



UNIVERSIDADE ESTADUAL DE CAMPINAS

FACULDADE DE ENGENHARIA MECÂNICA

ES670 - Projeto de Sistemas Embarcados

Relatório - Projeto Prático Parte 6 Requisito 6: ADC

Nome:

Daniel Dello Russo Oliveira

Davi Rodrigues

RA

101918

116581

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1 Objetivo

O objetivo do projeto é, de maneira incremental, implementar no *target* os requisitos apresentados no roteiro[1] inicialmente desenvolvendo o modelo e depois implementando cada requisito. Estes requisitos são referentes à configuração e implementação de entradas de teclado, acionamento de LEDs, *display* de sete segmentos, protocolo de comunicação, *display LCD*, medição de velocidade de rotação, *PWM*, *ADC* e Controlador.

2 Modelagem

Utilizando o Rational Rhapsody Modeler e tomando como base os requisitos propostos mostrados na figura 1, complementamos o modelo inicial[2] (requisitos de teclado e LEDs) adicionando um bloco ao modelo referente aos *displays* de sete segmentos (REQ1C), conforme mostrado na figura 3. Adicionamos também alguns blocos auxiliares relacionados ao gerenciamento de pinos *GPIO* e a interrupções periódicas, que foram utilizados para nossa implementação do *display* de sete segmentos e do *buzzer*. Ao tratar o gerenciamento do *display* e do *buzzer* através de interrupções, livramos a *thread* principal para que essa lide com outros problemas sem precisar se preocupar com a atualização periódica dos *displays*.

Continuamos a complementar nosso diagrama adicionando um bloco responsável pela comunicação serial e um pela interpretação dos comandos referentes ao protocolo do requisito REQ2, adicionamos também um bloco responsável pelo controle do display LCD referente ao REQ3. Blocos responsáveis pelo controle do ventilador e pela medição da velocidade do mesmo, referentes aos requisitos REQ4 e REQ5 foram acrescentados ao diagrama. Novos blocos responsáveis pelo aquecedor e pelo sensor de temperatura do REQ6 foram adicionados.

Integramos também o padrão executivo cíclico cooperativo ao nosso projeto, tornando nosso código mais determinístico.

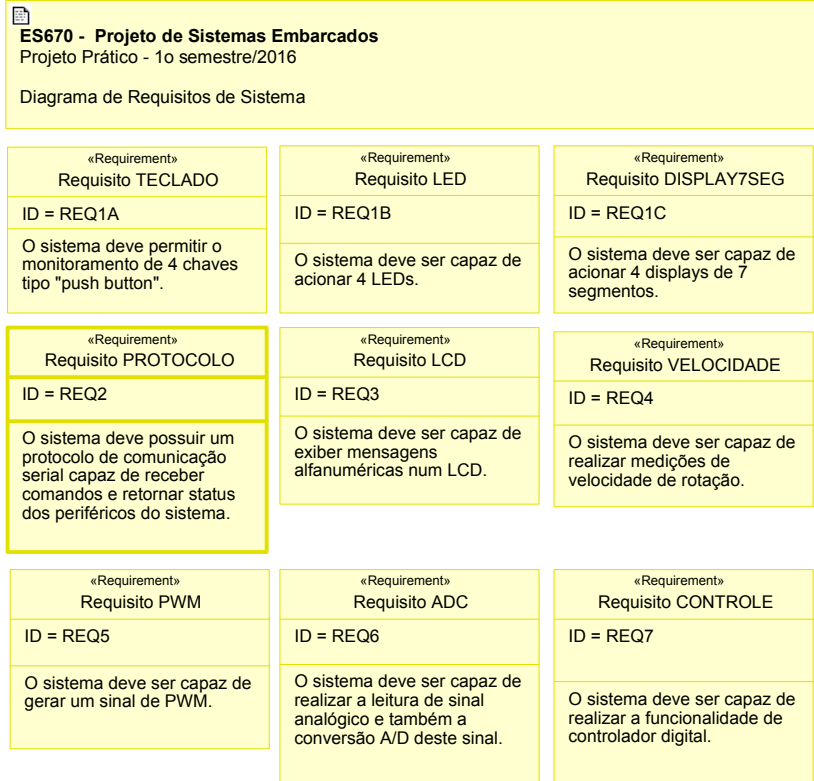



Figura 1: Diagrama de requisitos

**ES670 - Projeto de Sistemas Embarcados**
Projeto Prático - 1o semestre/2016
Diagrama de Pacotes

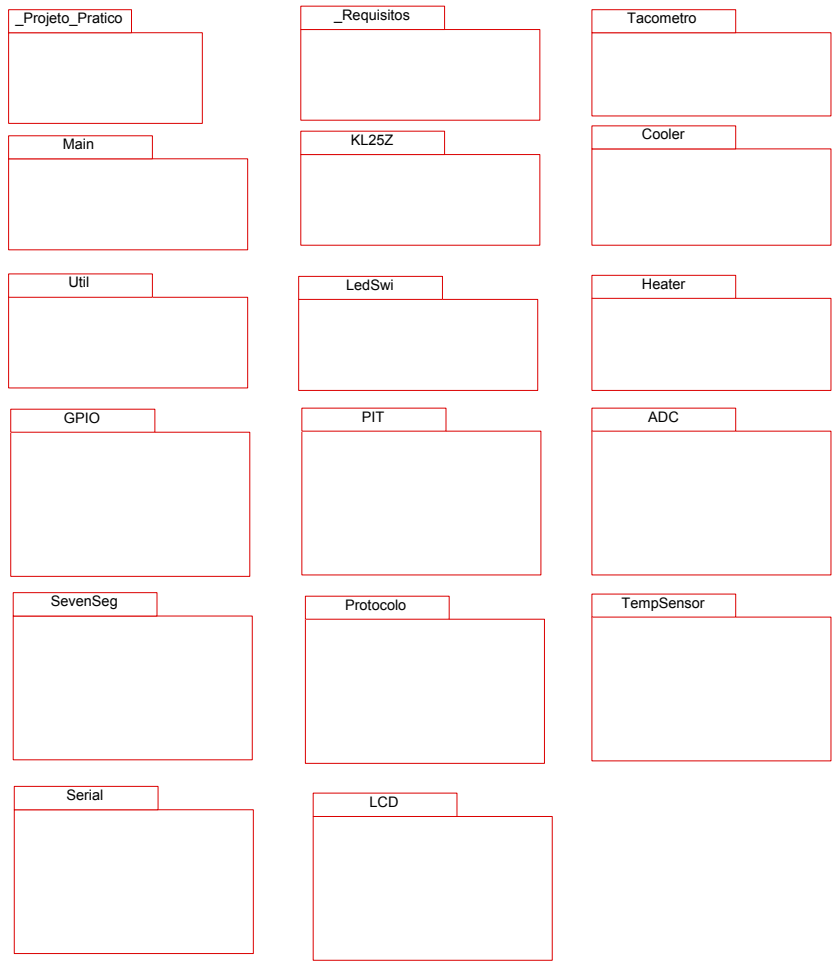


Figura 2: Diagrama de pacotes

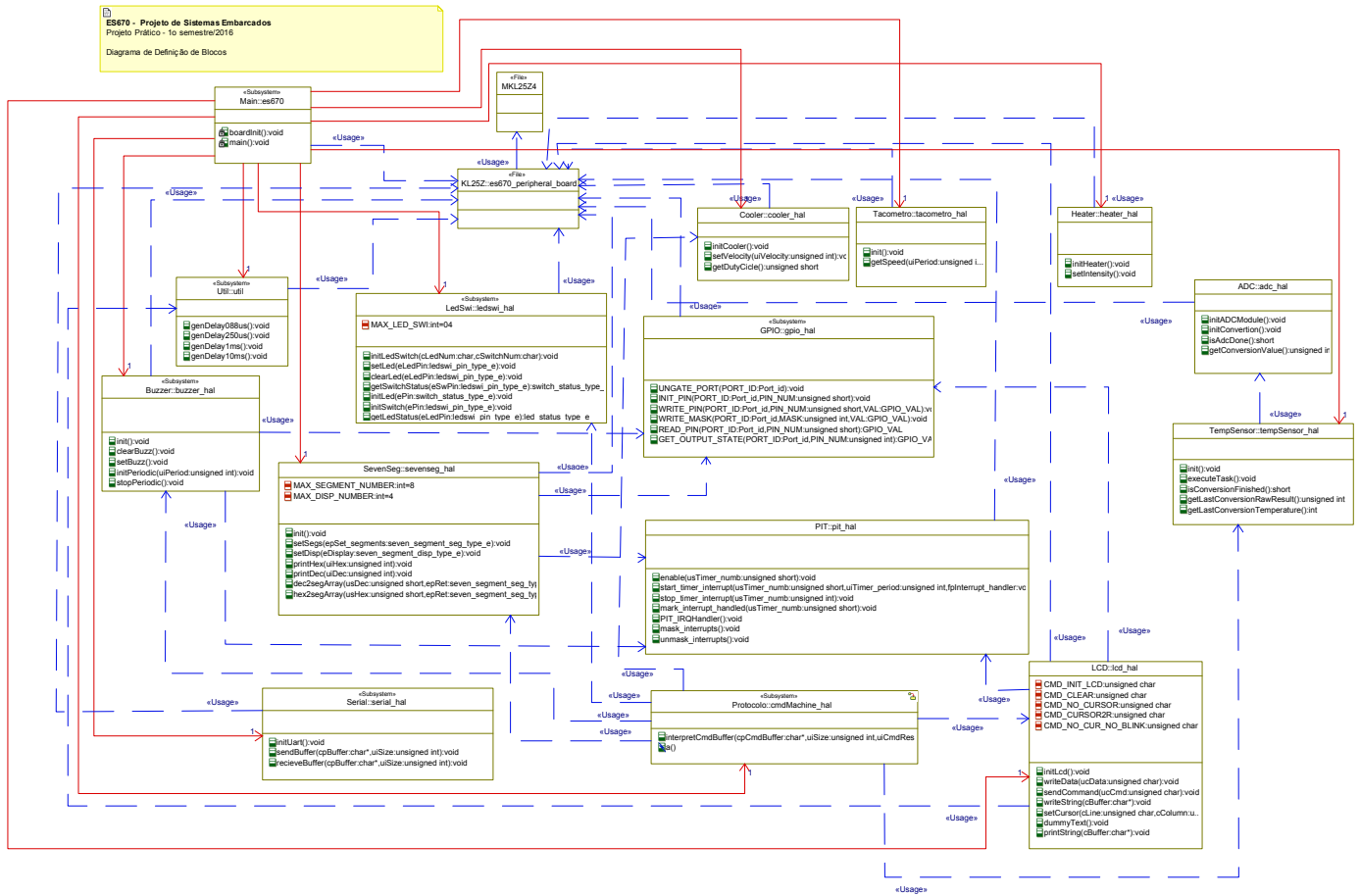


Figura 3: Diagrama de definição de blocos

O bloco de *GPIO_hal* tem operações para desbloquear o *clock* para uma porta, inicializar um pino em uma dada direção, escrever em um pino, escrever em um conjunto de pinos da mesma porta, ler a entrada em um pino e ler o valor de saída que está sendo controlado em um pino.

O bloco *pit_hal* tem operações para inicializar o *PIT*, criar interrupções periódicas em um dos dois *timers* disponíveis, desativar as interrupções em um *timer*, marcar uma interrupção como tratada (deve ser feito pelos tratamentos de interrupção), mascarar as interrupções de *PIT* e desmascarar essas interrupções. Além disso esse bloco tem mais uma operação chamada *PIT_IRQHandler* que trata as interrupções do *PIT*, essa operação precisa ser visível para o *linker*,

mas não deve ser chamada pelo usuário. É importante ressaltar que o *clock* do *PIT* é o *bus_clock* que no nosso caso é de *20MHz*

As operações do bloco *sevenseg_hal* cobrem a inicialização dos *displays*, seleção manual de quais segmentos estarão ativos (feita através da passagem de um vetor com os segmentos desejados), ativação manual de um dos *displays* (desativando todos os outros), conversão de dígito hexadecimal ou decimal em vetor de segmentos (para ser passado para a função de seleção de segmentos) e impressão automática de um valor hexadecimal ou decimal através das interrupções de *timer*.

O bloco do *buzzer_hal* também ganhou duas novas operações, uma para criar uma onda quadrada no *buzzer* com um certo período (e *duty cycle* de 50%), através de interrupções de *timer*, e outra para remover essa onda.

O bloco *ledswi_hal* foi alterado para lidar melhor com a inicialização separada dos pinos como Led e Switch e também foi adicionada uma função para ler o estado atual de um pino configurado como LED.

O bloco *serial_hal* é responsável pela configuração da UART para comunicação serial e pelo envio de recebimento de dados através desse protocolo.

O bloco *lcd_hal* é responsável pelo controle do display LCD, ele segue a implementação passada pelo professor, porém as chamadas as bibliotecas padrão foram substituídas por chamadas ao bloco *GPIO_hal* e manipulações de registradores. Uma função que imprime um texto ao display, após limpar a exibição e resetar a posição do cursor, foi acrescentada.

O bloco *cmdMachine_hal* lida com a interpretação dos comandos e geração da string de resposta. Em nossa implementação, escolhemos tratar uma string já bufferada de *commands* ao invés de trabalhar caractere a caractere. A máquina de estados do tratamento dos comandos pode ser vista na figura 4.

O bloco *tacometro_hal* é responsável pela medição da velocidade do ventilador ligado à placa e sua função *getCurrentSpeed* deve ser chamada de maneira periódica a fim de resetar o contador usado para medir a velocidade.

O bloco *cooler_hal* é responsável pelo controle do ventilador ligado à placa.

são acionados através dos seguintes caracteres: 'B' para buzzer, 'S' para switch, 'L' para led, 'D' para o display sete segmentos, 'P' para imprimir no LCD.

No caso do buzzer, após interpretar o caracter 'B', a máquina espera ler até três caracteres numéricos que correspondem ao tempo em que o buzzer permanecerá ativo, retornando para o estado 'statez_idle' após, para avaliar a próxima ação do buffer de entrada.

Para o switch, após a leitura de 'S', a máquina de estados espera a leitura de um caractere numérico, de 1 a 4, que corresponde de qual switch faremos a leitura. Recebemos como retorno 'O' caso o switch esteja acionado, e 'C' caso contrário. No caso do led, após a leitura de 'L' a máquina de estado espera mais um caractere indicando a ação desejada. Este caractere pode ser 'S' no caso de set, 'R' para read e 'C' para clear. Para todos estes casos, a máquina de estados esperará um caractere numérico indicando em qual dos leds a ação deverá ser executada.

Para o display sete segmentos, após leitura de um 'D' a máquina de estados espera ler até quatro caracteres hexadecimais que serão mostrados no display, retornando para o estado 'state_idle'. No caso do display LCD, após a leitura de um caractere 'P' a máquina de estados lê uma string de até 30 caracteres (sem espaços em branco) e a imprime no display LCD, retornando para o estado 'state_idle'.

O controle do ventilador também foi acrescentado à máquina de estados, ao receber um comando 'C' ela espera ler até quatro caracteres hexadecimais que determinarão o duty-cycle do PWM, retornando para o estado 'state_idle'.

Quando o comando 'T' é lido, o resultado "raw" da última tarefa de leitura é retornado via porta serial e máquina de estados retorna ao estado 'state_idle'. Após cada ação executada com sucesso, o sistema responderá com 'ACK'.

