shower control... (he then told a bit more about the fuzzy control and its

and its introduction etc. I found that quite pleasant at that moment, to have a short break

break). Let's move on to communications, what did we look at?

"We looked at the physical layer and the data link layer. At the

physical layer is about how the data is encoded on the wire. The

data link layer then already has protocols that define how media access takes place or how

errors are detected and corrected."

On the physical layer, what did we look at there?

"There we looked at how data can be encoded, for example with Manchester or NRZ-I.

Also, how clocking works when you don't have an extra line that sets the clock.

For example, there is bit stuffing, where a 0 is inserted after a certain number of 1s.

is inserted after a certain number of 1s. Then you can send a random signal in front, which has enough edge changes in any case.

or with Manchester for example, because this is a self clocking method,

because there is another change at every new clock pulse, even if there are several 0s in a row.

In addition, we have considered that problems can take place via dispersion and reflection."

What does the signal on the line look like?

Here he wants to see the signal from the superimposed oscillations, which is approximately a

Square wave signal.

What do you do about reflection or dispersion?

"Well, in the case of reflection, there is the formula for the reflection coefficient r= RT-Zw /RT-Zw. If one then

the terminating resistor is equal to the characteristic impedance, it becomes 0.

With the dispersion it concerns that the velocity changes frequency-dependently and the signal is signal is damped."

There you have just thrown something together, these are two different things. What was

dispersion again? So what does a signal look like after a long line?

It is useful to know the sketch from the slide about dispersion, which shows that it is difficult to recognize

to recognize where exactly the edge was

I tried to explain/draw that, but got all tangled up.

What can be done about it then?

"Use a repeater."

Exactly. With embedded systems, after all, in the production environment at the level you still have

one problem above all. What is that?

"There you still have the problem of electromagnetic fields from the environment. These can

also lead to malfunctions.

Is there anything you can do about it?

Yes, you can use shielding or "twist" two lines into each other like this."

The end.

In general, it was a pretty pleasant exam. If I did not know something, Prof. Berns

tried to help me and explain what he was getting at. He also explained a lot of things again, even

additional information if I answered correctly, and he always told it himself, so that

so that you can take a breath.

In the topics he addresses, he goes m.M.n. already further into the subject, ie details (circuits,

formulas etc) is useful. Smaller gaps are forgiven by Prof. Berns, if the rest comes safely.

After the exam he talked with me for a relatively long time, so that the examinee after me only started about 25 minutes after the actual start of his exam.

minutes after the actual start of his exam (I also had to wait 15 minutes - so don't be

in case of doubt, do not become even more nervous :-).

Questions:

Introductory questions:

- What is an embedded system?

Here I already knew from protocols that also non-functional requirements are asked for.

and especially realtime capability and integrated them into my answer.

Signal processing

- What do you do with the digitally processed data in the MSR circuit to use it again as an electrical signal?

as an electrical signal?

Jerkf¨ uhrung with D/A converter, S&H amplifier ¨ ¨arker, filter.

- Draw the structure of the R-2R converter and explain how it works.

I could still explain the circuit and general operation.

- Consider only the last link/bit and derive the voltage components.

Here I failed quite a bit and forgot voltage divider rules and parts of the last link.

forgotten. Prof. Berns helped me a lot.

- Now we have considered the voltage divider, but at the end there is an OV.

How does it look like with the output voltage at one link?

Infinite resistance at the OV, therefore U = I -3R. With the voltage divider

I could not assemble this correctly.

- Now we have a finished analog signal. Why do we need a S&H amplifier.

Holds input values for a certain time. Used here as a deglitcher, so that we can get ¨

only the result of the input change at the output. Generates a staircase shaped

output.

- And what does the lowpass do with the signal?

Smoothes the staircase function back to the original signal. ¨

- Then draw the circuit and explain how the behavior comes about.

The circuit is drawn, because of the capacitor the lowpass reacts "tr¨age" to voltage changes.

Voltage changes and thus filters high frequencies.

- Draw the current and voltage waveform.

Descents drawn, unfortunately with wrong sign, but seemed to have done nothing.

have done.

1

- Draw the ideal and real course of the frequency band at the low pass.

First the course of the output voltage for both F ¨ ¨alle drawn, then the hint

to frequency band

- No question, but briefly told about RLC low pass and that there are even more accurate.

- We still need a component after the jerk guide, then to drive an actuator like the ¨

electric motor. Which one is that?

Power electronics, amplified the too low output voltage, for EM H bridges. ¨

- What else can it do besides amplification?

Determine running direction

Regulation

- What does the regulation look like?

Block diagram drawn and briefly explained.

- We have learned about the simple PID controller. What do the single elements do?

Abbreviation explained, a little bit lost in the effects on the system.

- How do we determine the parameters?

Ziegler-Nichols explained.

- What other method is there?

I didn't know, he meant look at harmonic oscillation and set parameters manually.

- And how could I even calculate parameters?

I had misunderstood the question and tried to find a mathematical solution.

a mathematical solution. He then broke off and pointed out properties of the system, especially the oscillation.

the oscillatory stability.

- How do you determine if a system is stable?

He explained the pole-zero-diagram, added the Bode-diagram and ¨

told about the problems of such analyses.

