Final Examination of Embedded Systems SS 2011

Time: 90 minutes

18. Juli 2011

Any form of written auxiliary material is permitted! Name: ..........................................................

Exercise sheet is to be handed in! Study group: ............................................................

Assignment 1: (33)

A digital signal should be generated at port P8.2 of a C164 (20MHz). The cycle time of the signal, which has a 1:1 duty cycle (active duration of the pulse is half of the cycle time) should be adjustable. Use the CAPCOM2-System for signal generation.

a) Which operation mode is suitable for generating a periodic digital output signal via CAPCOM2 with as little additional software as possible?

b) By which resource is the cycle time and by which is the active duration time determined?

c) With which input clock must the necessary timer be clocked, when the maximum cycle time of the output signal should be 200ms?

d) Give the necessary initializations for the signal with a cycle time of 200ms and the required duty cycle.

e) Which actions are necessary to change the cycle time of the output signal without changing the duty cycle? In which routine of an appropriate application program should these actions be executed?

The call of the function with the prototype "newPeriod(float fValue)" changes the cycle time of the output signal to the value fValue (in ms). The following range of the value is possible:

\[0.1 \text{ms} < fValue < 200 \text{ms}\]

This range has to be tested by the function. In addition all actions which are necessary for the change of the frequency have to be done.

d) Realize "newPeriod()“ and, if necessary, further required routines so that after the call of this function the output signal will be changed appropriately.
Assignment 2: (41)

Two temperature sensors of identical type are delivering a voltage signal at its outputs, which is proportional to the measured temperature. The output voltage is 5V at 60°C and 0V at -40°C. These signals are fed to the inputs P5.0 and P5.1 (AD0, AD1). Both temperatures should be ascertained cyclically in an RTX-tiny based C164-system ($f_{CPU} = 20$MHz, Timer-Tick 1ms) with cooperative scheduling. For this purpose measurements are to be started in time intervals of 100ms, in which as fast and as simultaneously as possible 10 values from each sensor should be captured. The average of these 10 single measurements represents the current value.

a) In which operation mode is the AD-conversion to be performed in order to meet the requirements "as fast as possible" and "as simultaneously as possible"?

The 20 (2*10) individual measurements should be realized by appropriate usage of PEC. Use PEC-channel 7.

b) List the settings to be carried out by the program in order to start the measurements appropriately. The timing of the AD-conversion is already suitably preset.

The task with the following prototype is to be defined:

```c
void ad_Tsk(void) _task_ AD_TNR;
```

This task is started during system initialization and runs permanently. It provides the 100ms interval, the start of the individual measurements and waits appropriately to deposit the current temperatures in the module-global variables `tsens1` and `tsens2`.

c) The process triggered in b is terminated by the execution of an interrupt-service-routine, in which the termination of the waiting state of the task is also provided. Realize this ISR.

d) Now realize `ad_Tsk()`.

Assignment 3: (35)

By passing through three light barriers mounted at a distance of 0.3m from each other we get following graphs for the signals S1, S2, S3:

The signals S1, S2 and S3 are fed to the ports P1H.5, P1H.6 and P1H.7 of a C164 (20MHz). The time differences $T_A$ and $T_B$ are to be determined in order to gain information about velocity and acceleration of the vehicle.
The maximum occurring velocity may be 60 m/sec. The systematic impreciseness at the measurement of time $T_B$ must not be greater than 0.1%.

Use the CAPCOM2-unit of the C164 for the measurement, the time base is delivered by Timer 8.

a) With which minimum input frequency must Timer 8 be clocked, to meet the above precision requirements?

b) Which minimum velocity can be measured with the prerequisites of a), if for the determination of $T_B$ a timer overrun should not be considered?

c) Which further registers of CAPCOM2 are necessary to measure $T_A$ and $T_B$, and in which operation mode are they to be used?

It is the task of an appropriate interrupt service-routine to determine $T_A$ and $T_B$ as a number of T8-Timer-Ticks to make it available for use.

d) Which event triggers the interrupt? – Realize the body of the ISR!

The function mwOk() returns 1 when a new measurement is finished. The function givMw() calculates the velocity with the dimension km/h based on $T_B$. $T_A$ is used in order to ascertain if it is an acceleration- or a deceleration process. Therefore the following is valid: If the averaged velocity deviates in interval $T_A$ less than 5% from the velocity in interval $T_B$, there is no change in velocity.

Use the following data type to return the result of the measurement:

```c
typedef struct {
    float fSpeed; // calculated velocity
    int iAcc; // -1: deceleration; 0: no change; 1: acceleration
} M_typ;
```

The following application should be possible:

```c
void main(void) {
    M_typ messw;
    ....
    if(mwOk()){
        givMw(&messw);
        printf("velocity: %.2f acceleration: %2d\n", messw.fSpeed, messw.iAcc);
    }
    ....
}
```

e) Realize mwOk() and givMw() in C.
Assignment 4: (20)

For CAN-transmissions identifiers with 11-Bit length are used exclusively. The identifiers are transmitted and received beginning with the most-significant-bit. The **global mask** of the CAN-Controller may be specified as **0x30F**.

Two Receive-Objects (CAN-Object 11 and 12) are defined, its arbitration-registers contain the following identifiers:

<table>
<thead>
<tr>
<th>Receive-Object</th>
<th>Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0x734</td>
</tr>
<tr>
<td>12</td>
<td>0x035</td>
</tr>
</tbody>
</table>

The following three CAN- messages are to be considered, whose identifiers are as follows:

<table>
<thead>
<tr>
<th>Identifier of message</th>
<th>Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0x314</td>
</tr>
<tr>
<td>2</td>
<td>0x336</td>
</tr>
<tr>
<td>3</td>
<td>0x025</td>
</tr>
</tbody>
</table>

a) Which of the above messages does the arbitration gain, if they should be sent **simultaneously** on the bus? – the binary 0 is sent dominant.

b) Which of the above messages transmitted over the CAN-BUS will be copied in which Receive-Object of the above described CAN-Controller, if they arrive **one after the other**? – Justify your answer.

The CAN-BUS is used for the transmission of the values of the velocity measurement from assignment 3. This is done using Object 10 of the CAN-Controller, which is already initialized suitably as Transmit Object. The arbitration register contains the value 0x747. The transmission is triggered via the call of the function `vCAN()`, its prototype is:

```c
void vCAN( M_typ ); // Type definition see assignment 3
```

c) Realize function `vCAN()`, which transfers the data for object 10 appropriately prepared from the parameters of the function, to the CAN-Controller and triggers the immediate transmission!

d) Explain briefly what is happening, if a "remote frame" with the identifier 0x3B7 is received!

**Good luck!!**