3 Diagramas Esquemáticos

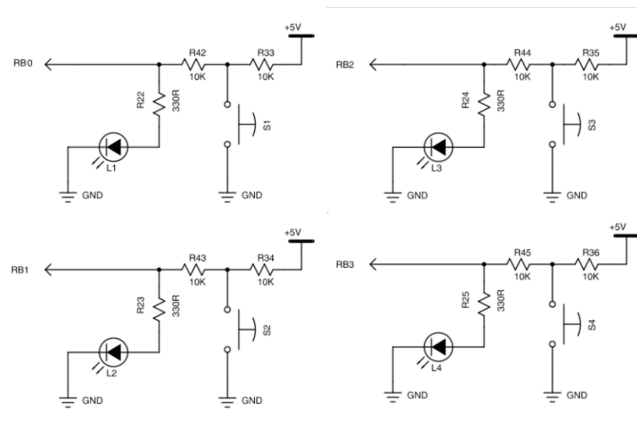


Figura 5: Esquema teclado e LEDs

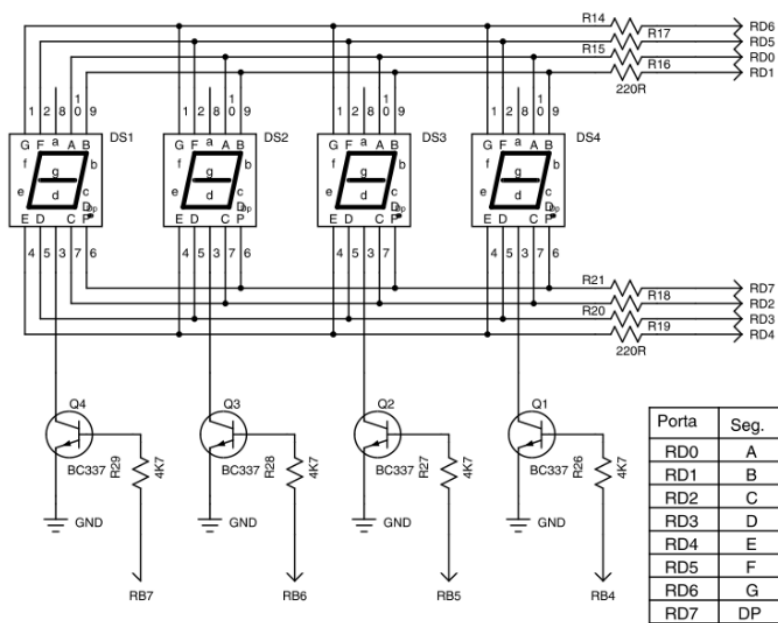


Figura 6: Esquema sete segmentos

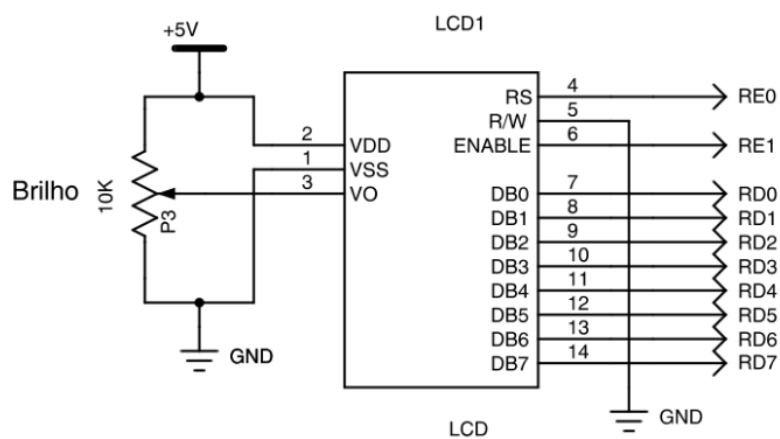


Figura 7: Esquema display LCD

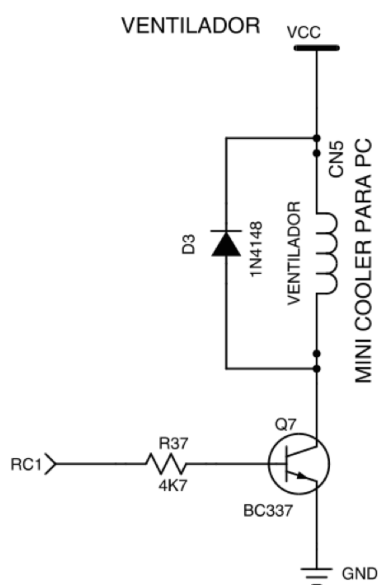


Figura 8: Esquema do ventilador

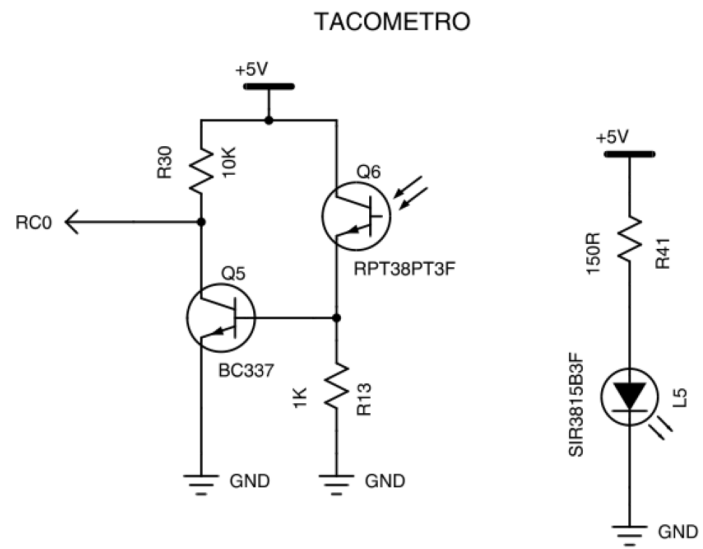


Figura 9: Esquema do tacômetro

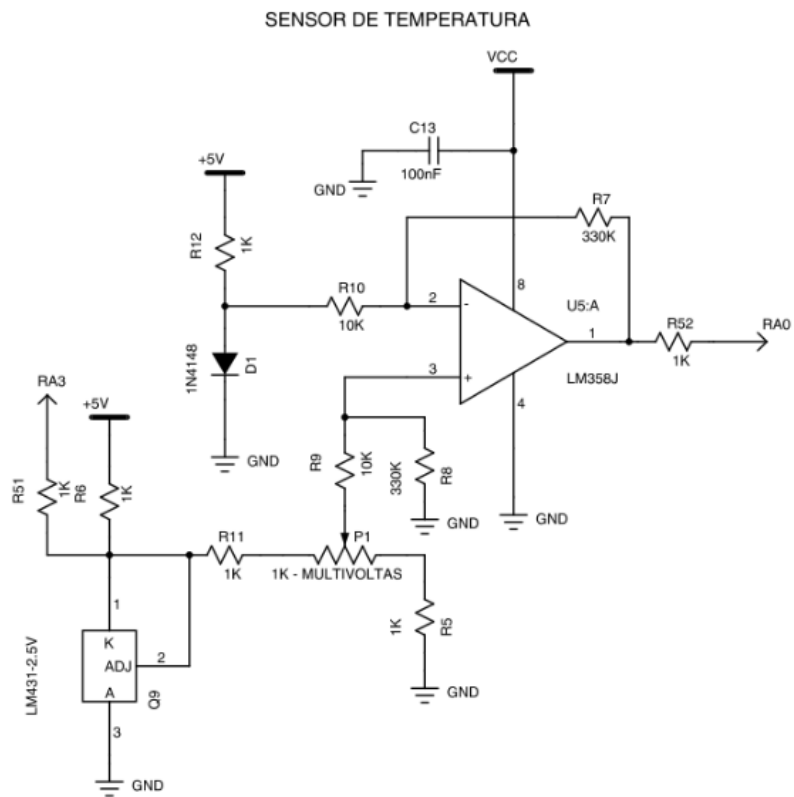


Figura 10: Esquema do sensor de temperatura

AQUECEDOR

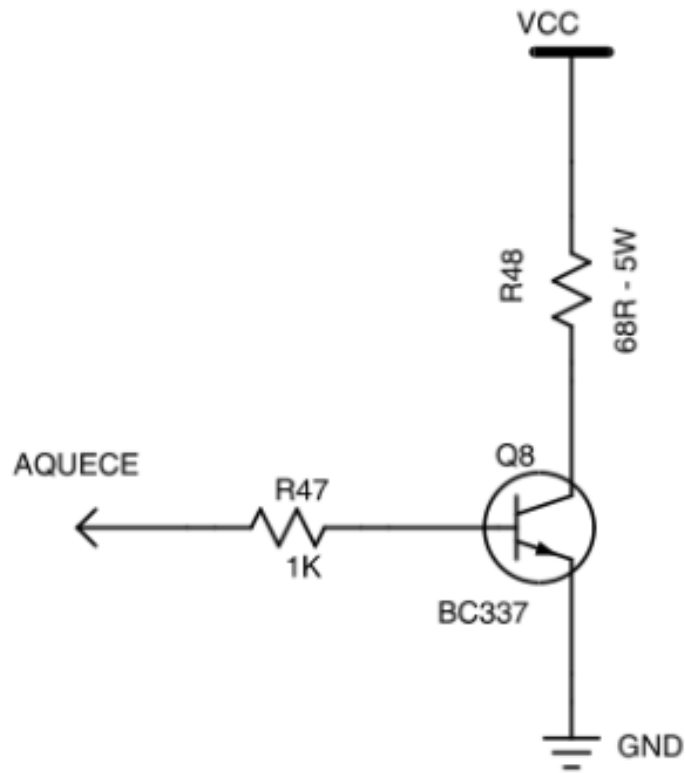


Figura 11: Esquema do aquecedor

Os pinos apresentados acima, devem ser mapeados para os da placa *FRDM-KL25Z* através do mapeamento apresentado na figura 12

KL25Z ADAPTER Marclio

FUNCAIONALIDADE	ESPECIFICAÇÃO	PINO	TIPO	PORTA DO ARM	HEADER ARM	SOQUETE PIC
Display 7S	Segmento A	RD0	GPIO	PTC0	PTC0	J1 03 19
Display 7S	Segmento B	RD1	GPIO	PTC1	PTC1LLWU P6RTC CLKIN	J10 12 20
Display 7S	Segmento C	RD2	GPIO	PTC2	PTC2	J10 10 21
Display 7S	Segmento D	RD3	GPIO	PTC3	PTC3LLWU P7	J1 05 22
Display 7S	Segmento E	RD4	GPIO	PTC4	PTC4LLWU P8	J1 07 27
Display 7S	Segmento F	RD5	GPIO	PTC5	PTC5LLWU P9	J1 09 28
Display 7S	Segmento G	RD6	GPIO	PTC6	PTC6LLWU P10	J1 11 29
Display 7S	Segmento DP	RD7	GPIO	PTC7	PTC7	J1 01 30
Display 7S	Display 1	RB7	GPIO	PTC13	PTC13	J2 03 40
Display 7S	Display 2	RB6	GPIO	PTC12	PTC12	J2 01 39
Display 7S	Display 3	RB5	GPIO	PTC11	PTC11	J1 15 38
Display 7S	Display 4	RB4	GPIO	PTC10	PTC10	J1 13 37
LCD	RS	RE0	GPIO	PTC8	PTC8	J1 14 18
LCD	ENABLE	RE1	GPIO	PTC9	PTC9	J1 16 19
LCD	DB0	RD0	GPIO	PTC0	PTC0	J1 03 19
LCD	DB1	RD1	GPIO	PTC1	PTC1LLWU P6RTC CLKIN	J10 12 20
LCD	DB2	RD2	GPIO	PTC2	PTC2	J10 10 21
LCD	DB3	RD3	GPIO	PTC3	PTC3LLWU P7	J1 05 22
LCD	DB4	RD4	GPIO	PTC4	PTC4LLWU P8	J1 07 27
LCD	DB5	RD5	GPIO	PTC5	PTC5LLWU P9	J1 09 28
LCD	DB6	RD6	GPIO	PTC6	PTC6LLWU P10	J1 11 29
LCD	DB7	RD7	GPIO	PTC7	PTC7	J1 01 30
BUZZER		RA5	GPIO	PTD0	FTM0_CH0	J2 06 7
Teclado/LED	S1/LED1	RB0	GPIO	PTA1	PTA1	J1 02 33
Teclado/LED	S2/LED2	RB1	GPIO	PTA2	PTA2	J1 04 34
Teclado/LED	S3/LED3	RB2	GPIO	PTA4	PTA4	J1 10 35
Teclado/LED	S4/LED4	RB3	GPIO	PTA5	PTA5	J1 12 36

Página 1

Figura 12: Mapeamento entre pinos dos esquemáticos e da placa FRDM-KL25Z

Como pode ser visto na figura 6, é necessário fazer um gerenciamento dos pinos PTC0 a PTC7 para selecionar os segmentos que serão ativados e PTC10 a PTC13 para selecionar quais *displays* estarão ativos. Para isso, é preciso alternar qual *display* está ativo e fazer a mudança nos segmentos para que cada *display* esteja mostrando um valor diferente. É importante lembrar que a frequência dessa alternância seja escolhida de modo que o olho humano não perceba que os *displays* estão ligando e desligando. Afim de garantir que essa alternância funcionará apropriadamente nós utilizamos o módulo *PIT* para gerar uma interrupção a cada $3.125ms$, conforme sugerido na aula 6 [4].

O controle do LCD é feito escrevendo o dado desejado nos pinos de dados (DB*), sinalizando se o dado enviado é um comando (Low) ou um caractere a ser escrito (HIGH) através do pino RS e enviando um pulso de duração bem definida no pino ENABLE. Algum dos comandos que podem ser enviados são mostrados na tabela 1.

Tabela 1: Protocolo de comandos para o display LCD

Nome	Código	Descrição
CMD_INIT_LCD	00001111	Inicializa o display LCD
CMD_CLEAR	00000001	Limpa exibição
CMD_NO_CURSOR	00001100	Esconde a posição do cursor
CMD_CURSOR2R	00000110	Cursor a direita do texto
CMD_NO_CUR_NO_BLINK	00111000	Esconde o cursor e não pisca
CMD_MOV_CUR	1L00CCCC	Move cursor para posição [L, X]. L = linha (0, 1) CCCC = coluna(0 a 15)

Para medir a velocidade do ventilador, ligamos o tacômetro a um contador e contamos o número de pulsos dentro de um período pré determinado de tempo.

4 Matriz de Rastreabilidade

A matriz de rastreabilidade apresentada na tabela 2 relaciona cada um dos requisitos com a sua implementação.

Tabela 2: Matriz de Rastreabilidade

ID do Requisito	Implementação
REQ1A	ledswi_hal.c - void ledswi_initLedSwitch(char cLedNum, char cSwitchNum) - switch_status_type_e ledswi_getSwitchStatus(char cSwitchNum) - void ledswi_initSwich(ledswi_pin_type_e ePin)
REQ1B	ledswi_hal.c - void ledswi_initLedSwitch(char cLedNum, char cSwitchNum) - void ledswi_setLed(char cLedNum) - void ledswi_clearLed(char cLedNum) - void ledswi_initLed(ledswi_pin_type_e ePin) - led_status_type_e ledswi_getLedStatus(ledswi_pin_type_e eLedPin)
REQ1C	sevenseg_hal.c - void sevenseg_init(void) - void sevenseg_setSegs(seven_segment_seg_type_e* epSet_segments) - void sevenseg_setDisp(seven_segment_disp_type_e eDisplay) - void sevenseg_printDec(unsigned int uiDec) - void sevenseg_printHex(unsigned int uiHex)
REQ2	serial_hal.c - void serial_initUart(void) - void serial_sendBuffer(char *cpBuffer, unsigned int uiSize) - int serial_recieveBuffer(char *cpBuffer, unsigned int uiSize) cmdMachine_hal.c - void cmdmachine_interpretCmdBuffer(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes) - int handleError(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes) - int handleBuzzer(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes); - int getBuzzMs(char *cpCmdBuffer) - unsigned int handleSwitch(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes) - unsigned int handleLed(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes) - ledswi_pin_type_e parseLedNum(char cLedInput) - unsigned int handleIdle(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes) - unsigned int handleLCD(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes) - unsigned int handleSevenSeg(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes) - int getSevenSegHex(char *cpCmdBuffer)
REQ3	lcd_hal.c - void lcd_initLcd(void) - void lcd_writeData(unsigned char ucData) - void lcd_sendCommand(unsigned char ucCmd) - void lcd_writeString(const char *cBuffer) - void lcd_printString(const char *cBuffer) - void lcd_setCursor(unsigned char cLine, unsigned char cColumn) - void lcd_dummyText(void)
REQ4	tacometro_hal.c - void tacometro_init(void) - unsigned int tacometro_getSpeed(unsigned int uiPeriod)
REQ5	cooler_hal.c - void cooler_initCooler(void) - void cooler_setVelocity(uint16_t uiVelocity) - unsigned short cooler_getDutyCicle()
REQ6	tempSensor_hal.c - void tempSensor_init() - void tempSensor_executeTask() - short tempSensor_isConversionFinished() - uint16_t tempSensor_getLastConversionRawResult() - int tempSensor_getLastConversionTemperature()

5 Notas

5.1 Comunicação Serial e Executivo Cíclico

Até então quase todo o processamento do nosso sistema estava atrelado à execução de um comando vindo por comunicação serial, logo utilizávamos chamadas que bloqueavam nossa thread principal no aguardo do próximo comando. Agora não podemos fazer mais isso e devemos incluir um pooling da porta serial durante todo o período ocioso do nosso loop principal para garantir que não vamos perder informações vindas por comunicação serial. Uma outra alternativa (que julgamos desnecessária dada a periodicidade do nosso sistema) seria a implementação de interrupções da UART.

5.2 PWM

Uma coisa que deve ser levada em consideração quando configuramos o PWM é que sempre que executamos uma instrução de escrita para alterar a configuração do módulo de PWM o timer deve estar desabilitado e essa instrução leva um tempo para que a escrita seja efetuada, logo é recomendado escrever no registrador em uma única instrução e bit a bit.

5.3 LCD e Interrupções

Para escrever no LCD precisamos gerar um pulso no seu pino de enable. Para garantir que esse pulso terá a duração certa, foi preciso mascarar as interrupções durante esse pulso. Como as interrupções do display tem um período de aproximadamente 3ms e o pulso do LCD tem a mesma duração encontramos várias dificuldades ao controlar os dois sem mascarar as interrupções pela duração do pulso, logo adaptamos nosso código. Quando atualizamos as informações do painel LCD de maneira regular, notamos um leve efeito de "flicker" nos displays 7 segmentos.