Questions:

Introductory questions:

- What is an embedded system?

Here I already knew from protocols that non-functional requirements and especially real-time capability are also asked for and I have integrated these into my

integrated into my answer.

Signal processing:

- What are the steps that take place during sampling?

(Anti-)aliasing filter, time quantization, amplitude quantization.

For the first two steps I have explained the corresponding procedures in detail, as well as possible problems. The A/D converters were

with the following question more exactly.

- How does the parallel converter work?

Here the explanation offered itself at a small circuit sketch.

In particular I also mentioned the problem of rounding off and the improved

Rounding mentioned.

Regulation:

- How does a closed loop control work?

By means of a block diagram I have explained the individual components of the regulation.

explained. This was followed by a transition to the fuzzy control.

- How does the fuzzy control work?

On the basis a small application case I explained the production of such a regulation. In particular I went into the following aspects:

- Linguistic variables and terms

1

- Membership functions

- Fuzzy rules

- Linking of rules by norms like the t-norm/s-norm

- Defuzzyfication

- What are the difficulties in creating a fuzzy rule?

The question aimed on the one hand at the creation of membership functions, as well as

on the other hand on the rules. Depending on the particular system, which is to be regulated

which is to be controlled, different choices of membership functions in the number and

in the number and the respective function form must be tested, until an acceptable regulation behavior is ensured.

With respect to rules, the difficulty is that the number of rules required is not trivial, especially for more complex systems.

Scheduling:

- Why do we need scheduling?

Tasks must be distributed sensibly to computational kernels, so that all are processed in time.

processed in time.

- Which procedures are available for scheduling?

Description of the procedures "Search" and "EDF" with the respective use case. Then asked about "RMS".

- Does Rate Monotonic Scheduling create a concrete schedule? No, only an

implicit plan.

[Embedded Systems. What are we asking about.

(He didn't ask what an embedded system was! I liked that.)]

[Let's start with communication. E.g. car, we have 100 processors and many sensors and so on.

They all have to talk to each other. What did we look at there?]

- Two layers, actually 7 (ISO/OSI model), but only 2 of them are considered (physical layer, link layer).

[Actually the third layer, the application] (but he didn't want to know more about that).

[Ok, lowest layer, what happens there, what were the problems?]

- We transmit digital signals (bit sequences) with cables by representing the step-shaped signal as a superposition of

Sine waves. We have given a fixed frequency at which we can clock and select the harmonics

(the frequencies) with which we want to approximate the step signal. The number of harmonics is inversely related to the

transmission rate (BPS). You need about 5-10 harmonics so that you can see the steps quite well

[Why do I need many harmonics for the steps?]

- You basically build the Fourier series, Fourier transform of square wave signal is sinc, it doesn't fall so fast.

[How do I calculate the number of harmonics?]

- Didn't know what he was getting at (I think I said depends on this fundamental frequency that you can clock at).

[What else does the number of harmonics depend on?]

- Transmission rate (But I had already more or less said that, I was confused because I thought he wanted to hear something else...).

something else... I don't think it depends on anything else, maybe how the square wave signal looks exactly?

From the material, shielding...? But then he doesn't want to know that.)

[Yeah right, exactly, what other problems do we have in the bottom layer?]

- Signal attenuation -> fix with repeaters

- Clock recovery

[Wanted to hear procedure]

- additional cable [not so great solution)

- Rules like return- to- zero, Manchester code....

[What is the idea of all these procedures?]

- Certain changes between zeros and ones correspond with some rule clock changes

(conversation didn't go so well here, he wasn't completely satisfied)

[What would the signal look like in the worst case? What do we want to avoid]

- Constant signal

[In the simplest case, the signal looks like what?]

- Wanted to hear "just the beat itself", then I can read it yes

[Ok, more problems.]

- Reflections, choosing 2 resistors the same

[Ok, 2nd layer, fuse layer. what were we looking at?]

- Error protection and media access

[Error protection, why do you need to call this & procedure]

- Interference with external fields, bit sequence arrives corrupted, want to be able to detect bit sequence as false in principle.

- Procedure: Parity, is not so good, CRC explained.

[Media access, what have we looked at?]

- Different basic systems, central arbiter (many lines) and distributed systems (fewer lines,

  but also data and control lines), token ring [what's the disadvantage there?] (especially for event-based systems, it's not

  but I don't know if I could name everything there), TDMA- especially stupid for alarm systems or

  unbalanced ratios

[That's why we introduced what?]

- Commercial bus systems.

[Yes, CAN for example, but what's behind it?]

- CSMA (CSMA/CD and CSMA/AD - sometimes names mixed up but it was not bad), principle explained

[How does it work with the comparison of the IDs?]

- Physical trick, can lift complete bus to maximum voltage or to ground.

[Exactly, it's faster than with comparator circuits, that's why it's done that way].

[Problem of the procedure?]

- Crap...

[How would you choose the IDs when new party is added].

- Ah yes, that's complicated, you might have to change quite a few other IDs, tree-like comparison.

[Exactly.]

[How would you assign priorities]

- Binary search?

[Nah, more so in direct modeling]

- Alarms and tasks that are not so important for real time.

[And what other tasks that need to be done over and over again? (answer already anticipated)]

- periodic tasks

[Exactly, e.g. sensors]

[Other topic, control. What are we doing there?]

- Control loop drawn, control element calculates manipulated variables from control deviation, thus reacts to disturbance variables in the path.

(as an example for a controlled variable I mentioned the path of a fork lift truck, he intervened and said, that is too complex, that would not be

is too complex, that would not be solved with control, better would be e.g. constant speed as controlled variable). Speed as controlled variable)

[Requirements for controllers]

- Small settling time, stability, stationary accuracy

[How do we design controllers now? If we want to do it mathematically]

- First model physical system, with differential equations, in VL block diagram generated.

- Then we take elementary elements and couple them back Would you like to see them?

[Well, how do you choose the elementary elements? And how does that work with the block diagram].

- P is so mostly in, I for steady-state accuracy, D for faster settling in

- Rules explained in block diagram, for multiplication convolution with impulse response in s-range called

[Only now he wanted to see elementary elements]

- P,I,D- elements explained, equations with control difference written down?

[How to set the controllers heuristically?]

- Ziegler- Nichols explained. For step response one needs the condition that the distance can be approximated with PT1- element

can be approximated

[How do control engineers get this approximation?]

- Linearization

[Wanted to hear something more about this]

- ...

[You have a WORKING POINT around which you can actually linearize. You then have to find that in practice].

[Define Laplace and Fourier transforms, why chose Laplace].

- One can transform more functions (less strong integrability criterion).

- Define ES

- What are functional requirements for ES?

- Record MSR circuit, then go into individual steps:

- As an example of conversion from physical quantity to electrical voltage.

Accelerometer with capacitor:

- What does the circuit look like? Why is bridge circuit used? (It is

always measured from 0V and the measuring range is smaller and known)

- How does acceleration become voltage? (Acceleration moves mass ->

Distance to capacitor changes -> Capacitance changes -> Bridge voltage is generated.

bridge voltage is generated) Here it is best to have the equation of the capacitance in

depending on the plate distance at the start.

- Why do you have the lowpass and the S&H element before the A/D converter?

- Draw lowpass, explain aliasing and sampling condition

- What does the cutoff frequency depend on? (On the efficiency of the lowpass)

- What is the ideal and the real curve of the lowpass? (No

frequencies after the cutoff frequency and shortly before it a steepest possible

drop in the ideal case)

- Explain dual-slope method, sketch phases and draw circuit

- Relationship between S&H element and A/D converter? (A/D converter like the

dual slope method needs a constant signal for a certain time)

Atmosphere was super relaxed, Prof. Berns helped with gaps and I had

a 1.7 despite some gaps in the details.

A tip: Use the paper extensively, so that some things can be explained better and for many things there are sketches or diagrams.

there are sketches or diagrams etc. that show the connections nicely.

->my answers

[Notes from Professor Berns.]

What is an embedded system?

->Properties mentioned as well as special non-functional requirements.

We had this MSR circuit what is it good for?

-> illustrates how an embedded system is built up

-> drawn + individual steps briefly explained

How does the acceleration sensor work?

-> circuit drawn and explained

Why do we have the voltage divider in the measuring bridge?

->only small changes in the capacitors [with measuring bridge we always measure from 0 -> more accurate]

Explain steps Analog -> Digital:

->first sampling theorem explained

Why do we need the low pass now

->so that no aliasing occurs

[Have to set a fixed limit somewhere according to our sampling signal]

S&H -> circuit recorded and explained

What is actually an OPV?

->could only explain the properties but not the structure [inside a bipolar transistor]

A/D converter -> parallel converter: how does it work?

-> recorded -> explained

So now to the communication:

We had covered 2 layers what were they?

->bit layer: looks at the medium chosen for transmission as well as dealing with physical problems that occur

->Security layer: detection of errors, determination of the media access of the participants

Which problems were there with the physical layer, how did it look with the clock?

->clock recovery ->frequent edge changes needed to keep communication participants synchronous to stay synchronous -> extra line /Manchester code / 4/5bit code [is chosen so that as many as possible edge changes occur]

-> dispersion/attenuation -> repeater

[more he did not want to know then]

Explain the data link layer in more detail:

->error detection -> CRC

->media access- > fixed access (TDMA, FDMA), master-slave, token ring(drawn) explained

How to do it with CAN bus?

->CSMA explained

->CD explained

->CA explained

[both no real time guarantee you just have to adjust the priorities correctly, so that e.g. one sensor does not have the highest priority and blocks the bus all the time]

->shortly explained the advantages of Flex-Ray

How do we actually get the messages on the line?

->with the help of a square wave signal which is generated from several superimposed harmonics (e.g. sinusoidal oscillations) -> explained with drawing

How many oscillations do we need?

->I didn't know [about 5]

-What is an embedded system?

-Requirements for Embedded Systems

-Fuzzy control in detail (including linguistic variables & terms, t-norms, inference, ... Does it make a difference if you use centroid or max for defuzzification?)

-Communication, what was there? Bit layer detailed (bit codes, physical interference, bandwidth, ... How is a square wave signal generated?)

-How to obtain a digital signal? (S&H, Nyquist theorem, low pass, is 2 times the frequency really enough? (Nah, low pass is not optimal), A/D Wanlder weighing method (can't you also build a tree of comparators that can do this instantly?))