5.4 Leitura do Estado dos LEDs

Como uma extensão ao protocolo proposto no roteiro [1], acrescentamos o comando *LRd* onde *d* é um dígito de 1 a 4, que nos retorna o estado atual do LED referenciado. Para recuperar esse estado devemos saber qual valor está sendo controlado para um pino de saída digital, o que é feito lendo o registrador GPIOx_PDOR.

5.5 Interrupções do Buzzer e mudança de Baud Rate

Ao utilizar interrupções para cuidar do acionamento e controle do Buzzer, conseguimos executar essa funcionalidade de maneira assíncrona, garantindo que essa funcionalidade não vai interferir com ou ser interferida pelas outras. Isso é notavelmente importante com a comunicação serial, uma vez que a velocidade de leitura é crítica e se essa for alterada, corremos o risco de perder informações ou alterar o tempo de execução de nosso ciclo.

5.6 Bufferização dos comandos

Para diminuir a chance de perder informações que são enviadas por serial, escolhemos ler uma série de caracteres e armazená-los em um buffer antes de interpretá-los, ao invés de ler e interpretar caractere a caractere. Interrompemos esse processo de leitura no caso de buffer overflow ou quando encontramos uma quebra de linha. Interpretar uma série de comandos bufferizados introduziu uma dificuldade extra ao projeto, pois agora nossa máquina de estados tem que levar em consideração que um comando pode estar errado e o próximo não, logo o primeiro deve ser ignorado e o segundo executado.

5.7 Gerenciamento de GPIO e macros

Detectamos logo no início do projeto um defeito estrutural no código fornecido quando lidando com GPIO: o identificador da porta e o número do pino utilizado eram referenciados em diversos locais diferentes do código dificultando de maneira agravante mudanças na configuração de hardware. Para resolver isso inicialmente pensamos em utilizar o arquivo *fsl_gpio_hal.h* da biblioteca da *FRDM-K125Z*, mas isso não nos foi permitido. Como calcular as posições na memória de cada registrador seria reimplementar a biblioteca, escolhemos por criar macros que geram o mesmo estilo de código utilizado no exemplo fornecido através do operador de concatenação (`##`) do pré processador. Esse operador apresenta algumas particularidades, a principal sendo que macros que o utilizam em seu corpo não tem seus argumentos expandidos [5]. Para circular essa dificuldade criamos uma outras macros que funcionam como uma *wrappers* para essas macros, fazendo assim que seus argumentos sejam expandidos antes da chamada da concatenação.

As macros que fazem a concatenação propriamente ditas não devem ser chamadas pelo usuário (sendo identificadas por um `_` no início de seus nomes).

Outra dificuldade relacionada a esse módulo é que a expansão dos argumentos das macros não para quando chega em alguma *token* não definida, no caso o identificador das portas (A,B,C,D,E). Para contornar esse problema utilizamos *typedefs* para definir esses identificadores como *tokens* válidas.

5.8 Interrupções por timer

Outro problema que enfrentamos foi com a implementação das interrupções por timer através do PIT, notavelmente pela dificuldade de encontrar uma documentação clara sobre o NVIC e pois a documentação fornecida para o PIT inverte a endianness dos registradores em relação aos registradores de GPIO. Nota: Documentação disponível no site arm.com, na referência do registrador Arm-M0+ sobre o NVIC [6] encontramos a seguinte frase: "See the ARMv6-M Architecture Reference Manual for more information about the NVIC registers and their addresses, access types, and reset values.". Já na página ARMv6-M Architecture Reference Manual [7] somos informados que esse manual só está disponível em formato PDF e para clientes registrados.

5.9 Leitura de entradas digitais

Nesse laboratório tivemos dificuldades relacionadas à leitura do estado dos botões. O problema encontrado ocorreu pois quando o desbloqueamos o *clock* para uma porta do controlador no código fornecido estávamos desabilitando o *clock* para todas as outras portas. Como o *clock* só afeta significativamente os pinos configurados como *input*, se o módulo *ledswi_hal* fosse inicializado por último (como é feito no código do professor) o problema não seria notado.

5.10 Estilo de Documentação

Não conseguimos nos adaptar ao estilo de comentários sugerido pelo professor, que nos parece introduzir uma quantidade desnecessária de burocracia. Formatar todos os comentários para caber dentro daquele quadrado tomava mais tempo que o planejamento e a implementação do código e muita informação redundante estava sendo inserida (bastava ler a interface da função para saber seu nome e o tipo de seus argumentos). Escolhemos substituir todos os comentários do código pelo padrão *javadoc*, com o qual estamos mais familiarizados, que é capaz de documentar de maneira eficiente o código.

5.11 Rhapsody Modeler e Wine

Também tivemos dificuldades com a instalação do *Rhapsody Rational Modeler* no *Linux* (através do *Wine*), pois ele necessita da instalação das seguintes dlls nativas do *Windows*: *mfc42*, *comctl32*, *msvcrt* e *riched20*.

Ainda temos um problema com o Rhapsody quando tentamos editar textos dentro de um estado, por isso nossa máquina de estados só executa sua lógica nas transições.

5.12 Outros

É relevante lembrar de utilizar o modificador *volatile* para variáveis que serão modificadas durante o tratamento de interrupções, dessa maneira o otimizador sabe que não deve alterar comandos que envolvem essa variável.

6 Referências

- [1] Roteiro de Laboratório - Semanas 04 e 05 (disponibilizado para os alunos)
- [2] Projeto do Modelo Inicial do Sistema (disponibilizado para os alunos)
- [3] Código Fonte Inicial em Linguagem C (disponibilizado para os alunos)
- [4] Notas de Aula - Semanas 06 (disponibilizado para os alunos)
- [5] The C Preprocessor (Concatenation) <https://gcc.gnu.org/onlinedocs/cpp/Concatenation.html#Concatenation>
- [6] Cortex-M0+ Technical Reference Manual <http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.ddi0413c/Cihfihfe.html>
- [7] ARMv6-M Architecture Reference Manual <http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.ddi0413c/Cihfihfe.html>

7 Apêndice

Listagem dos códigos fonte:

7.1 ../Sources/ADC/adc.c

```
1  /*
2  * File name: adc.c
3  *
4  * Created on: 06/06/2016
5  * Author: msoliveira
6  */
7
8  #include "KL25Z/es670_peripheral_board.h"
9
10 #define ADC0_SC1A_COC0 (ADC0_SC1A >> 7)
11
12 /**
13 * Configure ADC module
14 */
15 void adc_initADCModule(void) {
16     /* un-gate port clock*/
17     SIM_SCGC6 |= SIM_SCGC6_ADC0(CGC_CLOCK_ENABLED); //Enable clock for ADC
18
19     /* un-gate port clock*/
20     SIM_SCGC5 |= SIM_SCGC5_PORTE(CGC_CLOCK_ENABLED);
21
22     /* set pin as ADC In */
23     PORT_PCR_REG(ADC_PORT_BASE_PNT, ADC_VOLT_PIN) =
24     PORT_PCR_MUX(ADC_VOLT_PIN_MUX_ALT); //Voltage Sensor
25     PORT_PCR_REG(ADC_PORT_BASE_PNT, ADC_TEMP_PIN) =
26     PORT_PCR_MUX(ADC_TEMP_PIN_MUX_ALT); //Temperature Sensor
27
28     ADC_WR_CFG1(ADC_NUM_BASE_PNT,
29     (
30         ADC_CFG1_ADICLK(0x1) // bus/2 clock selection
31         | ADC_CFG1_MODE(0x3) // 16-bit Conversion mode selection
32         | ADC_CFG1_ADLSMP(0x0) // Short sample time configuration
33         | ADC_CFG1_ADIV(0x0) // Clock Divide Select (Divide by 1)
34         | ADC_CFG1_ADLPC(0x1) // Normal power Configuration
35     )
36 );
37 }
```

```

36     ADC_WR_SC2(ADC_NUM_BASE_PNT,
37         (
38             ADC_SC2_REFSEL(0x0)           //external pins
39         | ADC_SC2_DMAEN(0x0)             //dma disabled
40         | ADC_SC2_ACFE(0x0)             //compare disabled
41         | ADC_SC2_ADTRG(0x0)            //sw trigger
42     )
43 );
44
45     ADC_WR_CFG2(ADC_NUM_BASE_PNT,
46         (
47             ADC_CFG2_ADLSTS(0)           // default time
48         | ADC_CFG2_ADHSC(0)             // normal conversion sequence
49         | ADC_CFG2_ADACKEN(0)           // adack clock disabled
50         | ADC_CFG2_MUXSEL(ADC_MUX_IDX)  // 'a' channels
51     )
52 );
53 }
54
55
56 /**
57  * Init conversion from A to D
58  */
59 void adc_initConversion(void) {
60     ADC_WR_SC1(ADC_NUM_BASE_PNT, ADC_MUX_IDX,
61         (
62             ADC_SC1_ADCH(ADC_CHANNEL_SEL) //Channel 4 - SE4A
63         | ADC_SC1_DIFF(0)                 //single ended
64         | ADC_SC1_AIEN(0)                 //interrupt disabled
65     )
66 );
67 }
68
69 /**
70  * Check if conversion is done
71  * @return 1 if done, 0 otherwise
72  */
73 short adc_isAdcDone(void)
74 {
75     return ADC_BRD_SC1_COCO(ADC_NUM_BASE_PNT, ADC_MUX_IDX);
76 }
77
78 /**
79  * Retrieve converted value

```

```
80  * @return The conversion result
81  */
82  uint16_t adc_getConversionValue(void)
83  {
84      return ADC_RD_R(ADC_NUM_BASE_PNT, ADC_MUX_IDX); // return the register value that
85      keeps the result of conversion
86  }
```

7.2 ../Sources/ADC/adc.h

```
1  /*
2  * File name: adc.h
3  *
4  * Created on: 06/06/2016
5  * Author: msoliveira
6  */
7
8  #include <stdint.h>
9
10 /**
11  * Configure ADC module
12  */
13 void adc_initADCModule(void);
14
15 /**
16  * Init conversion from A to D
17  */
18 void adc_initConversion(void);
19
20 /**
21  * Check if conversion is done
22  * @return 1 if done, 0 otherwise
23  */
24 short adc_isAdcDone(void);
25
26 /**
27  * Retrieve converted value
28  * @return The conversion result
29  */
30 uint16_t adc_getConversionValue(void);
```

7.3 ../Sources/Buzzer/buzzer_hal.c

```
1  /* ***** */
2  /* File name:      buzzer_hal.c */
3  /* File description: File dedicated to the hardware abstraction layer*/
4  /*                related buzzer from the peripheral board */
5  /* Author name:    dloubach */
6  /* Creation date:   12jan2016 */
7  /* Revision date:   13abr2016 */
8  /* ***** */
9
10 #include "GPIO/gpio_hal.h"
11 #include "buzzer_hal.h"
12 #include "KL25Z/es670_peripheral_board.h"
13 #include "PIT/pit_hal.h"
14
15 static volatile int interrupt_counter = -1;
16
17 /**
18  * Initialize the buzzer device
19  */
20 void buzzer_init(void)
21 {
22     GPIO_UNGATE_PORT(BUZZER_PORT_ID);
23     GPIO_INIT_PIN(BUZZER_PORT_ID, BUZZER_PIN, GPIO_OUTPUT);
24     pit_enable();
25 }
26
27
28
29 /**
30  * Clear the buzzer
31  */
32 void buzzer_clearBuzz(void)
33 {
34     GPIO_WRITE_PIN(BUZZER_PORT_ID, BUZZER_PIN, GPIO_LOW);
35 }
36
37
38
39 /**
40  * Set the buzzer
41  */
42 void buzzer_setBuzz(void)
```

```

43 {
44     GPIO_WRITE_PIN(BUZZER_PORT_ID, BUZZER_PIN, GPIO_HIGH);
45 }
46
47 /**
48  * Handler for buzzer interruptions
49  */
50 void _buzzer_interrupt_handler(void){
51     static volatile unsigned short usBusOn = 0;
52     if(!usBusOn){
53         buzzer_setBuzz();
54     }else{
55         buzzer_clearBuzz();
56     }
57     usBusOn = !usBusOn;
58     //If not in undefined mode decrease counter
59     if(interrupt_counter > 0){
60         interrupt_counter--;
61     }
62     //Stop interruptions when signal duration is finished
63     if(!interrupt_counter){
64         buzzer_stopPeriodic();
65     }
66     //Mark interruption as handled
67     pit_mark_interrupt_handled(BUZZER_PIT_TIMER_NUMB);
68 }
69
70 /**
71  * Starts the buzzer with the specified period
72  *
73  * @param uiBuzzFreq_hz The frequency of the buzzer signal, in Hz
74  * @param uiDuration_ms How many milliseconds the buzzer should be producing sound
75  *                       if 0 buzzer will stay on indeterminally.
76  */
77 void buzzer_initPeriodic(unsigned int uiBuzzFreq_hz, unsigned int uiDuration_ms){
78     unsigned int uiPeriod_us = 500000/uiBuzzFreq_hz; /* 50% duty cycle */
79     if(uiDuration_ms > 0){
80         interrupt_counter = uiDuration_ms/(uiPeriod_us/1000);
81     }else{
82         interrupt_counter = -1;
83     }
84     //Init timer 1
85     pit_start_timer_interrupt(BUZZER_PIT_TIMER_NUMB, uiPeriod_us,
86                             &_buzzer_interrupt_handler);

```

```
86 }
87
88 /**
89  * Stops any periodic buzzer signal
90  */
91 void buzzer_stopPeriodic(void){
92     interrupt_counter = -1;
93     pit_stop_timer_interrupt(BUZZER_PIT_TIMER_NUMB);
94     buzzer_clearBuzz();
95 }
```

7.4 ../Sources/Buzzer/buzzer_hal.h

```
1  /* ***** */
2  /* File name:      buzzer_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for handling BUZZER from the */
5  /*                peripheral board */
6  /* Author name:    dloubach */
7  /* Creation date:   12jan2016 */
8  /* Revision date:   13abr2016 */
9  /* ***** */
10
11 #ifndef SOURCES_BUZZER_HAL_H_
12 #define SOURCES_BUZZER_HAL_H_
13
14 /**
15  * Initialize the buzzer device
16  */
17 void buzzer_init(void);
18
19
20 /**
21  * Clear the buzzer
22  */
23 void buzzer_clearBuzz(void);
24
25
26 /**
27  * Set the buzzer
28  */
29 void buzzer_setBuzz(void);
30
31 /**
32  * Starts the buzzer with the specified period
33  *
34  * @param uiBuzzFreq_hz The frequency of the buzzer signal, in Hz
35  * @param uiDuration_ms How many milliseconds the buzzer should be producing sound
36  *                      if 0 buzzer will stay on indeterminally.
37  */
38 void buzzer_initPeriodic(unsigned int uiBuzzFreq_hz, unsigned int uiDuration_ms);
39
40 /**
41  * Stops any periodic buzzer signal
42  */
```

```
43 void buzzer_stopPeriodic(void);  
44  
45  
46 #endif /* SOURCES_BUZZER_HAL_H_ */
```

7.5 ../Sources/Cooler/cooler_hal.c

```
1  /* ***** */
2  /* File name:      cooler_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                for cooler control */
5  /* Author name:    ddello */
6  /* Creation date:   13maio2016 */
7  /* Revision date:   13maio2016 */
8  /* ***** */
9
10 #include "cooler_hal.h"
11 #include "KL25Z/es670_peripheral_board.h"
12 #include "GPIO/gpio_hal.h"
13
14 /**
15  * Initialize the cooler module
16  */
17 void cooler_initCooler(void){
18     /* Init cooler pin */
19     SIM_SCGC5 |= SIM_SCGC5_PORTA(1u);
20     PORT_PCR_REG(COOLER_PORT_BASE_PNT , COOLER_PIN) = PORT_PCR_MUX(COOLER_PIN_MUX_ALT);
21
22     /* INIT TPM */
23     //Init TPM Clock source as OSCERCLOCK
24     SIM_WR_SOPT2_TPMSRC(SIM,0x2);
25     //Enable clock to TPM1
26     SIM_SCGC6 |= SIM_SCGC6_TPM1(0x1);
27     //PWM mode
28     TPM_WR_SC_CPWMS(COOLER_TPM_BASE_PNT, 0x0); //Edge Aligned
29     /* Channel mode configuration should be done with the channel disabled and need
30        acknowledge*/
31     TPM_WR_CnSC(COOLER_TPM_BASE_PNT , COOLER_TPM_CHANNEL_INDEX , TPM_CnSC_ELSB(1) |
32                TPM_CnSC_MSB(1));
33     /* Wait till mode change is acknowledged */
34     while (!
35         (
36             TPM_RD_CnSC(COOLER_TPM_BASE_PNT , COOLER_TPM_CHANNEL_INDEX)
37             & (TPM_CnSC_ELSB(1) | TPM_CnSC_MSB(1))
38         )
39     );
40     //Same period as OSCRCCLK
41     TPM_WR_MOD(COOLER_TPM_BASE_PNT , 0xFFFE);
42     //Duty cycle
```

```

41     TPM_WR_CnV_VAL(COOLER_TPM_BASE_PNT, COOLER_TPM_CHANNEL_INDEX, 0);
42     //Prescale 1:1
43     TPM_WR_SC_PS(COOLER_TPM_BASE_PNT, 0x0);
44     //Select LTPM Clock Source for TPM module
45     TPM_WR_SC_CMOD(COOLER_TPM_BASE_PNT, 0x1);
46 }
47
48
49 /**
50  * Set the cooler velocity
51  *
52  * @param uiVelocity Cooler velocity from 0 (stopped) to 0xFFFF (max)
53  */
54 void cooler_setVelocity(uint16_t uiVelocity){
55     TPM_WR_CnV_VAL(COOLER_TPM_BASE_PNT, COOLER_TPM_CHANNEL_INDEX, uiVelocity);
56 }
57
58 /**
59  * Get the cooler PWM duty cycle in %.
60  *
61  * @return Duty Cycle (0 to 100)
62  */
63 unsigned short cooler_getDutyCycle(){
64     return (TPM_RD_CnV_VAL(COOLER_TPM_BASE_PNT, COOLER_TPM_CHANNEL_INDEX)*100)/0xFFFF;
65 }