-D/A R2R chains

Sequence was another, this is now how it came to me.

Exam: Fundamentals of Embedded Systems

Examiner: Prof. Berns

Date: 17.11.2016

Questions:

- Properties and requirements of Embedded Systems, give example of each.

name

- Regulation: draw the diagram and explain with an example what happens in

the individual steps; what is the route? -> the whole system

- Fuzzy control: explain the procedure precisely and carry it out by means of an example

(took quite a long time)

- Signal processing process: explain feedback, then at D/A conversion directly

to R2R chain ladder. I should draw it first and then explain why the voltage is always halved.

voltage is always halved (also took quite a long time). After that came

question what else could be done -> PWM: explain the principle; important

was also that the normally attached low pass can be a motor!

The exam went about 45 min, however, you could have told more if you could have explained the

Terminology and some topics could have been explained better. The preparation was 3

weeks, although with the right study plan you could have done it in 2.

Resources such as youtube, simple physics and Josef Raddy, helped a lot in better

understanding the material about the mathematical formulas(e.g. low pass). With index cards to

the MSR circuit you are well positioned, because this is how you work through the exam.

worked through. Exercises are also very helpful for better understanding. In case of ambiguities

ask your supervisor, they are always helpful.

Questions:

1. what is an embedded system (see book/script)?

2. what are the properties of such a system(script and best with an example like a drone)?

like a drone)

3. which distinctions are there?(reactive/transitive)

4. draw the MSR circuit and briefly explain the individual points.(book)

5.Draw a voltage divider.

6.What sensors and meschanic transducers have we looked at?

7. draw the accelerometer.

Explain how the accelerometer works, where the voltage is taken and how the acceleration is

and how the acceleration affects the voltage difference. 9.

9. explain the structure and the steps in the D/A converter.(3 steps)

10. how do the single parts work like S&H(circuit) low pass(circuit) and

the drawing of the transformation in the frequency domain.

11. which D/A converters do you know, do you draw the dual slope and explain

what is the purpose of the OV (ask online or supervisor).

12. explain fuzzy control.

13. fuzzy example, how is defuzzified and what are t,s norm.

It is best to pick an example like a drone and also a sensor like

the accelerometer and go through the MSR circuit using this.

Understanding of the circuits and electrical engineering should also be present although

I spent too much time with transistors, which were then not asked. Try to steer the

Conversation itself in a direction to steer.

Audited Lecture: Fundamentals of Embedded Systems

Examiner: Prof. Berns

Date of exam: November 2014

Type of exam: Master

Duration of exam: 30mins

Questions:

* What is an embedded system and what are its characteristics?
* What is the difference between open and closed loop control?
* What controllers have we discussed in the lecture?
* How to obtain the parameters of the controller?
* Fuzzy control: explain + advantages and disadvantages.
* How to check stability?
* Laplacetransformation + explain properties.

Remarks:

* pleasant, relaxed atmosphere
* Satisfied with examiner

Audited lecture(s) with indication of the semester: Fundamentals of Embedded Systems, SS 2014.

Examiner: Prof. Karsten Berns

Assessor: Alexander Köpper

Date of examination: 23.9.2014

Type of exam: Bachelor

Duration of exam: ~35 minutes

Literature for preparation: Script / slides of the lecture.

*Questions

-(my) answers

*What is an embedded system?

-An information processing system that is part of a larger system.

*What are its characteristics?

-Size, power consumption, memory, processing power, real-time capability, ...

*What is real time and what distinction did we have there?

-Ober bound on the time to process a task. Hard & soft real time, with soft a too late result is still usable with cutbacks, with hard it is useless.

*We had this measure-control-rule cycle. Now we look at the feedback side. What does it basically look like?

-D/A converter, actuator, gearbox.

*What options of D/A did we have?

-Parallel converter, PWM, R2R

*Describe PWM and parallel converter in more detail.

-PWM switches quickly between on and off, the on phase takes longer the larger the number being converted. Parallel converter puts a reference voltage through weighted resistors and adds.

*For parallel converter: what is the op-amp doing there?

-It's an adder, it adds the voltages that drop across the resistors.

*What comes after the D/A?

-Sample&Hold element and a low pass filter.

*Why S&H element, why filter?

-S&H to get rid of glitches (e.g. switching from 0111 -> 1000 with unwanted intermediate state 0000), filter to smooth the steps.

*What does an S&H link look like?

-painting, two operational amplifiers with switch and capacitor. See script.

*What are the two op amps for?

-The rear one taps the stored voltage from the capacitor without draining current. The front one also does not load the input.

*Will there be no current flowing then?

-Theoretically not, practically a very small one.

*A DC motor is also called a converter, what does it convert?

-Electrical energy into mechanical.

*Communication - we had the lowest two layers. What problems do they have?

-Security layer: error checking, media access. Physical layer: dispersion, attenuation, reflection, clock recovery, interference from external influences (I didn't mention more, he interrupted me before).

*What do we do about it? (He asked this each time I listed a problem).

-Dispersion/attenuation: use repeaters. Reflection: set terminating resistor equal to line resistor. Clock recovery: clock on extra line, bit stuffing, Manchester coding, 4B5B code. Error checking: parity bit, CRC. Media access: central master, token ring, TDMA/FDMA, random protocols.

*This with random bus access, how does the CAN bus do it, for example?

-Each participant has a priority. When it wants to transmit, it first checks whether the bus is free, then it writes its priority to the bus, starting with the MSB. At the same time it reads. The line acts as wired-AND (or -OR). If it reads something other than what it writes, it knows that someone with a higher priority also wants to write and pulls out. In the end only the one with the highest priority is left and can send.

*How does CRC?

-Division with remainder by check polynomial, append remainder to message. Receiver divides complete message, if not 0 comes out, an error happened.

*Bit transmission: How to get bits on a line?

-Modeling a square wave signal with Fourier transform, transmitting a certain number of harmonics. The more we transmit, the sharper the signal but the smaller the bandwidth.

*What is a control?

-System gets default value and produces output. The difference (the error) is fed into the controller, which calculates a countermeasure, communicates it to the actuator, and the actuator feeds it into the system.

*We also had the fuzzy control, how does it work?

-I make fuzzy values from sharp input variables, apply rules, get fuzzy output values and calculate them back into sharp output values.

*How does this conversion of input variables work?

-Determine a function for each fuzzy set, for example overlapping triangles.

*How do I connect premises, how do I connect results?

-I want to connect premises, I take a t-norm, for example minimum, I want to connect results, I take an s-norm, for example maximum.

Comments:

Prof. Berns is very relaxed and asks clear questions. If you get into trouble explaining something, he sometimes asks you to draw it after all. When it becomes clear that you don't know something, he doesn't dwell on it, but explains what he wanted to hear and asks the next question. You get mimic and gestural feedback while you're talking, so it's worth paying attention to that. Exam room was a nice bright and clear office.

The whole thing felt more like a nice conversation than an exam at times. The time went by quickly. At the end, he talked to me a bit about my studies, how far I've come and what I'm still planning to do. So the whole thing was really pretty relaxed.

Audited lecture(s) with indication of the semester: Fundamentals of Embedded Systems SS13

Examiner: Berns

Assessor: Zhao

Date of examination: 27.08.13

Type of exam (Internship/VDP/HD/Bachelor/Master): Bachelor

Duration of examination: ca. 35min

Literature for preparation: lecture notes and memory protocols

Questions:

-What is an embedded system?

-> Characterized by requirements for real-time capability, space, power consumption, temperature.

-> Has sensors, sometimes also actuators

-> Reactive and transforming systems

-What is real-time capability or what is there?

-> Explain hard/soft real-time capability

-What scheduling methods are there?

-> Roughly explain every single method

-Which layers were addressed?

-> 1&2 layer

-What problems are addressed in each layer?

-> Layer 1: Dispersion, fix with repeater and reflection, fix with termination resistance (name formula),

differential transmission to compensate for external interference, twisting of cables to cancel induction on each other

-> Layer 2: Bus arbitration, error protection

-> Explain CRC briefly

-> Explain clock recovery or individual transmission protocols

-How does CSMA/(CD/CA) work?

-How do you assign IDs in CSMA/CA?

-> Meant was, that there are different classes of processes, alarms get highest priority,

-> priority roughly reciprocal of the period duration, otherwise frequent processes block the bus

-How does signal processing work?

-> briefly explain with low pass, S&H amplifier and A/D converter

-explain low pass

-S&H amplifier explain

-Enumerate different A/D converters

-Explain dual-slope method

-Explain fuzzy control

->Want to know what e.g. linguistic variables are

-> What is s- and t-norm resp. where do you use them?

-> Truncation of the sets

-> How to make the sharp output variable.

Comments:

Professor Berns is a very nice examiner, the atmosphere is totally relaxed.

If you don't know something he gives you a short time to think, or tries to push you in the right direction.

If you still don't know, he explains briefly afterwards.

All in all, a very pleasant exam, which you need not be afraid of if you have learned.

Questions:

[legend]

- Questions

° Answers

~ Note during exam

- What are embedded systems?

    ° Systems that are in interaction with their environment.

    ° Gives reactive and transforming (explained).

- What are the non-functional requirements for such systems?

    ° Maintainability, weight, energy consumption (each with justification).

    ° Real-time capability (hard and soft barrier explained)

    ° I came after small hint on it: Störunanfälligkeit (Because of large engines in factories etc.)

- Because of this susceptibility to interference.... what other problems can there be?

    ° (List all problems of the physical layer, I directly mentioned the solution)

    Reflection (don't name the formula, but the requirement that the terminating resistor must be the characteristic impedance), attenuation, interference (electromagnetic waves, interference due to the antenna properties of untwisted cables, and also the grounding at different ends).

- Now we were on the lowest layer where we have mainly physical problems, what layer comes above and what problems do we have there?

    ° data link layer

    ° Media access, error detection/troubleshooting

- What is there to say about media access?

    There are different procedures, it depends on whether you consider random or not.

    ° Then I said: In the case of non-elective, there is the master-slave method (this is explained) and the token ring/bus method (this is still explained).

- Then there is still this CAN bus ... how does that run there with the medium access?