```

7.6 ../Sources/Cooler/cooler_hal.h

```
1  /* ***** */
2  /* File name:      cooler_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for cooler control */
5  /* Author name:     ddello */
6  /* Creation date:    13maio2016 */
7  /* Revision date:    13maio2016 */
8  /* ***** */
9
10 #ifndef SOURCES_COOLER_HAL_H_
11 #define SOURCES_COOLER_HAL_H_
12
13 #include <stdint.h>
14
15 /**
16  * Initialize the cooler module
17  */
18 void cooler_initCooler(void);
19
20
21 /**
22  * Set the cooler velocity
23  *
24  * @param uiVelocity Cooler velocity from 0 (stopped) to 0xFFFF (max)
25  */
26 void cooler_setVelocity(uint16_t uiVelocity);
27
28 /**
29  * Get the cooler PWM duty cycle in %.
30  *
31  * @return Duty Cycle (0 to 100)
32  */
33 unsigned short cooler_getDutyCycle();
34
35 #endif /* SOURCES_COOLER_HAL_H_ */
```

7.7 ../Sources/fsl_debug_console.c

```
1  /*
2  * Copyright (c) 2013 - 2014, Freescale Semiconductor, Inc.
3  * All rights reserved.
4  *
5  * Redistribution and use in source and binary forms, with or without modification,
6  * are permitted provided that the following conditions are met:
7  *
8  * o Redistributions of source code must retain the above copyright notice, this list
9  *   of conditions and the following disclaimer.
10 *
11 * o Redistributions in binary form must reproduce the above copyright notice, this
12 *   list of conditions and the following disclaimer in the documentation and/or
13 *   other materials provided with the distribution.
14 *
15 * o Neither the name of Freescale Semiconductor, Inc. nor the names of its
16 *   contributors may be used to endorse or promote products derived from this
17 *   software without specific prior written permission.
18 *
19 * THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND
20 * ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED
21 * WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE
22 * DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR
23 * ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES
24 * (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES;
25 * LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON
26 * ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
27 * (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS
28 * SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
29 */
30
31 #include <stdarg.h>
32 #include <stdio.h>
33 #include <stdlib.h>
34 #include "fsl_device_registers.h"
35 #include "fsl_debug_console.h"
36 #if defined(UART_INSTANCE_COUNT)
37 #include "fsl_uart_hal.h"
38 #endif
39 #if defined(LPUART_INSTANCE_COUNT)
40 #include "fsl_lpuart_hal.h"
41 #endif
42 #if defined(UART0_INSTANCE_COUNT)
```

```

43 #include "fsl_lpsci_hal.h"
44 #endif
45 #include "fsl_clock_manager.h"
46 #include "fsl_os_abstraction.h"
47 #include "print_scan.h"
48
49 #if (defined(USB_INSTANCE_COUNT) && (defined(BOARD_USE_VIRTUALCOM)))
50     #include "usb_device_config.h"
51     #include "usb.h"
52     #include "usb_device_stack_interface.h"
53     #include "usb_descriptor.h"
54     #include "virtual_com.h"
55 #endif
56
57 extern uint32_t g_app_handle;
58 #if __ICCARM__
59 #include <yfuns.h>
60 #endif
61
62 static int debug_putc(int ch, void* stream);
63
64 /*****
65  * Definitions
66  *****/
67
68 /*! @brief Operation functions definitions for debug console. */
69 typedef struct DebugConsoleOperationFunctions {
70     union {
71         void (* Send)(void *base, const uint8_t *buf, uint32_t count);
72         #if defined(UART_INSTANCE_COUNT)
73             void (* UART_Send)(UART_Type *base, const uint8_t *buf, uint32_t count);
74         #endif
75         #if defined(LPUART_INSTANCE_COUNT)
76             void (* LPUART_Send)(LPUART_Type* base, const uint8_t *buf, uint32_t count);
77         #endif
78         #if defined(UART0_INSTANCE_COUNT)
79             void (* UART0_Send)(UART0_Type* base, const uint8_t *buf, uint32_t count);
80         #endif
81         #if (defined(USB_INSTANCE_COUNT) && defined(BOARD_USE_VIRTUALCOM))
82             void (* USB_Send)(uint32_t base, const uint8_t *buf, uint32_t count);
83         #endif
84     } tx_union;
85     union{
86         void (* Receive)(void *base, uint8_t *buf, uint32_t count);

```

```

87 #if defined(UART_INSTANCE_COUNT)
88     uart_status_t (* UART_Receive)(UART_Type *base, uint8_t *buf, uint32_t count);
89 #endif
90 #if defined(LPUART_INSTANCE_COUNT)
91     lpuart_status_t (* LPUART_Receive)(LPUART_Type* base, uint8_t *buf, uint32_t
        count);
92 #endif
93 #if defined(UART0_INSTANCE_COUNT)
94     lpsci_status_t (* UART0_Receive)(UART0_Type* base, uint8_t *buf, uint32_t
        count);
95 #endif
96 #if (defined(USB_INSTANCE_COUNT) && defined(BOARD_USE_VIRTUALCOM))
97     usb_status_t (* USB_Receive)(uint32_t base, uint8_t *buf, uint32_t count);
98 #endif
99
100     } rx_union;
101 } debug_console_ops_t;
102
103 /*! @brief State structure storing debug console. */
104 typedef struct DebugConsoleState {
105     debug_console_device_type_t type; /*<! Indicator telling whether the debug console
        is initied. */
106     uint8_t instance;                /*<! Instance number indicator. */
107     void* base;                      /*<! Base of the IP register. */
108     debug_console_ops_t ops;         /*<! Operation function pointers for debug uart
        operations. */
109 } debug_console_state_t;
110
111 /*****
112  * Variables
113  *****/
114 /*! @brief Debug UART state information.*/
115 static debug_console_state_t s_debugConsole;
116
117 /*****
118  * Code
119  *****/
120 /* See fsl_debug_console.h for documentation of this function.*/
121 debug_console_status_t DbgConsole_Init(
122     uint32_t uartInstance, uint32_t baudRate, debug_console_device_type_t device)
123 {
124     if (s_debugConsole.type != kDebugConsoleNone)
125     {
126         return kStatus_DEBUGCONSOLE_Failed;

```

```

127     }
128
129     /* Set debug console to initialized to avoid duplicated init operation.*/
130     s_debugConsole.type = device;
131     s_debugConsole.instance = uartInstance;
132
133     /* Switch between different device. */
134     switch (device)
135     {
136 #if (defined(USB_INSTANCE_COUNT) && defined(BOARD_USE_VIRTUALCOM)) /*&& defined()*/
137         case kDebugConsoleUSBCDC:
138             {
139                 VirtualCom_Init();
140                 s_debugConsole.base = (void*)g_app_handle;
141                 s_debugConsole.ops.tx_union.USB_Send = VirtualCom_SendDataBlocking;
142                 s_debugConsole.ops.rx_union.USB_Receive =
143                 VirtualCom_ReceiveDataBlocking;
144             }
145             break;
146 #endif
147 #if defined(UART_INSTANCE_COUNT)
148         case kDebugConsoleUART:
149             {
150                 UART_Type * g_Base[UART_INSTANCE_COUNT] = UART_BASE_PTRS;
151                 UART_Type * base = g_Base[uartInstance];
152                 uint32_t uartSourceClock;
153
154                 s_debugConsole.base = base;
155                 CLOCK_SYS_EnableUartClock(uartInstance);
156
157                 /* UART clock source is either system or bus clock depending on
158                 instance */
159                 uartSourceClock = CLOCK_SYS_GetUartFreq(uartInstance);
160
161                 /* Initialize UART baud rate, bit count, parity and stop bit. */
162                 UART_HAL_SetBaudRate(base, uartSourceClock, baudRate);
163                 UART_HAL_SetBitCountPerChar(base, kUart8BitsPerChar);
164                 UART_HAL_SetParityMode(base, kUartParityDisabled);
165 #if FSL_FEATURE_UART_HAS_STOP_BIT_CONFIG_SUPPORT
166                 UART_HAL_SetStopBitCount(base, kUartOneStopBit);
167 #endif
168
169                 /* Finally, enable the UART transmitter and receiver*/
170                 UART_HAL_EnableTransmitter(base);

```

```

169         UART_HAL_EnableReceiver(base);
170
171         /* Set the funciton pointer for send and receive for this kind of
device. */
172         s_debugConsole.ops.tx_union.UART_Send = UART_HAL_SendDataPolling;
173         s_debugConsole.ops.rx_union.UART_Receive = UART_HAL_ReceiveDataPolling;
174     }
175     break;
176 #endif
177 #if defined(UART0_INSTANCE_COUNT)
178     case kDebugConsoleLPSCI:
179     {
180         /* Declare config sturcture to initialize a uart instance. */
181         UART0_Type * g_Base[UART0_INSTANCE_COUNT] = UART0_BASE_PTRS;
182         UART0_Type * base = g_Base[uartInstance];
183         uint32_t uartSourceClock;
184
185         s_debugConsole.base = base;
186         CLOCK_SYS_EnableLpsciClock(uartInstance);
187
188         uartSourceClock = CLOCK_SYS_GetLpsciFreq(uartInstance);
189
190         /* Initialize LPSCI baud rate, bit count, parity and stop bit. */
191         LPSCI_HAL_SetBaudRate(base, uartSourceClock, baudRate);
192         LPSCI_HAL_SetBitCountPerChar(base, kLpsci8BitsPerChar);
193         LPSCI_HAL_SetParityMode(base, kLpsciParityDisabled);
194 #if FSL_FEATURE_LPSCI_HAS_STOP_BIT_CONFIG_SUPPORT
195         LPSCI_HAL_SetStopBitCount(base, kLpsciOneStopBit);
196 #endif
197
198         /* Finally, enable the LPSCI transmitter and receiver*/
199         LPSCI_HAL_EnableTransmitter(base);
200         LPSCI_HAL_EnableReceiver(base);
201
202         /* Set the funciton pointer for send and receive for this kind of
device. */
203         s_debugConsole.ops.tx_union.UART0_Send = LPSCI_HAL_SendDataPolling;
204         s_debugConsole.ops.rx_union.UART0_Receive =
LPSCI_HAL_ReceiveDataPolling;
205     }
206     break;
207 #endif
208 #if defined(LPUART_INSTANCE_COUNT)
209     case kDebugConsoleLPUART:

```

```

210         {
211             LPUART_Type* g_Base[LPUART_INSTANCE_COUNT] = LPUART_BASE_PTRS;
212             LPUART_Type* base = g_Base[uartInstance];
213             uint32_t lpuartSourceClock;
214
215             s_debugConsole.base = base;
216             CLOCK_SYS_EnableLpuartClock(uartInstance);
217
218             /* LPUART clock source is either system or bus clock depending on
instance */
219             lpuartSourceClock = CLOCK_SYS_GetLpuartFreq(uartInstance);
220
221             /* initialize the parameters of the LPUART config structure with
desired data */
222             LPUART_HAL_SetBaudRate(base, lpuartSourceClock, baudRate);
223             LPUART_HAL_SetBitCountPerChar(base, kLpuart8BitsPerChar);
224             LPUART_HAL_SetParityMode(base, kLpuartParityDisabled);
225             LPUART_HAL_SetStopBitCount(base, kLpuartOneStopBit);
226
227             /* finally, enable the LPUART transmitter and receiver */
228             LPUART_HAL_SetTransmitterCmd(base, true);
229             LPUART_HAL_SetReceiverCmd(base, true);
230
231             /* Set the funciton pointer for send and receive for this kind of
device. */
232             s_debugConsole.ops.tx_union.LPUART_Send = LPUART_HAL_SendDataPolling;
233             s_debugConsole.ops.rx_union.LPUART_Receive =
LPUART_HAL_ReceiveDataPolling;
234
235         }
236         break;
237     #endif
238     /* If new device is requiried as the low level device for debug console,
239     * Add the case branch and add the preprocessor macro to judge whether
240     * this kind of device exist in this SOC. */
241     default:
242         /* Device identified is invalid, return invalid device error code. */
243         return kStatus_DEBUGCONSOLE_InvalidDevice;
244     }
245
246     /* Configure the s_debugConsole structure only when the inti operation is
successful. */
247     s_debugConsole.instance = uartInstance;
248

```

```

249     return kStatus_DEBUGCONSOLE_Success;
250 }
251
252 /* See fsl_debug_console.h for documentation of this function.*/
253 debug_console_status_t DbgConsole_DeInit(void)
254 {
255     if (s_debugConsole.type == kDebugConsoleNone)
256     {
257         return kStatus_DEBUGCONSOLE_Success;
258     }
259
260     switch(s_debugConsole.type)
261     {
262 #if defined(UART_INSTANCE_COUNT)
263         case kDebugConsoleUART:
264             CLOCK_SYS_DisableUartClock(s_debugConsole.instance);
265             break;
266 #endif
267 #if defined(UART0_INSTANCE_COUNT)
268         case kDebugConsoleLPSCI:
269             CLOCK_SYS_DisableLpSciClock(s_debugConsole.instance);
270             break;
271 #endif
272 #if defined(LPUART_INSTANCE_COUNT)
273         case kDebugConsoleLPUART:
274             CLOCK_SYS_DisableLpuartClock(s_debugConsole.instance);
275             break;
276 #endif
277         default:
278             return kStatus_DEBUGCONSOLE_InvalidDevice;
279     }
280
281     s_debugConsole.type = kDebugConsoleNone;
282
283     return kStatus_DEBUGCONSOLE_Success;
284 }
285
286 #if (defined(__KSDK_STDLIB__))
287 int _WRITE(int fd, const void *buf, size_t nbytes)
288 {
289     if (buf == 0)
290     {
291         /* This means that we should flush internal buffers. Since we*/
292         /* don't we just return. (Remember, "handle" == -1 means that all*/

```

```

293         /* handles should be flushed.*/
294         return 0;
295     }
296
297
298     /* Do nothing if the debug uart is not initialized.*/
299     if (s_debugConsole.type == kDebugConsoleNone)
300     {
301         return -1;
302     }
303
304     /* Send data.*/
305     s_debugConsole.ops.tx_union.Send(s_debugConsole.base, (uint8_t const *)buf,
306     nbytes);
307     return nbytes;
308 }
309
310 int _READ(int fd, void *buf, size_t nbytes)
311 {
312
313     /* Do nothing if the debug uart is not initialized.*/
314     if (s_debugConsole.type == kDebugConsoleNone)
315     {
316         return -1;
317     }
318
319     /* Receive data.*/
320     s_debugConsole.ops.rx_union.Receive(s_debugConsole.base, buf, nbytes);
321     return nbytes;
322 }
323 #elif __ICCARM__
324
325 #pragma weak __write
326 size_t __write(int handle, const unsigned char * buffer, size_t size)
327 {
328     if (buffer == 0)
329     {
330         /* This means that we should flush internal buffers. Since we*/
331         /* don't we just return. (Remember, "handle" == -1 means that all*/
332         /* handles should be flushed.*/
333         return 0;
334     }
335