° CSMA / CA (pronounced afterwards), each participant receives identifier = priority)

° First a bit edge (SOF - but I didn't mention it as a term) on which the participants can synchronize, then all participants who want to send start to send their priorities. If a participant - because he reads what is on the bus - finds out that he has sent a recessive bit but a dominant bit, he aborts his attempt. The last station to send wins.

- How is it prevented with CAN that a participant sends the whole time and the others do not get a word?

First of all, priority groups are selected. Participants that belong to a priority group get similar ID's (close to each other). Then there are additional waiting times which must be kept, so that someone can send afterwards

- Soooo... before we can do that with communicating data, we have to get there first... how do we do that?

° MSR circuit painted and explained (But the sub points of sampling etc. not yet).

- On sampling... what do we use the first filter for?

° This is a low pass filter, used to filter out aliasing effects.

~ I've been pushing around about aliasing and couldn't explain it exactly, he helped me and explained it to me (but I couldn't remember it :D)

- What comes after the lowpass?

° Sample & Hold amplifier

- Can you draw it and explain it?

° Painted (two OP's, in between switch, ground and capacitor)

- What are the OPs for?

° The second one is there to ensure that the capacitor is discharged slowly and the value is better maintained

° On the other hand, unlike resistors, OPs do not let power through (and so the loss in the system is lower)

- Yes, now the A/D converters are coming, there is this dual slope, can you show me the circuit and explain what happens?

° Circuit drawn

° there are 3 phases: Empty, Charge, Discharge (Counting)

- Well, now we have done all that ... what do we actually want from all the descriptions (do not know the question 100%)

He wanted to hear the step response

- How do we get this step response?

° Block diagrams, we know the step responses of the individual systems and can combine them using simple calculation rules.

- Can you name these calculation rules?

° All written down and named (series, parallel, feedback)

- Can I just calculate with the components?

° No, first the step response of the individual components must be Laplacetransformed.

- Why this? What can this Laplace transformation do? What does it do?

Transfers from the time domain to the image domain, simplifies calculations, convolution becomes multiplication, derivatives become fractions, one can determine stability, etc.

- How can one determine this stability?

° Takes final step response of the system (i.e. composition of all components), determines zeros and poles, recognizes the stability via pole-zero diagram.

° Briefly explains the individual states (one slide from the script)

- What else is there for this?

° The Bode diagram

I then said that I didn't understand it so well, but ...

° I then listed some crap that I made up, which was partly true, but I'd rather not write it here, he then explained something else to me

~ He has ended quite abruptly.

Introduction by Berns:

We have a six-axis machine that is supposed to get coffee cups out of the cupboard, put them in the coffee machine, press the button, take the cup and put it in our hand. There's already actuator technology in there now.

Q: What sensors would they put in there now?

A: Position/velocity/acceleration sensors.

Q: Describe an angle encoder.

A: Picture from script, explains why T + 0.25*T.

Q: If the cup is filled now, how do we know?

A: (Was thinking). Hint: How is the filled cup different from the unfilled one?

Weight. Load cell to measure the weight force. -> Load cell painted on, explains how it works.

4 bars with strain gauges made of constantan. These are compressed or stretched by forces.

Q: Now we have our sensor values, how do we get that to the microcontroller to run our algorithms on the data?

A: Sampling, consisting of low pass, S&H and A/D converter. Lowpass he wanted to know only extremely superficially, S&H circuit diagram drawn and

explained everything about it. As A/D converter he wanted to hear the weighing method. Principle drawn, explained, in each step one bit (SAC).

Reference voltage is generated with the help of a D/A converter, because voltage divider is not so cool. (e.g. temperature drifts)

Q: Explain the regulation, what is so great about it?

A: I drew the block diagram according to DIN BH 90210 and explained each element. Analog subtractor to form control difference.

Q: Which linear control elements do you know?

A: P-/I-/D-element, in each case transfer function written down and explained like the rules.

P-element: permanent control difference

I-element: Exact, but needs longer integration time

PI-member to PID-member to extend, provides for the fact that faster Ausgereglt is.

Q: How do we determine the transfer function?

A: I drew the PID controller as a block diagram. Then I started to explain LaPlace. Integral becomes mult. with s, differential becomes division with

s.

Q: What is the difference to the Fourier transform?

A: LaPlace is more general, extension by damping factor e^-at. Fourier requires absolute integrability of the time function, which we have

but LaPlace is more general.

Q: What is the use of bringing signals into the LaPlace domain?

A: Convolution becomes multiplication, wanted to paint block diagram to series circuit and explain at it. He then wanted to use the formula for

the feedback in the block diagram, simply named.

Q: We can measure the forces and moments in the TCP wonderfully. Since the TCP is supposed to be at rest, we have to compensate for them. How do we do that?

A: (This was the jump to GDR) Dynamic model, wrote down the general equation of motion. Newton-Euler and LaGrange method

called.

Q: All right, explain Newton-Euler.

A: 4 steps:

1. determine everything known: Inertia, friction etc.

2. determine homogeneous transformation matrices (Denavit-Hartenberg, I was allowed to explain completely)

3. outer iteration (velocities and accelerations, forces and moments in the centers of mass by Newton (f = m * a) and

Eulerian conservation of momentum.

4. inner iteration (determination of forces and moments in the joints).

be able to explain everything exactly.