```



```

336     /* This function only writes to "standard out" and "standard err",*/
337     /* for all other file handles it returns failure.*/
338     if ((handle != _LLIO_STDOUT) && (handle != _LLIO_STDERR))
339     {
340         return _LLIO_ERROR;
341     }
342
343     /* Do nothing if the debug uart is not initialized.*/
344     if (s_debugConsole.type == kDebugConsoleNone)
345     {
346         return _LLIO_ERROR;
347     }
348
349     /* Send data.*/
350     s_debugConsole.ops.tx_union.Send(s_debugConsole.base, (uint8_t const *)buffer,
351     size);
352     return size;
353 }
354 #pragma weak __read
355 size_t __read(int handle, unsigned char * buffer, size_t size)
356 {
357     /* This function only reads from "standard in", for all other file*/
358     /* handles it returns failure.*/
359     if (handle != _LLIO_STDIN)
360     {
361         return _LLIO_ERROR;
362     }
363
364     /* Do nothing if the debug uart is not initialized.*/
365     if (s_debugConsole.type == kDebugConsoleNone)
366     {
367         return _LLIO_ERROR;
368     }
369
370     /* Receive data.*/
371     s_debugConsole.ops.rx_union.Receive(s_debugConsole.base, buffer, size);
372
373     return size;
374 }
375
376 #elif (defined(__GNUC__))
377 #pragma weak _write
378 int _write (int handle, char *buffer, int size)

```

```

379 {
380     if (buffer == 0)
381     {
382         /* return -1 if error */
383         return -1;
384     }
385
386     /* This function only writes to "standard out" and "standard err",*/
387     /* for all other file handles it returns failure.*/
388     if ((handle != 1) && (handle != 2))
389     {
390         return -1;
391     }
392
393     /* Do nothing if the debug uart is not initialized.*/
394     if (s_debugConsole.type == kDebugConsoleNone)
395     {
396         return -1;
397     }
398
399     /* Send data.*/
400     s_debugConsole.ops.tx_union.Send(s_debugConsole.base, (uint8_t *)buffer, size);
401     return size;
402 }
403
404 #pragma weak _read
405 int _read(int handle, char *buffer, int size)
406 {
407     /* This function only reads from "standard in", for all other file*/
408     /* handles it returns failure.*/
409     if (handle != 0)
410     {
411         return -1;
412     }
413
414     /* Do nothing if the debug uart is not initialized.*/
415     if (s_debugConsole.type == kDebugConsoleNone)
416     {
417         return -1;
418     }
419
420     /* Receive data.*/
421     s_debugConsole.ops.rx_union.Receive(s_debugConsole.base, (uint8_t *)buffer, size);
422     return size;

```

```

423 }
424 #elif defined(__CC_ARM) && !defined(MQX_STUDIO)
425 struct __FILE
426 {
427     int handle;
428     /* Whatever you require here. If the only file you are using is */
429     /* standard output using printf() for debugging, no file handling */
430     /* is required. */
431 };
432
433 /* FILE is typedef in stdio.h. */
434 #pragma weak __stdout
435 FILE __stdout;
436 FILE __stdin;
437
438 #pragma weak fputc
439 int fputc(int ch, FILE *f)
440 {
441     /* Do nothing if the debug uart is not initialized.*/
442     if (s_debugConsole.type == kDebugConsoleNone)
443     {
444         return -1;
445     }
446
447     /* Send data.*/
448     s_debugConsole.ops.tx_union.Send(s_debugConsole.base, (const uint8_t*)&ch, 1);
449     return 1;
450 }
451
452 #pragma weak fgetc
453 int fgetc(FILE *f)
454 {
455     uint8_t temp;
456     /* Do nothing if the debug uart is not initialized.*/
457     if (s_debugConsole.type == kDebugConsoleNone)
458     {
459         return -1;
460     }
461
462     /* Receive data.*/
463     s_debugConsole.ops.rx_union.Receive(s_debugConsole.base, &temp, 1);
464     return temp;
465 }
466

```

```

467 #endif
468
469 /*****Code for debug_printf/scanf/assert*****/
470 int debug_printf(const char *fmt_s, ...)
471 {
472     va_list ap;
473     int result;
474     /* Do nothing if the debug uart is not initialized.*/
475     if (s_debugConsole.type == kDebugConsoleNone)
476     {
477         return -1;
478     }
479     va_start(ap, fmt_s);
480     result = _doprint(NULL, debug_putc, -1, (char *)fmt_s, ap);
481     va_end(ap);
482
483     return result;
484 }
485
486 static int debug_putc(int ch, void* stream)
487 {
488     const unsigned char c = (unsigned char) ch;
489     /* Do nothing if the debug uart is not initialized.*/
490     if (s_debugConsole.type == kDebugConsoleNone)
491     {
492         return -1;
493     }
494     s_debugConsole.ops.tx_union.Send(s_debugConsole.base, &c, 1);
495
496     return 0;
497 }
498
499
500 int debug_putchar(int ch)
501 {
502     /* Do nothing if the debug uart is not initialized.*/
503     if (s_debugConsole.type == kDebugConsoleNone)
504     {
505         return -1;
506     }
507     debug_putc(ch, NULL);
508
509     return 1;
510 }

```

```

511
512 int debug_scanf(const char *fmt_ptr, ...)
513 {
514     char    temp_buf[IO_MAXLINE];
515     va_list ap;
516     uint32_t i;
517     char result;
518
519     /* Do nothing if the debug uart is not initialized.*/
520     if (s_debugConsole.type == kDebugConsoleNone)
521     {
522         return -1;
523     }
524     va_start(ap, fmt_ptr);
525     temp_buf[0] = '\0';
526
527     for (i = 0; i < IO_MAXLINE; i++)
528     {
529         temp_buf[i] = result = debug_getchar();
530
531         if ((result == '\r') || (result == '\n'))
532         {
533             /* End of Line */
534             if (i == 0)
535             {
536                 i = (uint32_t)-1;
537             }
538             else
539             {
540                 break;
541             }
542         }
543
544         temp_buf[i + 1] = '\0';
545     }
546
547     result = scan_prv(temp_buf, (char *)fmt_ptr, ap);
548     va_end(ap);
549
550     return result;
551 }
552
553 int debug_getchar(void)
554 {

```

```

555     unsigned char c;
556
557     /* Do nothing if the debug uart is not initialized.*/
558     if (s_debugConsole.type == kDebugConsoleNone)
559     {
560         return -1;
561     }
562     s_debugConsole.ops.rx_union.Receive(s_debugConsole.base, &c, 1);
563
564     return c;
565 }
566 /*****
567  * EOF
568  *****/

```

7.8 ../Sources/GPIO/gpio_hal.h

```
1  /* ***** */
2  /* File name:      gpio_hal.h */
3  /* File description: This file has a couple of useful macros to */
4  /*                control and init the GPIO pins from the KLM25Z */
5  /* Author name:    ddello */
6  /* Creation date:   01abr2016 */
7  /* Revision date:   13abr2016 */
8  /* ***** */
9
10 #ifndef SOURCES_GPIO_GPIO_HAL_H_
11 #define SOURCES_GPIO_GPIO_HAL_H_
12
13 #include "KL25Z/es670_peripheral_board.h"
14
15 /**
16  * Ungates the clock for a gpio port
17  * @param PORT_ID the GPIO port id(A,B)
18  */
19 #define GPIO_UNGATE_PORT(PORT_ID)\
20     _GPIO_UNGATE_PORT(PORT_ID)
21
22 //Wrapper macro above is needed for argument expansion when using concatenation
23 #define _GPIO_UNGATE_PORT(PORT_ID)\
24     /* un-gate port clock*/\
25     SIM_SCGC5 |= SIM_SCGC5_PORT ## PORT_ID (CGC_CLOCK_ENABLED)
26
27 /**
28  * inits a pin as GPIO in the given direction
29  * @param PORT_ID the GPIO port id(A,B)
30  * @param PIN_NUM pin number in port
31  * @param DIR pin direction (GPIO_HIGH, GPIO_LOW)
32  */
33 #define GPIO_INIT_PIN(PORT_ID, PIN_NUM, DIR)\
34     _GPIO_INIT_PIN(PORT_ID, PIN_NUM, DIR)
35
36 //Wrapper macro above is needed for argument expansion when using concatenation
37 #define _GPIO_INIT_PIN(PORT_ID, PIN_NUM, DIR)\
38     /* set pin as gpio */\
39     PORT_PCR_REG(PORT ## PORT_ID , PIN_NUM) = PORT_PCR_MUX(GPIO_MUX_ALT);\
40     /* Set pin direction */\
41     if(DIR == GPIO_OUTPUT){\
42         GPIO ## PORT_ID ## _PDDR |= GPIO_PDDR_PDD(0x01 << PIN_NUM);\
```

```

43     }else{\
44         GPIO ## PORT_ID ## _PDDR &= ~GPIO_PDDR_PDD(0x01 << PIN_NUM);\
45     }
46
47
48 /**
49  * Writes a pin with the given value
50  * @param PORT_ID the GPIO port id(A,B)
51  * @param PIN_NUM pin number in port
52  * @param VAL pin value (GPIO_HIGH, GPIO_LOW)
53  */
54 #define GPIO_WRITE_PIN(PORT_ID, PIN_NUM, VAL)\
55     _GPIO_WRITE_PIN(PORT_ID, PIN_NUM, VAL)
56
57 //Wrapper macro above is needed for argument expansion when using concatenation
58 #define _GPIO_WRITE_PIN(PORT_ID, PIN_NUM, VAL)\
59     if(VAL == GPIO_HIGH){\
60         GPIO ## PORT_ID ## _PSOR = GPIO_PSOR_PTSO( (0x01U << PIN_NUM) );\
61     }else{\
62         GPIO ## PORT_ID ## _PCOR = GPIO_PCOR_PTCO( (0x01U << PIN_NUM) );\
63     }
64
65 /**
66  * Writes the given value to the pins given in the MASK
67  * @param PORT_ID the GPIO port id(A,B)
68  * @param MASK 31 bit Mask with 1 in the bits corresponding to the pins of interest.
69  * @param VAL pins value (GPIO_HIGH, GPIO_LOW)
70  */
71 #define GPIO_WRITE_MASK(PORT_ID, MASK, VAL)\
72     _GPIO_WRITE_MASK(PORT_ID, MASK, VAL)
73
74 #define _GPIO_WRITE_MASK(PORT_ID, MASK, VAL)\
75     if(VAL == GPIO_HIGH){\
76         GPIO ## PORT_ID ## _PSOR = GPIO_PSOR_PTSO(MASK);\
77     }else{\
78         GPIO ## PORT_ID ## _PCOR = GPIO_PCOR_PTCO(MASK);\
79     }
80
81
82 /**
83  * Reads the status of a GPIO PIN
84  * @param PORT_ID the GPIO port id(A,B)
85  * @param PIN_NUM pin number in port
86  * @param VAL pin value (GPIO_HIGH, GPIO_LOW)

```



```

87  */
88  #define GPIO_READ_PIN(PORT_ID, PIN_NUM)\
89      _GPIO_READ_PIN(PORT_ID, PIN_NUM)
90
91  //Wrapper macro above is needed for argument expansion when using concatenation
92  #define _GPIO_READ_PIN(PORT_ID, PIN_NUM)\
93      ( ((GPIO ## PORT_ID ## _PDIR & (0x01u << PIN_NUM)) >> PIN_NUM) )
94
95  /**
96   * Reads the driven status of a output GPIO PIN
97   * @param PORT_ID the GPIO port id(A,B)
98   * @param PIN_NUM pin number in port
99   * @param VAL pin value (GPIO_HIGH, GPIO_LOW)
100  */
101  #define GPIO_GET_OUTPUT_STATE(PORT_ID, PIN_NUM)\
102      _GPIO_GET_OUTPUT_STATE(PORT_ID, PIN_NUM)
103
104  //Wrapper macro above is needed for argument expansion when using concatenation
105  #define _GPIO_GET_OUTPUT_STATE(PORT_ID, PIN_NUM)\
106      ( ((GPIO ## PORT_ID ## _PDOR & (0x01u << PIN_NUM)) >> PIN_NUM) )
107
108  #endif /* SOURCES_GPIO_GPIO_HAL_H_ */

```

7.9 ../Sources/Heater/heater_hal.c

```
1  /* ***** */
2  /* File name:      heater_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                for heater control */
5  /* Author name:    ddello */
6  /* Creation date:   14jun2016 */
7  /* Revision date:   14jun2016 */
8  /* ***** */
9
10 #include "heater_hal.h"
11 #include "KL25Z/es670_peripheral_board.h"
12 #include "GPIO/gpio_hal.h"
13
14 /**
15  * Initialize the heater module
16  */
17 void heater_initHeater(void){
18     /* Init HEATER pin */
19     SIM_SCGC5 |= SIM_SCGC5_PORTA(1u);
20     PORT_PCR_REG(HEATER_PORT_BASE_PNT , HEATER_PIN) = PORT_PCR_MUX(HEATER_PIN_MUX_ALT);
21
22     /* INIT TPM */
23     //Init TPM Clock source as OSCERCLOCK
24     SIM_WR_SOPT2_TPMSRC(SIM,0x2);
25     //Enable clock to TPM1
26     SIM_SCGC6 |= SIM_SCGC6_TPM1(0x1);
27     //PWM mode
28     TPM_WR_SC_CPWMS(HEATER_TPM_BASE_PNT, 0x0); //Edge Aligned
29     /* Channel mode configuration should be done with the channel disabled and need
30        acknowledge*/
31     TPM_WR_CnSC(HEATER_TPM_BASE_PNT , HEATER_TPM_CHANNEL_INDEX , TPM_CnSC_ELSB(1) |
32                TPM_CnSC_MSB(1));
33     /* Wait till mode change is acknowledged */
34     while (!
35         (
36             TPM_RD_CnSC(HEATER_TPM_BASE_PNT , HEATER_TPM_CHANNEL_INDEX)
37             & (TPM_CnSC_ELSB(1) | TPM_CnSC_MSB(1))
38         )
39     );
40     //Same period as OSCRCCLK
41     TPM_WR_MOD(HEATER_TPM_BASE_PNT , 0xFFFE);
42     //Duty cycle
```

```

41     TPM_WR_CnV_VAL(HEATER_TPM_BASE_PNT, HEATER_TPM_CHANNEL_INDEX, 0);
42     //Prescale 1:1
43     TPM_WR_SC_PS(HEATER_TPM_BASE_PNT, 0x0);
44     //Select LTPM Clock Source for TPM module
45     TPM_WR_SC_CMOD(HEATER_TPM_BASE_PNT, 0x1);
46 }
47
48
49 /**
50  * Set the heater intensity
51  *
52  * @param uiIntensity heater intensity from 0 (stopped) to 0xFFFF (max)
53  */
54 void heater_setIntensity(uint16_t uiIntensity){
55     TPM_WR_CnV_VAL(HEATER_TPM_BASE_PNT, HEATER_TPM_CHANNEL_INDEX, uiIntensity);
56 }

```

7.10 ../Sources/Heater/heater_hal.h

```
1  /* ***** */
2  /* File name:      heater_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for heater control */
5  /* Author name:     ddello */
6  /* Creation date:    14jun2016 */
7  /* Revision date:    14jun2016 */
8  /* ***** */
9
10 #ifndef SOURCES_HEATER_HAL_H_
11 #define SOURCES_HEATER_HAL_H_
12
13 #include <stdint.h>
14
15 /**
16  * Initialize the heater module
17  */
18 void heater_initHeater(void);
19
20
21 /**
22  * Set the heater intensity
23  *
24  * @param uiIntensity heater intensity from 0 (stopped) to 0xFFFF (max)
25  */
26 void heater_setIntensity(uint16_t uiIntensity);
27
28 #endif /* SOURCES_HEATER_HAL_H_ */
```

7.11 ../Sources/KL25Z/es670_peripheral_board.h

```
1  /* ***** */
2  /* File name:      es670_peripheral_board.h      */
3  /* File description: Header file containing the peripherals mapping */
4  /*                of the peripheral board for the ES670 hardware*/
5  /* Author name:    dloubach                      */
6  /* Creation date:   16out2015                     */
7  /* Revision date:   25fev2016                     */
8  /* ***** */
9
10 #ifndef SOURCES_ES670_PERIPHERAL_BOARD_H_
11 #define SOURCES_ES670_PERIPHERAL_BOARD_H_
12
13 /* system includes */
14 #include <MKL25Z4.h>
15 #include "MKL25Z4_extension.h"
16
17 /*                General uC definitions                */
18
19 /* Clock gate control */
20 #define CGC_CLOCK_DISABLED      0x00U
21 #define CGC_CLOCK_ENABLED      0x01U
22
23 /* GPIO input / output */
24 #define GPIO_INPUT              0x00U
25 #define GPIO_OUTPUT            0x01U
26
27 #define GPIO_MUX_ALT            0x01u
28
29 #define GPIO_HIGH              1
30 #define GPIO_LOW               0
31
32 /* Workaround for PORT_ID macro expansion to stop at port level*/
33 typedef int A;
34 typedef int B;
35 typedef int C;
36 typedef int D;
37 typedef int E;
38
39 /*                END OF General uC definitions                */
40
41
42 /*                BUZZER Definitions                */
```

```

43 #define BUZZER_PORT_BASE_PNT      PORTD                      /*
    peripheral port base pointer */
44 #define BUZZER_GPIO_BASE_PNT      PTD                        /*
    peripheral gpio base pointer */
45 #define BUZZER_PORT_ID            D                          /* peripheral
    port identifier*/
46
47 #define BUZZER_PIT_TIMER_NUMB      1
48
49 #define BUZZER_PIN                  0                        /* buzzer
    pin */
50 #define BUZZER_DIR                  kGpioDigitalOutput
51 #define BUZZER_ALT                  0x01u
52 /*                                END OF BUZZER definitions          */
53
54
55 /*                                LED and SWITCH Definitions          */
56 #define LS_PORT_BASE_PNT            PORTA                      /*
    peripheral port base pointer */
57 #define LS_PORT_ID                  A                          /*
    peripheral port identifier*/
58 #define LS_GPIO_BASE_PNT            PTA                        /*
    peripheral gpio base pointer */
59
60 /* THIS PIN CONFLICTS WITH PTA1 USED AS UART0_RX IN THE OPENSDA SERIAL DEBUG PORT */
61 #define LS1_PIN                      1                        /*
    led/switch #1 pin */
62 #define LS1_DIR_OUTPUT              (GPIO_OUTPUT << LS1_PIN)
63 #define LS1_DIR_INPUT              (GPIO_OUTPUT << LS1_PIN)
64 #define LS1_ALT                      0x01u                    /* GPIO
    alternative */
65
66 /* THIS PIN CONFLICTS WITH PTA2 USED AS UART0_TX IN THE OPENSDA SERIAL DEBUG PORT */
67 #define LS2_PIN                      2                        /*
    led/switch #2 pin */
68 #define LS2_DIR_OUTPUT              (GPIO_OUTPUT << LS2_PIN)
69 #define LS2_DIR_INPUT              (GPIO_OUTPUT << LS2_PIN)
70 #define LS2_ALT                      LS1_ALT
71
72 #define LS3_PIN                      4                        /*
    led/switch #3 pin */
73 #define LS3_DIR_OUTPUT              (GPIO_OUTPUT << LS3_PIN)
74 #define LS3_DIR_INPUT              (GPIO_OUTPUT << LS3_PIN)
75 #define LS3_ALT                      LS1_ALT

```

```

76
77 #define LS4_PIN 5 /*
    led/switch #4 pin */
78 #define LS4_DIR_OUTPUT (GPIO_OUTPUT << LS4_PIN)
79 #define LS4_DIR_INPUT (GPIO_OUTPUT << LS4_PIN)
80 #define LS4_ALT LS1_ALT
81
82 /*          END OF LED and SWITCH definitions          */
83
84 /*          SEVEN SEGMENT DISPLAY Definitions          */
85 #define SEV_SEG_PORT_BASE_PNT PORTC /*
    peripheral port base pointer */
86 #define SEV_SEG_PORT_ID C /*
    peripheral port identifier*/
87 #define SEV_SEG_GPIO_BASE_PNT PTC /*
    peripheral gpio base pointer */
88
89 #define SEV_SEG_PIT_TIMER_NUMB 0 /* timer number for seven seg
    PIT */
90
91 #define SEGA_PIN 0 /* Segment
    A*/
92 #define SEGA_DIR_OUTPUT (GPIO_OUTPUT << SEGA_PIN)
93 #define SEGA_ALT 0x01u /* GPIO
    alternative */
94
95 #define SEGB_PIN 1
96 #define SEGB_DIR_OUTPUT (GPIO_OUTPUT << SEGB_PIN)
97 #define SEGB_ALT SEGA_ALT
98
99 #define SEGC_PIN 2
100 #define SEGC_DIR_OUTPUT (GPIO_OUTPUT << SEGC_PIN)
101 #define SEGC_ALT SEGA_ALT
102
103 #define SEGD_PIN 3
104 #define SEGD_DIR_OUTPUT (GPIO_OUTPUT << SEGD_PIN)
105 #define SEGD_ALT SEGA_ALT
106
107 #define SEGE_PIN 4
108 #define SEGE_DIR_OUTPUT (GPIO_OUTPUT << SEGE_PIN)
109 #define SEGE_ALT SEGA_ALT
110
111 #define SEGF_PIN 5
112 #define SEGF_DIR_OUTPUT (GPIO_OUTPUT << SEGF_PIN)

```

```

113 #define SEGF_ALT                SEGA_ALT
114
115 #define SEGG_PIN                6
116 #define SEGG_DIR_OUTPUT        (GPIO_OUTPUT << SEGG_PIN)
117 #define SEGG_ALT                SEGA_ALT
118
119 #define SEGDP_PIN                7
120 #define SEGDP_DIR_OUTPUT        (GPIO_OUTPUT << SEGDP_PIN)
121 #define SEGDP_ALT                SEGA_ALT
122
123 #define SEG_DISP1_PIN            13
124 #define SEG_DISP1_DIR_OUTPUT    (GPIO_OUTPUT << SEG_DISP1_PIN)
125 #define SEG_DISP1_ALT            SEGA_ALT
126
127 #define SEG_DISP2_PIN            12
128 #define SEG_DISP2_DIR_OUTPUT    (GPIO_OUTPUT << SEG_DISP2_PIN)
129 #define SEG_DISP2_ALT            SEGA_ALT
130
131 #define SEG_DISP3_PIN            11
132 #define SEG_DISP3_DIR_OUTPUT    (GPIO_OUTPUT << SEG_DISP3_PIN)
133 #define SEG_DISP3_ALT            SEGA_ALT
134
135 #define SEG_DISP4_PIN            10
136 #define SEG_DISP4_DIR_OUTPUT    (GPIO_OUTPUT << SEG_DISP4_PIN)
137 #define SEG_DISP4_ALT            SEGA_ALT
138
139 /*                END of SEVEN SEGMENT DISPLAY Definitions                */
140
141
142 /*                END OF General uC definitions                */
143
144
145 /*                LCD definitions                */
146
147 /* LCD Register Selector
148  * Used as register selector input
149  * When (LCD_RS = LCD_RS_HIGH) => DATA register is selected
150  * When (LCD_RS = LCD_RS_LOW)  => INSTRUCTION register is selected
151  */
152 #define LCD_PORT_BASE_PNT        PORTC                /*
153     peripheral port base pointer */
154 #define LCD_PORT_ID              C
155 #define LCD_GPIO_BASE_PNT        PTC                /*
156     peripheral gpio base pointer */

```



```

155
156 #define LCD_RS_PIN 8 /* register
    selector */
157 #define LCD_RS_DIR GPIO_OUTPUT
158
159 #define LCD_ENABLE_PIN 9 /* enable
    pin */
160 #define LCD_ENABLE_DIR GPIO_OUTPUT
161
162 #define LCD_RS_HIGH GPIO_HIGH
163 #define LCD_RS_DATA LCD_RS_HIGH
164
165 #define LCD_RS_LOW GPIO_LOW
166 #define LCD_RS_CMD LCD_RS_LOW
167
168 #define LCD_ENABLED 1U
169 #define LCD_DISABLED 0U
170
171 #define LCD_DATA_DIR GPIO_OUTPUT /* LCD data pins
    */
172
173 #define LCD_DATA_DB0_PIN 0
174 #define LCD_DATA_DB1_PIN 1
175 #define LCD_DATA_DB2_PIN 2
176 #define LCD_DATA_DB3_PIN 3
177 #define LCD_DATA_DB4_PIN 4
178 #define LCD_DATA_DB5_PIN 5
179 #define LCD_DATA_DB6_PIN 6
180 #define LCD_DATA_DB7_PIN 7
181 /* END OF LCD definitions */
182
183 /* COOLER DEFINITIONS */
184 #define COOLER_PORT_ID A
185 #define COOLER_PORT_BASE_PNT PORTA
186 #define COOLER_PIN 13
187 #define COOLER_PIN_MUX_ALT 0x3
188
189 #define COOLER_TPM_BASE_PNT TPM1
190 #define COOLER_TPM_CHANNEL_INDEX 1
191
192
193 /* END OF COOLER DEFINITIONS */
194
195 /* HEATER DEFINITIONS */

```

```

196 #define HEATER_PORT_ID          A
197 #define HEATER_PORT_BASE_PNT    PORTA
198 #define HEATER_PIN              12
199 #define HEATER_PIN_MUX_ALT      0x3
200
201 #define HEATER_TPM_BASE_PNT      TPM1
202 #define HEATER_TPM_CHANNEL_INDEX 0
203
204
205 /*          END OF HEATER DEFINITIONS          */
206
207 /*          TACOMETER DEFINITIONS          */
208 #define TACOMETRO_PORT_ID        E
209 #define TACOMETRO_PORT_BASE_PNT  PORTE
210 #define TACOMETRO_PIN            29
211 #define TACOMETRO_PIN_ALT        0x4    /*ALT4 FTM_CLOCKINO*/
212
213 #define TACOMETRO_TPM_BASE        TPM0
214
215 /*          END OF TACOMETER DEFINITIONS          */
216
217 /*          ADC DEFINITIONS          */
218 #define ADC_PORT_ID              E
219 #define ADC_PORT_BASE_PNT        PORTE
220 #define ADC_NUM_BASE_PNT         ADC0_BASE_PTR
221 #define ADC_MUX_IDX              0    //MUX A
222 #define ADC_CHANNEL_SEL          0x4
223 #define ADC_TEMP_PIN             21
224 #define ADC_VOLT_PIN             20
225 #define ADC_TEMP_PIN_MUX_ALT     0x0
226 #define ADC_VOLT_PIN_MUX_ALT     0x0
227
228 #define HEATER_TPM_BASE_PNT      TPM1
229 #define HEATER_TPM_CHANNEL_INDEX 0
230
231
232 /*          END OF ADC DEFINITIONS          */
233
234
235 #endif /* SOURCES_ES670_PERIPHERAL_BOARD_H_ */

```

7.12 ../Sources/LCD/lcd_hal.c

```
1  /* ***** */
2  /* File name:      lcd_hal.c */
3  /* File description: File dedicated to the hardware abstraction layer*/
4  /*                related to the LCD HARDWARE based on the KS006U */
5  /*                controller */
6  /* Author name:    dloubach */
7  /* Creation date:   16out2015 */
8  /* Revision date:   13mai2016 */
9  /* ***** */
10
11 #include "lcd_hal.h"
12 #include "KL25Z/es670_peripheral_board.h"
13 #include "Util/util.h"
14 #include "GPIO/gpio_hal.h"
15
16 /* line and columns */
17 #define LINE0      0U
18 #define COLUMN0    0U
19
20 #define LOCO_BASE   0x80 /* line 0, column 0 */
21 #define L1CO_BASE   0xC0 /* line 1, column 0 */
22 #define MAX_COLUMN  15U
23
24 /**
25  * Initialize the LCD function
26  */
27 void lcd_initLcd(void)
28 {
29     /* pins configured as outputs */
30
31     /* un-gate port clock*/
32     GPIO_UNGATE_PORT(LCD_PORT_ID);
33
34     /* set pin as gpio output*/
35     GPIO_INIT_PIN(LCD_PORT_ID, LCD_RS_PIN, LCD_RS_DIR);
36     GPIO_INIT_PIN(LCD_PORT_ID, LCD_ENABLE_PIN, LCD_ENABLE_DIR);
37     GPIO_INIT_PIN(LCD_PORT_ID, LCD_DATA_DB0_PIN, LCD_DATA_DIR);
38     GPIO_INIT_PIN(LCD_PORT_ID, LCD_DATA_DB1_PIN, LCD_DATA_DIR);
39     GPIO_INIT_PIN(LCD_PORT_ID, LCD_DATA_DB2_PIN, LCD_DATA_DIR);
40     GPIO_INIT_PIN(LCD_PORT_ID, LCD_DATA_DB3_PIN, LCD_DATA_DIR);
41     GPIO_INIT_PIN(LCD_PORT_ID, LCD_DATA_DB4_PIN, LCD_DATA_DIR);
42     GPIO_INIT_PIN(LCD_PORT_ID, LCD_DATA_DB5_PIN, LCD_DATA_DIR);
```

```

43     GPIO_INIT_PIN(LCD_PORT_ID , LCD_DATA_DB6_PIN, LCD_DATA_DIR);
44     GPIO_INIT_PIN(LCD_PORT_ID , LCD_DATA_DB7_PIN, LCD_DATA_DIR);
45
46     // turn-on LCD, with no cursor and no blink
47     lcd_sendCommand(CMD_NO_CUR_NO_BLINK);
48
49     // init LCD
50     lcd_sendCommand(CMD_INIT_LCD);
51
52     // clear LCD
53     lcd_sendCommand(CMD_CLEAR);
54
55     // LCD with no cursor
56     lcd_sendCommand(CMD_NO_CURSOR);
57
58     // cursor shift to right
59     lcd_sendCommand(CMD_CURSOR2R);
60
61 }
62
63
64
65 /**
66  * Send command or data to LCD
67  * @param ucBuffer Char to be send
68  * @param cDataType Command LCD_RS_CMD or data LCD_RS_DATA
69  */
70 void lcd_write2Lcd(unsigned char ucBuffer, unsigned char cDataType)
71 {
72     /* writing data or command */
73     if(LCD_RS_CMD == cDataType){
74         /* will send a command */
75         GPIO_WRITE_PIN(LCD_PORT_ID, LCD_RS_PIN, LCD_RS_CMD);
76     } else{
77         /* will send data */
78         GPIO_WRITE_PIN(LCD_PORT_ID, LCD_RS_PIN, LCD_RS_DATA);
79     }
80
81     /* write in the LCD bus */
82     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB0_PIN, ((ucBuffer & (1u << 0u)) >> 0u));
83     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB1_PIN, ((ucBuffer & (1u << 1u)) >> 1u));
84     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB2_PIN, ((ucBuffer & (1u << 2u)) >> 2u));
85     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB3_PIN, ((ucBuffer & (1u << 3u)) >> 3u));
86     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB4_PIN, ((ucBuffer & (1u << 4u)) >> 4u));

```

```

87     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB5_PIN, ((ucBuffer & (1u << 5u)) >> 5u));
88     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB6_PIN, ((ucBuffer & (1u << 6u)) >> 6u));
89     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_DATA_DB7_PIN, ((ucBuffer & (1u << 7u)) >> 7u));
90
91     pit_mask_interrupts();
92     /* enable, delay, disable LCD */
93     /* this generates a pulse in the enable pin */
94     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_ENABLE_PIN, LCD_ENABLED);
95     util_genDelay1ms();
96     GPIO_WRITE_PIN(LCD_PORT_ID, LCD_ENABLE_PIN, LCD_DISABLED);
97     util_genDelay1ms();
98     util_genDelay1ms();
99     pit_unmask_interrupts();
100 }
101
102
103
104 /**
105  * Write data to be displayed
106  * @param ucData Char to be written
107  */
108 void lcd_writeData(unsigned char ucData)
109 {
110     /* just a relay to send data */
111     lcd_write2Lcd(ucData, LCD_RS_DATA);
112 }
113
114
115
116 /**
117  * Write command to LCD
118  * @param ucCmd Command to be executed
119  */
120 void lcd_sendCommand(unsigned char ucCmd)
121 {
122     /* just a relay to send command */
123     lcd_write2Lcd(ucCmd, LCD_RS_CMD);
124 }
125
126
127
128 /**
129  * Set cursor line and column
130  * @param cLine = LINE0..LINE1

```

```

131  * @param cColumn = COLUMN0..MAX_COLUMN
132  */
133 void lcd_setCursor(unsigned char cLine, unsigned char cColumn)
134 {
135     char cCommand;
136
137     if(LINE0 == cLine)
138         /* line 0 */
139         cCommand = LOC0_BASE;
140     else
141         /* line 1 */
142         cCommand = L1C0_BASE;
143
144     /* maximum MAX_COLUMN columns */
145     cCommand += (cColumn & MAX_COLUMN);
146
147     // send the command to set the cursor
148     lcd_sendCommand(cCommand);
149 }
150
151
152
153 /**
154  * Write string to be displayed
155  * @param cBuffer String to be written in LCD
156  */
157 void lcd_writeString(const char *cBuffer)
158 {
159     while(*cBuffer)
160     {
161         lcd_writeData(*cBuffer++);
162     };
163 }
164
165 /**
166  * Print string to the display, clears display and handles cursor
167  * @param cBuffer String to be written in LCD
168  */
169 void lcd_printString(const char *cBuffer)
170 {
171     // clear LCD
172     lcd_sendCommand(CMD_CLEAR);
173
174     // set the cursor line 0, column 1

```

```

175     lcd_setCursor(0,1);
176     unsigned int uiCursorCollum = 0;
177     while(*cBuffer)
178     {
179         lcd_writeData(*cBuffer++);
180         if(++uiCursorCollum == MAX_COLUMN){
181             lcd_setCursor(1,0);
182             uiCursorCollum = 0;
183         }
184     };
185 }
186
187
188 /**
189  * Write a dummy hard coded text
190  */
191 void lcd_dummyText(void)
192 {
193     // clear LCD
194     lcd_sendCommand(CMD_CLEAR);
195
196     // set the cursor line 0, column 1
197     lcd_setCursor(0,1);
198
199     // send string
200     lcd_writeString("*** ES670 ***");
201
202     // set the cursor line 1, column 0
203     lcd_setCursor(1,0);
204     lcd_writeString("Prj Sis Embarcad");
205 }