END, go outside for a moment.

Comments:

Super great exam climate, examiner is happy to explain more precisely what he wants to know when asked. A lot of detailed knowledge is asked.

Plan a lot of preparation time, a lot of material!

Questions:

Fundamentals of embedded systems:

- MSR- circuit diagram, say what is converted to what at each step, with examples.

- Sampling:

Sampling theorem mentioned and explained, what do we use to transform to frequency domain? Fourier transform

Explain Fourier roughly (I didn't get it right): name integral etc.

Teifpass (circuit diagram, function)

S & H: (circuit diagram, function)

A/D converter: explain weighing method, D/A for voltages

how this works you should be able to explain in detail, I was not able to explain it exactly enough

Question I can not reconstruct exactly, he wanted to go for voltage divider, this then explain briefly.

He also wanted to know the rule for determining the voltage at each point using the resistors, which I could not think of, see script

- Which OSI layers did we have in the lecture?

name link layer, physical layer

for the link layer: CRC as an example, explained

to the physical layer: possible errors in bit transmission and their solutions

see script, I gave 3 examples

to the clock recovery: what is there so? I could answer only partly, he wanted to hear e.g. Manchester

processor architecture:

- Which number systems?

Signed Digit Numbers, name Residue Number System, explain coding

SD: Which advantage?: Only dependence on previous digit, explain transfer bits, parallel execution -> one step

RNS: solve by chin. Remainder theorem; explain operations (addition, multiplication), that multiplication in one step

- then Prof. Schneider jumped to VLIW, superscalar processors and dynamic scheduling he mysteriously skipped completely

explain Software Pipelining, some detailed questions were asked, one should really know the meaning of each term (e.g. the times etc.)

he wanted to know what is packed into the VLIW commands and if the prologue always looks similar (explain prologue, kernel, epilogue at this point)

- then to vector calculators

how does it work with the single vector commands in the pipeline? Pipeline chaining explained

what is a convoy? maximum sequence of instructions which contains no data conflicts or structure conflicts.

what do you do if the vector is shorter? he wanted to have the Vector Length Register explained, somehow I didn't get it

and instead mentioned Strip Mining and was allowed to explain that afterwards, Vector Mask he also wanted to hear, I didn't get it either.

But when you split vector instructions you have a loop again, isn't that just as bad as with the scalar processor?

must be increased substantially more rarely etc.

I did not manage especially with the processor part to give times an overview myself, that would be good if one does that as soon as he asks something to a new chapter.

For example I missed it to call the things times by the name e.g. with vector commands one saves loops, which Prof. Schneider added then still.

I think that it is good to provide such infomation by yourself.

Comments:

The examiners were very nice and noticed that I was excited. If I did not know something exactly, they explained it accordingly,

so that I could possibly still figure it out.

Audited lecture(s) with indication of the semester: Fundamentals of Embedded Systems WS2010

Examiner: Prof. Berns

Assessor: Name I don't know exactly

Date of exam: 26.10.2010

Type of exam (internship/VDP/HD/Bachelor/Master): Bachelor

Duration of exam: ca 30 min

Literature for preparation: script, web & book by Berns/Schürmann/Trapp

Questions:

What is an embedded system, what are its properties?

- communicates with the environment by means of sensors and actuators

- is real-time capable (here also explanation for hard/soft real-time)

- light

- fast

- energy efficient

we have sensor values now, what do we do with them, how do we process them

- he wanted here on the picture analog signal -> sampling -> digital signal processing -> feedback -> analog signal

- He then asked me about sampling in detail:

  * Low pass (what does the circuit look like, for what -> keep sampling theorem).

  * Sample + Hold (draw the circuit(two opamps, capacitor + switch in between) and explain)

  * A/D conversion first name all in the lecture discussed and explain dual slope (draw circuit, etc.).

Now we want to change the data yes in the digital world, how and with what do we do that?

- Digital filters, gives FIR & IIR, properties of FIR + IIR

- How to analyze digital filters -> Z-transformation, know the formula and what the e stands for ->attenuator

- What does a filter do -> filtering out unwanted frequencies (mostly with bandpass)

- What are the characteristics of digital filters (attenuation in the stop band, overshoot in the pass band, slope in the transition region)

We now have several components that all want to communicate with each other, so what are the problems on the lower two layers

-Bit transmission layer:

  * Attenuation/dispersion (wave propagation depending on frequency) -> active signal regeneration using repeaters.

  * reflection (superposition of reflected and incoming value) -> know formula, terminating resistor must be equal to line resistance

  * electromagnetic radiation -> twisted pair or coaxial cable

  * synchronization/clock recovery -> know bit stuffing, line coding

- Fuse layer

  * error protection -> CRC, how does it work

  * Media access method -> CSMA, explain CA using CAN as an example

- Difference CAN + Flexray, why is Flexray Better:

  * CAN not necessarily fair, e.g. messages with high ID may never get to it

-> another static phase with Flexray, which works with TDMA, so that each participant gets it once

Remarks:

- Very relaxed exam atmosphere, Prof. Berns talks a lot and sometimes adds things we didn't look at in the lecture.

- Mr. Berns unfortunately came 20 minutes late -> nervousness went up

- Appropriate grading

Questions:

MSR circuit, signal processing

What is the MSR circuit, what does it look like?

- The circuit should be explained and examples of the individual components should be given.

Signal processing has already been discussed in the MSR circuit, explain the individual sections in detail.

- explain the chain of lowpass, sample&hold, AD-conversion briefly and concisely

- give examples for AD- and DA-conversion

- DA-Converter: choose one of the mentioned and explain it (I explained AD first, but after a short time I was pointed out with a

(I explained AD first, but after a short time it was pointed out with a smile and I was allowed to start again -> relaxed exam atmosphere)

- Parallel converter: explain problems (resistance conditions), improvements (3x4 bits instead of 12, or R2R chain ladder)

- How does the R2R chain conductor work, and why does it work like this -> voltage divider

Change of topic to communication: which layers were covered?

- Layer 1 and 2

Problems on layer 1?

- Disturbances by magnetic fields, reflection

- What is meant by reflection, how to eliminate the problem -> he wanted to get at the terminating resistor

- Coding and clock extraction mentioned by me, Berns goes into it and asks "what for, which procedures".

Layer2, what problems?

- Media access, if random CSMA(+CA/CD).

- Error detection/recovery -> was asked about parity bit, CRC etc.)

CAN bus

- media access, error detection already mentioned by me before, Berns asks how exactly this works now

- Arbitration via IDs

- Explain error detection

- How must IDs be chosen for processes/participants with the same priority -> similar ID + waiting time after sending process

- What makes Flexray better? 2 Phase, Static+Dynamic

Scheduling:

- Which methods, briefly explain

- graphical algorithm for scheduling by game rooms, I couldn't, Berns didn't go into it any further

Change of topic to control:

- Draw a control loop (DIN xy) and explain it.

- what is the difference between control and regulation: he wanted to point out that a model of the line is needed for the control.

- How do we calculate what happens in each step?

-> differential equations + Laplace transformation

- Why Laplace transform, what does it do?

- Now we have everything that happens in the individual steps; how do we now bring it all together?

-> in series: multiplication (because we are in the frequency domain, otherwise it would be convolution)

-> parallel sensor: addition

- Which controllers do we know? P,I,D,T
- PI-controller, which behavior at constant disturbance

Remarks:

Pleasant examination in a relaxed atmosphere. If one does not know something (and says so), Mr. Berns gives the answer and asks the next question. You get enough time to talk, even if you want to elaborate a bit more, and you are not directly interrupted. If you don't find the right key words that Mr. Berns wants to hear, he helps you along quite well, so that you can still give the answer yourself. What went down well with me was that I was able to say a lot more about communication and bus systems. So, for example, the transfer from the lectures on "Distributed and Networked Systems" is helpful.

Even though the control and scheduling part didn't go very well (I only knew the basics), I still got a good grade in the end.

Audited lecture(s) with indication of the semester: Fundamentals of Embedded Systems ss2010

Examiner: Karsten Berns

Assessor: Thomas Wahl

Date of the exam: 24.08.2010

Type of exam (internship/VDP/HD/Bachelor/Master): Bachelor

Duration of exam: 35 min

Literature for preparation: Lecture notes, first part of "Embedded Systems: System Basics and Development of Embedded Software".

Questions:

What are embedded systems, what are their properties?

- here he also wanted to hear real time, and to have explained what hard and soft time bounds are

What is the process of digital signal processing?

- Explain low pass, anti-aliasing, why does low pass filter out high frequencies?
- S&H amplifiers: why, structure, function

- How to determine sampling frequency => Fourier spectrum + sampling theorem or given by A/D converter
- A/D conversion
    - name all known methods
    - draw the weighing method, explain it
    - why D/A-converter at weighing method, there are also other possibilities to generate equivalent voltage
        -> voltage divider would need too many resistor conditions, difficult to build
        - Functionality of voltage divider
- D/A-conversion: What to do to have not so many resistor conditions?

  -> Draw R-2-R chain ladder + explain it

How does the block diagram of the control look like?

- draw + explain
- How do we calculate what happens in each step?

  -> differential equations + Laplace transformation
- Why Laplace transformation, what does it do? What does the formula look like?
- Now we have everything that happens in the individual steps; how do we bring it all together?

  -> in series: multiplication (because we are in the frequency domain, otherwise it would be convolution)

  -> parallel sensor: addition
- Laplace transformer: how can we simplify this?

  -> look in the appropriate tables

Fuzzy control:

- What are fuzzy sets, membership functions, ...
- Ling. Explain variables + terms
- How do we get a fuzzy quantity from the sharp input quantity?
- How are the rules constructed, how are they applied?

  -> Degree of correctness by means of t-norm, Veroderung of the rules by means of s-norm

  -> fuzzy sets are "truncated" and unified
- Defuzzification: name all known possibilities

Imagine, you have now n axes at which you want to regulate. This gives you a lot of tasks, how do you make sure that everything is processed in time?

- Apply a suitable scheduling method
- Which ones were presented in the lecture?
- Explain scheduling according to slackness and rate-monotonic scheduling.

Comments:

Overall very pleasant and relaxed exam; if you say you don't know something, Prof. Berns briefly tells you the answer and then moves on to the next topic. If you don't know what to do, Prof. Berns will help you out.