```

7.13 ../Sources/LCD/lcd_hal.h

```
1  /* ***** */
2  /* File name:      lcd_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for handling the LCD hardware from */
5  /*                the hardware kit */
6  /* Author name:     dloubach */
7  /* Creation date:    16out2015 */
8  /* Revision date:    13mai2016 */
9  /* ***** */
10
11 #ifndef SOURCES_LCD_HAL_H_
12 #define SOURCES_LCD_HAL_H_
13
14 /* lcd basic commands list */
15 #define CMD_INIT_LCD      0x0F
16 #define CMD_CLEAR         0x01
17 #define CMD_NO_CURSOR     0x0C
18 #define CMD_CURSOR2R      0x06 /* cursor to right */
19 #define CMD_NO_CUR_NO_BLINK 0x38 /* no cursor, no blink */
20
21
22 /**
23  * Initialize the LCD function
24  */
25 void lcd_initLcd(void);
26
27
28 /**
29  * Send command or data to LCD
30  * @param ucBuffer Char to be send
31  * @param cDataType Command LCD_RS_CMD or data LCD_RS_DATA
32  */
33 void lcd_writeData(unsigned char ucData);
34
35
36 /**
37  * Write command to LCD
38  * @param ucCmd Command to be executed
39  */
40 void lcd_sendCommand(unsigned char ucCmd);
41
42
```



```

43 /**
44  * Write string to be displayed
45  * @param cBuffer String to be written in LCD
46  */
47 void lcd_writeString(const char *cBuffer);
48
49 /**
50  * Print string to the display, clears display and handles cursor
51  * @param cBuffer String to be written in LCD
52  */
53 void lcd_printString(const char *cBuffer);
54
55 /**
56  * Set cursor line and column
57  * @param cLine = LINE0..LINE1
58  * @param cColumn = COLUMN0..MAX_COLUMN
59  */
60 void lcd_setCursor(unsigned char cLine, unsigned char cColumn);
61
62
63 /**
64  * Write a dummy hard coded text
65  */
66 void lcd_dummyText(void);
67
68
69 #endif /* SOURCES_LCD_HAL_H_ */

```

7.14 ../Sources/LedSwi/ledswi_hal.c

```
1  /* ***** */
2  /* File name:      ledswi_hal.c */
3  /* File description: This file has a couple of useful functions to */
4  /*                control LEDs and Switches from peripheral board */
5  /* Author name:    dloubach */
6  /* Creation date:   20jan2015 */
7  /* Revision date:   13abr2016 */
8  /* ***** */
9
10 #include "ledswi_hal.h"
11 #include "GPIO/gpio_hal.h"
12
13 #define USING_OPENSDA_DEBUG
14
15 /**
16  * As the hardware board was designed with LEDs/Switches sharing
17  * the same pins, this method configures how many LEDS and switches
18  * will be available for the application
19  * @param cLedNum num of LEDs
20  * @param cSwitchNum num of Switches (cLedNum + cSwitchNum <= MAX_LED_SWI)
21  */
22 void ledswi_initLedSwitch(char cLedNum, char cSwitchNum)
23 {
24     /* un-gate port clock*/
25     SIM_SCGC5 |= SIM_SCGC5_PORTA(CGC_CLOCK_ENABLED);
26
27     /* set pin as gpio */
28 #ifndef USING_OPENSDA_DEBUG
29     PORTA_PCR1 = PORT_PCR_MUX(LS1_ALT);
30     PORTA_PCR2 = PORT_PCR_MUX(LS2_ALT);
31 #endif
32     PORTA_PCR4 = PORT_PCR_MUX(LS3_ALT);
33     PORTA_PCR5 = PORT_PCR_MUX(LS4_ALT);
34
35
36     /* check if the number to configured is according to
37     hardware dev kit */
38     if((cLedNum + cSwitchNum) <= MAX_LED_SWI)
39     {
40         /* max number of peripherals to configure is ok, carry on */
41         switch(cSwitchNum)
42         {
```

```

43         case 0:
44             /* no switches in system configuration */
45             /* all leds */
46             GPIOA_PDDR |= GPIO_PDDR_PDD(LS1_DIR_OUTPUT | LS2_DIR_OUTPUT |
LS3_DIR_OUTPUT | LS4_DIR_OUTPUT);
47             break;
48
49         case 1:
50             /* just 1 switch */
51             GPIOA_PDDR |= GPIO_PDDR_PDD(LS2_DIR_OUTPUT | LS3_DIR_OUTPUT |
LS4_DIR_OUTPUT);
52             GPIOA_PDDR &= ~GPIO_PDDR_PDD(LS1_DIR_INPUT);
53             break;
54
55         case 2:
56             /* just 2 switches */
57             GPIOA_PDDR |= GPIO_PDDR_PDD(LS3_DIR_OUTPUT | LS4_DIR_OUTPUT);
58             GPIOA_PDDR &= ~GPIO_PDDR_PDD(LS1_DIR_INPUT | LS2_DIR_INPUT);
59             break;
60
61         case 3:
62             /* 3 switches */
63             GPIOA_PDDR |= GPIO_PDDR_PDD(LS4_DIR_OUTPUT);
64             GPIOA_PDDR &= ~GPIO_PDDR_PDD(LS1_DIR_INPUT | LS2_DIR_INPUT |
LS3_DIR_INPUT);
65             break;
66
67         case 4:
68             /* 4 switches */
69             GPIOA_PDDR &= ~GPIO_PDDR_PDD(LS1_DIR_INPUT | LS2_DIR_INPUT |
LS3_DIR_INPUT | LS4_DIR_INPUT);
70             break;
71     } /* switch(cSwitchNum) */
72
73 } /* if((cLedNum + cSwitchNum) <= MAX_LED_SWI) */
74
75 }
76
77
78 /**
79  * initializes pin as LED
80  * @param ePin which pin {1..4}
81  */
82 void ledswi_initLed(ledswi_pin_type_e ePin){

```

```

83     GPIO_INIT_PIN(LS_PORT_ID, ePin, GPIO_OUTPUT);
84 }
85
86 /**
87  * initializes pin as SWITCH
88  * @param ePin which pin {1..4}
89  */
90 void ledswi_initSwitch(ledswi_pin_type_e ePin){
91     GPIO_INIT_PIN(LS_PORT_ID, ePin, GPIO_INPUT);
92 }
93
94 /**
95  * set the led ON
96  * @param eLedPin which LED {1..4}
97  */
98 void ledswi_setLed(ledswi_pin_type_e eLedPin)
99 {
100     GPIO_WRITE_PIN(LS_PORT_ID, eLedPin, GPIO_HIGH);
101 }
102
103
104
105 /**
106  * set the led OFF
107  * @param eLedPin which LED {1..4}
108  */
109 void ledswi_clearLed(ledswi_pin_type_e eLedPin)
110 {
111     GPIO_WRITE_PIN(LS_PORT_ID, eLedPin, GPIO_LOW);
112 }
113
114
115 /**
116  * return the led status
117  *
118  * @param eLedPin which LED {1..4}
119  *
120  * @return If the led is ON or OFF
121  */
122 led_status_type_e ledswi_getLedStatus(ledswi_pin_type_e eLedPin){
123     led_status_type_e lstReturn = LED_OFF;
124     if(GPIO_GET_OUTPUT_STATE(LS_PORT_ID, eLedPin) == LED_ON){
125         lstReturn = LED_ON;
126     }

```

```

127     return(lstReturn);
128 }
129
130 /**
131  * return the switch status
132  *
133  * @param eSwPin which Switch {1..4}
134  *
135  * @return If the switch is ON or OFF
136  */
137 switch_status_type_e ledswi_getSwitchStatus(ledswi_pin_type_e eSwPin){
138     switch_status_type_e sstReturn = SWITCH_OFF;
139     if(GPIO_READ_PIN(LS_PORT_ID, eSwPin) == SWITCH_ON){
140         sstReturn = SWITCH_ON;
141     }
142     return(sstReturn);
143 }

```

7.15 ../Sources/LedSwi/ledswi_hal.h

```
1  /* ***** */
2  /* File name:      ledswi_hal.h */
3  /* File description: Header file containing the function/methods */
4  /*                prototypes of ledswi.c */
5  /* Author name:    dloubach */
6  /* Creation date:   09jan2015 */
7  /* Revision date:   13abr2016 */
8  /* ***** */
9
10 #ifndef SOURCES_LEDSWI_LEDSWI_HAL_H_
11 #define SOURCES_LEDSWI_LEDSWI_HAL_H_
12
13 #include "KL25Z/es670_peripheral_board.h"
14
15
16 #define MAX_LED_SWI      04
17
18 typedef enum
19 {
20     LS_1 =  LS1_PIN,
21     LS_2 =  LS2_PIN,
22     LS_3 =  LS3_PIN,
23     LS_4 =  LS4_PIN,
24     UNKNOWN = -1
25 } ledswi_pin_type_e;
26
27 typedef enum
28 {
29     SWITCH_ON,
30     SWITCH_OFF
31 } switch_status_type_e;
32
33 typedef enum
34 {
35     LED_OFF,
36     LED_ON
37 } led_status_type_e;
38
39 /**
40  * As the hardware board was designed with LEDs/Switches sharing
41  * the same pins, this method configures how many LEDS and switches
42  * will be available for the application
```

```

43  * @param cLedNum num of LEDs
44  * @param cSwitchNum num of Switches (cLedNum + cSwitchNum <= MAX_LED_SWI)
45  */
46  void ledswi_initLedSwitch(char cLedNum, char cSwitchNum);
47
48
49  /**
50   * initializes pin as LED
51   * @param ePin which pin {1..4}
52   */
53  void ledswi_initLed(ledswi_pin_type_e ePin);
54
55  /**
56   * initializes pin as SWITCH
57   * @param ePin which pin {1..4}
58   */
59  void ledswi_initSwitch(ledswi_pin_type_e ePin);
60
61  /**
62   * set the led ON
63   * @param eLedPin which LED {1..4}
64   */
65  void ledswi_setLed(ledswi_pin_type_e eLedPin);
66
67
68
69  /**
70   * set the led OFF
71   * @param eLedPin which LED {1..4}
72   */
73  void ledswi_clearLed(ledswi_pin_type_e eLedPin);
74
75
76  /**
77   * return the led status
78   *
79   * @param eLedPin which LED {1..4}
80   *
81   * @return If the led is ON or OFF
82   */
83  led_status_type_e ledswi_getLedStatus(ledswi_pin_type_e eLedPin);
84
85  /**
86   * return the switch status

```

```
87  *
88  * @param eSwPin which Switch {1..4}
89  *
90  * @return If the switch is ON or OFF
91  */
92  switch_status_type_e ledswi_getSwitchStatus(ledswi_pin_type_e eSwPin);
93  #endif /* SOURCES_LEDSWI_LEDSWI_HAL_H_ */
```

7.16 ../Sources/Main/es670.c

```
1 #include "KL25Z/es670_peripheral_board.h"
2 #include "LedSwi/ledswi_hal.h"
3 #include "Mcg/mcg_hal.h"
4 #include "Buzzer/buzzer_hal.h"
5 #include "SevenSeg/sevenseg_hal.h"
6 #include "PIT/pit_hal.h"
7 #include "Util/util.h"
8 #include "Serial/serial_hal.h"
9 #include "Protocol/cmdmachine_hal.h"
10 #include "LCD/lcd_hal.h"
11 #include "Util/tc_hal.h"
12 #include "Cooler/cooler_hal.h"
13 #include "Tacometro/tacometro_hal.h"
14 #include "Heater/heater_hal.h"
15 #include "TempSensor/tempSensor_hal.h"
16 #include <string.h>
17 #include <stdio.h>
18
19 /* defines */
20 #define RCV_BUF_SIZE 100
21 #define SND_BUF_SIZE 100
22 #define CYCLIC_EXECUTIVE_PERIOD 500 * 10000 /* 1000000 micro seconds */
23
24 /* globals */
25 volatile unsigned int uiFlagNextPeriod = 0; /* cyclic executive flag */
26 uint16_t temp = 0;
27
28
29 /**
30  * cyclic executive interrupt service routine
31  */
32 void main_cyclicExecuteIsr(void)
33 {
34     /* set the cyclic executive flag */
35     uiFlagNextPeriod = 1;
36 }
37
38
39 /**
40  * Initialize board and peripherals
41  */
42 void main_boardInit(){
```

```

43     mcg_clockInit();
44     ledswi_initLedSwitch(1,3);
45     serial_initUart();
46     lcd_initLcd();
47     lcd_dummyText();
48     sevenseg_init();
49     buzzer_init();
50     tacometro_init();
51     cooler_initCooler();
52     heater_initHeater();
53     tempSensor_init();
54 }
55
56 /**
57  * Reads serial comm, interprets received commands and prints output
58  */
59 void main_protocolCheck(){
60     static char rcvBuffer[RCV_BUF_SIZE];
61     static char sndBuffer[SND_BUF_SIZE];
62     if(UART0_BRD_S1_RDRF(UART0)){
63         int iCmdSize = 0;
64         iCmdSize = serial_recieveBuffer(rcvBuffer, RCV_BUF_SIZE);
65         if(iCmdSize > 0){
66             cmdmachine_interpretCmdBuffer(rcvBuffer, iCmdSize, sndBuffer);
67             serial_sendBuffer(sndBuffer, strlen(sndBuffer));
68         }
69     }
70 }
71
72 /**
73  * Checks current cooler speed and prints it to lcd panel
74  */
75 void main_checkCoolerSpeed(){
76     static char coolerSpeedBuffer[15];
77     sprintf(coolerSpeedBuffer, "%d rps - %d",
78             tacometro_getSpeed(CYCLIC_EXECUTIVE_PERIOD/1000), cooler_getDutyCicle());
79     lcd_printString(coolerSpeedBuffer);
80 }
81
82 /**
83  * Main function
84  */
85 int main(void)
86 {

```

```

86  main_boardInit();
87  heater_setIntensity(0x8000);
88
89  /* configure cyclic executive interruption */
90  tc_installLptmr0(CYCLIC_EXECUTIVE_PERIOD, main_cyclicExecuteIsr);
91
92  /* cooperative cyclic executive main loop */
93  while(1){
94  //    main_checkCoolerSpeed();
95      tempSensor_executeTask();
96
97      /* WAIT FOR CYCLIC EXECUTIVE PERIOD */
98      while(!uiFlagNextPeriod){
99          main_protocolCheck();
100     }
101     uiFlagNextPeriod = 0;
102
103 }
104 /* Never leave main */
105 return 0;
106 }

```

7.17 ../Sources/Mcg/mcg_hal.c

```
1  /* ***** */
2  /* File name:      mcg_hal.c */
3  /* File description: Multipurpose clk generator hardware abstraction */
4  /*                layer. Enables the clock configuration */
5  /* */
6  /*                Modes of Operation */
7  /*                FLL Engaged Internal (FEI)      = DEFAULT */
8  /*                FLL Engaged External (FEE) */
9  /*                FLL Bypassed Internal (FBI) */
10 /*                FLL Bypassed External (FBE) */
11 /*                PLL Engaged External (PEE) */
12 /*                PLL Bypassed External (PBE) */
13 /*                Bypassed Low Power Internal (BLPI) */
14 /*                Bypassed Low Power External (BLPE) */
15 /*                Stop */
16 /* */
17 /*                For clock definitions, check the chapter */
18 /*                5.4 Clock definitions from */
19 /*                KL25 Sub-Family Reference Manual */
20 /* */
21 /* Author name:      dloubach */
22 /* Creation date:     21out2015 */
23 /* Revision date:     13abr2016 */
24 /* ***** */
25
26 #include "mcg_hal.h"
27
28 /* systems include */
29 #include "fsl_smc_hal.h"
30 #include "fsl_port_hal.h"
31 #include "fsl_clock_manager.h"
32
33 /* XTAL0 PTA18 */
34 #define XTAL0_PORT          PORTA
35 #define XTAL0_PIN          18U
36 #define XTAL0_PINMUX       kPortPinDisabled
37
38 /* XTAL0 PTA19 */
39 #define XTAL0_PORT          PORTA
40 #define XTAL0_PIN          19U
41 #define XTAL0_PINMUX       kPortPinDisabled
42
```

```

43 /* OSC0 configuration */
44 #define OSC0_INSTANCE          0U
45 #define OSC0_XTAL_FREQ        8000000U /* 08 MHz*/
46 #define OSC0_SC2P_ENABLE_CONFIG false
47 #define OSC0_SC4P_ENABLE_CONFIG false
48 #define OSC0_SC8P_ENABLE_CONFIG false
49 #define OSC0_SC16P_ENABLE_CONFIG false
50 #define MCG_HG00              kOscGainLow
51 #define MCG_RANGE0            kOscRangeVeryHigh
52 #define MCG_EREFS0            kOscSrcOsc
53
54 /* RTC external clock configuration. */
55 #define RTC_XTAL_FREQ          0U
56 #define RTC_SC2P_ENABLE_CONFIG false
57 #define RTC_SC4P_ENABLE_CONFIG false
58 #define RTC_SC8P_ENABLE_CONFIG false
59 #define RTC_SC16P_ENABLE_CONFIG false
60 #define RTC_OSC_ENABLE_CONFIG  false
61 #define RTC_CLK_OUTPUT_ENABLE_CONFIG false
62
63 /* RTC_CLKIN PTC1 */
64 #define RTC_CLKIN_PORT          PORTC
65 #define RTC_CLKIN_PIN           1U
66 #define RTC_CLKIN_PINMUX        kPortMuxAsGpio
67
68
69 #define CLOCK_VLPR              1U /* very low power run mode */
70 #define CLOCK_RUN                2U /* run mode */
71
72 #ifndef CLOCK_INIT_CONFIG
73 #define CLOCK_INIT_CONFIG CLOCK_RUN
74 #endif
75
76
77 /* Configuration for enter VLPR mode, Core clock = 4MHz */
78 const clock_manager_user_config_t g_defaultClockConfigVlpr =
79 {
80     .mcgConfig =
81     {
82         .mcg_mode          = kMcgModeBLPI,          // Work in BLPI mode
83         .irclkEnable        = true,                  // MCGIRCLK enable
84         .irclkEnableInStop = false,                  // MCGIRCLK disable in STOP mode
85         .ircs               = kMcgIrcFast,          // Select IRC4M
86         .fcrdiv             = 0U,                    // FCRDIV is 0

```

```

87
88     .frdiv    = 0U,
89     .drs      = kMcgDcoRangeSelLow,           // Low frequency range
90     .dmx32    = kMcgDmx32Default,           // DCO has a default range of 25%
91
92     .pll0EnableInFllMode = false,           // PLL0 disable
93     .pll0EnableInStop  = false,           // PLL0 disable in STOP mode
94     .prdiv0          = 0U,
95     .vdiv0           = 0U,
96 },
97 .simConfig =
98 {
99     .pllFllSel = kClockPllFllSelFll,       // PLLFLLSEL select FLL
100    .er32kSrc  = kClockEr32kSrcLpo,        // ERCLK32K selection, use LPO
101    .outdiv1   = 0U,
102    .outdiv4   = 4U,
103 },
104 .oscerConfig =
105 {
106     .enable      = true,                 // OSCERCLK enable
107     .enableInStop = false,              // OSCERCLK disable in STOP mode
108 }
109 };
110
111 /* Configuration for enter RUN mode, Core clock = 40 MHz */
112 /*
113  * 24.5.1.1 Initializing the MCG
114  * KL25 Sub-Family Reference Manual, Rev. 3, September 2012
115  *
116  * Refer also to
117  * Table 24-18. MCG modes of operation
118  *
119  * On L-series devices the MCGFLLCLK frequency is limited to 48 MHz max
120  * The DCO is limited to the two lowest range settings (MCG_C4[DRST_DRS] must be set
121    * to either 0b00 or 0b01).
122  *
123  * FEE (FLL engaged external)
124  * fext / FLL_R must be in the range of 31.25 kHz to 39.0625 kHz
125  * FLL_R is the reference divider selected by the C1[FRDIV] bits
126  * F is the FLL factor selected by C4[DRST_DRS] and C4[DMX32] bits
127  *
128  * (fext / FLL_R) * F = (8 MHz / 256 ) * 1280 = 40 MHz
129  * */

```

```

130 const clock_manager_user_config_t g_defaultClockConfigRun =
131 {
132     /* ----- multipurpose clock generator configurations ----- */
133     .mcgConfig =
134     {
135         .mcg_mode          = kMcgModeFEE,          // Work in FEE mode
136
137         /* ----- MCGIRCLK settings ----- */
138         .irclkEnable       = true,                 // MCGIRCLK enable
139         .irclkEnableInStop = false,                // MCGIRCLK disable in STOP mode
140         .ircs              = kMcgIrcSlow,          // Select IRC 32kHz
141         .fcrdiv            = 0U,                   // FCRDIV is 0
142
143         /* ----- MCG FLL settings ----- */
144         .frdiv             = 0b011,                // Divide Factor is 256 (EXT OSC 8
MHz / 256 = 31.250 kHz)
145
146         // The resulting frequency must be in
the range 31.25 kHz to 39.0625 kHz
147         .drs               = kMcgDcoRangeSelMid,    // frequency range
148         .dmx32             = kMcgDmx32Default,      // DCO has a default range of 25%
149
150         /* ----- MCG PLL settings ----- */
151         .pll0EnableInFllMode = false,              // PLL0 disable
152         .pll0EnableInStop    = false,              // PLL0 disable in STOP mode
153         .prdiv0              = 0x0U,
154         .vdiv0               = 0x0U,
155     },
156     /* ----- system integration module configurations ----- */
157     .simConfig =
158     {
159         .pllFllSel = kClockPllFllSelFll,          // PLLFLLSEL select PLL
160         .er32kSrc  = kClockEr32kSrcLpo,           // ERCLK32K selection, use LPO
161         .outdiv1   = 0U,                           // core/system clock, as well as the
bus/flash clocks.
162         .outdiv4   = 1U,                           // bus and flash clock and is in
addition to the System clock divide ratio
163     },
164     /* ----- system oscillator output configurations ----- */
165     .oscerConfig =
166     {
167         .enable     = true,                        // OSCERCLK enable
168         .enableInStop = false,                    // OSCERCLK disable in STOP mode
169     }
170 };

```

```

170
171
172 /**
173  * Oscillator configuration
174  */
175 void mcg_initOsc0(void)
176 {
177     /* OSC0 configuration */
178     osc_user_config_t osc0Config =
179     {
180         .freq          = OSC0_XTAL_FREQ,
181         .hgo           = MCG_HGO0,
182         .range         = MCG_RANGE0,
183         .erefs         = MCG_EREFS0,
184         .enableCapacitor2p = OSC0_SC2P_ENABLE_CONFIG,
185         .enableCapacitor4p = OSC0_SC4P_ENABLE_CONFIG,
186         .enableCapacitor8p = OSC0_SC8P_ENABLE_CONFIG,
187         .enableCapacitor16p = OSC0_SC16P_ENABLE_CONFIG,
188     };
189
190     /* oscillator initialization */
191     CLOCK_SYS_OscInit(OSC0_INSTANCE, &osc0Config);
192 }
193
194
195
196 /**
197  * Function to initialize RTC external clock base on board configuration
198  */
199 void mcg_initRtcOsc(void)
200 {
201
202     #if RTC_XTAL_FREQ
203         // If RTC_CLKIN is connected, need to set pin mux. Another way for
204         // RTC clock is set RTC_OSC_ENABLE_CONFIG to use OSC0, please check
205         // reference manual for details
206         PORT_HAL_SetMuxMode(RTC_CLKIN_PORT, RTC_CLKIN_PIN, RTC_CLKIN_PINMUX);
207     #endif
208
209     #if ((OSC0_XTAL_FREQ != 32768U) && (RTC_OSC_ENABLE_CONFIG))
210     #error Set RTC_OSC_ENABLE_CONFIG will override OSC0 configuration and OSC0 must be 32k.
211     #endif
212
213     rtc_osc_user_config_t rtcOscConfig =

```



```

214     {
215         .freq                = RTC_XTAL_FREQ ,
216         .enableCapacitor2p   = RTC_SC2P_ENABLE_CONFIG ,
217         .enableCapacitor4p   = RTC_SC4P_ENABLE_CONFIG ,
218         .enableCapacitor8p   = RTC_SC8P_ENABLE_CONFIG ,
219         .enableCapacitor16p  = RTC_SC16P_ENABLE_CONFIG ,
220         .enableOsc           = RTC_OSC_ENABLE_CONFIG ,
221     };
222
223     /* OSC RTC initialization */
224     CLOCK_SYS_RtcOscInit(0U, &rtcOscConfig);
225 }
226
227
228
229 /**
230  * System clock configuration
231  */
232 void mcg_initSystemClock(void)
233 {
234     /* Set system clock configuration. */
235     #if (CLOCK_INIT_CONFIG == CLOCK_VLPR)
236         CLOCK_SYS_SetConfiguration(&g_defaultClockConfigVlpr);
237     #else
238         CLOCK_SYS_SetConfiguration(&g_defaultClockConfigRun);
239     #endif
240 }
241
242
243
244 /* ***** */
245 /* Method name:      mcg_clockInit */
246 /* Method description: main board clk configuration */
247 /* Input params:     n/a */
248 /* Output params:    n/a */
249 /* ***** */
250 void mcg_clockInit(void)
251 {
252     /* enable clock for PORTs */
253     CLOCK_SYS_EnablePortClock(PORTA_IDX);
254     CLOCK_SYS_EnablePortClock(PORTC_IDX);
255     CLOCK_SYS_EnablePortClock(PORTE_IDX);
256
257     /* set allowed power mode to allow all */

```

```
258     SMC_HAL_SetProtection(SMC, kAllowPowerModeAll);
259
260     /* configure OSC0 pin mux */
261     PORT_HAL_SetMuxMode(EXTALO_PORT, EXTALO_PIN, EXTALO_PINMUX);
262     PORT_HAL_SetMuxMode(XTALO_PORT, XTALO_PIN, XTALO_PINMUX);
263
264     /* setup OSC0 */
265     mcg_initOsc0();
266
267     /* setup OSC RTC */
268     mcg_initRtcOsc();
269
270     /* setup system clock */
271     mcg_initSystemClock();
272 }
```

7.18 ../Sources/Mcg/mcg_hal.h

```
1  /* ***** */
2  /* File name:      mcg_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for handling the Multipurpose clock */
5  /*                generator module */
6  /* Author name:    dloubach */
7  /* Creation date:   21out2015 */
8  /* Revision date:   25fev2016 */
9  /* ***** */
10
11 #ifndef SOURCES_MCG_HAL_H_
12 #define SOURCES_MCG_HAL_H_
13
14 /* ***** */
15 /* Method name:      mcg_clockInit */
16 /* Method description: main board clk configuration */
17 /* Input params:     n/a */
18 /* Output params:    n/a */
19 /* ***** */
20 void mcg_clockInit(void);
21
22
23
24 #endif /* SOURCES_MCG_HAL_H_ */
```

7.19 ../Sources/PIT/pit_hal.c

```
1  /* ***** */
2  /* File name:      pit_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                for handling the Periodic Interruption */
5  /*                Timer module */
6  /* Author name:    ddello */
7  /* Creation date:   10abr2016 */
8  /* Revision date:   10mai2016 */
9  /* ***** */
10 //Careful when handling PIT DOC! Bit endianness is inverted in relation to GPIO doc
11
12 #include "pit_hal.h"
13 #include "KL25Z/es670_peripheral_board.h"
14 #include "fsl_clock_manager.h"
15
16 #define PIT_IRQ_NUMBER PIT_IRQn
17
18 static unsigned char pit_enabled = 0;
19
20 /**
21  *Default timer interruption handler. Does nothing.
22  */
23 static void _nop_handler(void){
24     PIT_TFLG0 |= PIT_TFLG_TIF(0x1u);
25     PIT_TFLG1 |= PIT_TFLG_TIF(0x1u);
26 }
27
28 static void (*fpTimer0Handler)(void) = &_nop_handler;
29 static void (*fpTimer1Handler)(void) = &_nop_handler;
30
31 /**
32  * Pit interruption handler. Checks what timer caused the interruption and call the
33  * correct timer interruption handler.
34  */
35 void PIT_IRQHandler(void){
36     if(PIT_TFLG0){
37         (*fpTimer0Handler)();
38     }
39     if(PIT_TFLG1){
40         (*fpTimer1Handler)();
41     }
42 }
```

```

43
44 /**
45  * Enables Periodic Interruption Timer module.
46  * (With the stop on debug flag set to on)
47  */
48 void pit_enable(void){
49     SIM_SCGC6 |= SIM_SCGC6_PIT_MASK;
50     PIT_MCR &= ~PIT_MCR_MDIS(0x1u);
51     //Freeze in debug mode
52     PIT_MCR |= PIT_MCR_FRZ(0x1u);
53     NVIC_ClearPendingIRQ(PIT_IRQ_NUMBER);
54     NVIC_EnableIRQ(PIT_IRQ_NUMBER);
55     pit_enabled = 1;
56 }
57
58 /**
59  * Start interruptions for given timer, unchained mode.
60  * Timer interruptions are masked.
61  *
62  * @param usTimer_numb The number for the desired timer (0,1)
63  * @param uiTimer_period_ms The number of microseconds between interrupts
64  * @param fpInterrupt_handler Timer interrupt handler routine address pointer
65  */
66 void pit_start_timer_interrupt(unsigned short usTimer_numb, unsigned int
    uiTimer_period_us, void (*fpInterrupt_handler)(void)){
67     uint32_t ui32BusFreq = CLOCK_SYS_GetBusClockFreq()/1000000; //Freq in MHz
68     uint32_t ui32cyclePeriod = ui32BusFreq*uiTimer_period_us - 1;
69     if(!usTimer_numb){
70         fpTimer0Handler = fpInterrupt_handler;
71         PIT_LDVAL0 = PIT_LDVAL_TSV(ui32cyclePeriod);
72         PIT_TCTRL0 &= ~PIT_TCTRL_CHN(0x1u); /*Disable chain mode*/
73         PIT_TCTRL0 |= PIT_TCTRL_TIE(0x1u); /*Enable interrupts for timer 0*/
74         PIT_TCTRL0 |= PIT_TCTRL_TEN(0x1u); /*Enable timer 0*/
75     }else{
76         fpTimer1Handler = fpInterrupt_handler;
77         PIT_LDVAL1 = PIT_LDVAL_TSV(ui32cyclePeriod);
78         PIT_TCTRL1 &= ~PIT_TCTRL_CHN(0x1u); /*Disable chain mode*/
79         PIT_TCTRL1 |= PIT_TCTRL_TIE(0x1u); /*Enable interrupts for timer 1*/
80         PIT_TCTRL1 |= PIT_TCTRL_TEN(0x1u); /*Enable timer 1*/
81     }
82 }
83
84 /**
85  * Stop interruptions for given timer, unchained mode.

```

```

86  *
87  * @param usTimer_numb The number for the desired timer (0,1)
88  */
89 void pit_stop_timer_interrupt(unsigned short usTimer_numb){
90     if(!usTimer_numb){
91         PIT_TCTRL0 &= ~PIT_TCTRL_TIE(0x1u);
92         PIT_TCTRL0 &= ~PIT_TCTRL_TEN(0x1u);
93     }else{
94         PIT_TCTRL1 &= ~PIT_TCTRL_TIE(0x1u);
95         PIT_TCTRL1 &= ~PIT_TCTRL_TEN(0x1u);
96     }
97 }
98
99 /**
100  * Mark interruption as handled for the given timer, this should be called by timer
101  * interruption handlers once they are finished.
102  *
103  * @param usTimer_numb The number for the desired timer (0,1)
104  */
105 void pit_mark_interrupt_handled(unsigned short usTimer_numb){
106     if(!usTimer_numb){
107         PIT_TFLG0 |= PIT_TFLG_TIF(0x1u);
108     }else{
109         PIT_TFLG1 |= PIT_TFLG_TIF(0x1u);
110     }
111 }
112
113 /**
114  * Disables PIT interruptions temporarily
115  */
116 void pit_mask_interrupts(){
117     if(pit_enabled){
118         // NVIC_ClearPendingIRQ(PIT_IRQ_NUMBER);
119         NVIC_DisableIRQ(PIT_IRQ_NUMBER);
120         PIT_TCTRL0 &= ~PIT_TCTRL_TIE(0x1u);
121         PIT_TCTRL1 &= ~PIT_TCTRL_TIE(0x1u);
122     }
123 }
124
125 /**
126  * Re-enables PIT interruptions
127  */
128 void pit_unmask_interrupts(){
129     if(pit_enabled){

```

```
130 //      NVIC_ClearPendingIRQ(PIT_IRQ_NUMBER);
131      NVIC_EnableIRQ(PIT_IRQ_NUMBER);
132      PIT_TCTRL0 |= PIT_TCTRL_TIE(0x1u);      /*Enable interrupts for timer 0*/
133      PIT_TCTRL1 |= PIT_TCTRL_TIE(0x1u);      /*Enable interrupts for timer 1*/
134  }
135 }
```

7.20 ../Sources/PIT/pit_hal.h

```
1  /* ***** */
2  /* File name:      pit_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for handling the Periodic Interruption*/
5  /*                timer module */
6  /* Author name:     ddello */
7  /* Creation date:    10abr2016 */
8  /* Revision date:    10mai2016 */
9  /* ***** */
10
11 #ifndef SOURCES_PIT_PIT_HAL_H_
12 #define SOURCES_PIT_PIT_HAL_H_
13
14 /**
15  * Enables Periodic Interruption Timer module.
16  * (With the stop on debug flag set to on)
17  */
18 void pit_enable(void);
19
20 /**
21  * Start interruptions for given timer, unchained mode.
22  * Timer interruptions are masked.
23  *
24  * @param usTimer_numb The number for the desired timer (0,1)
25  * @param uiTimer_period_ms The number of microseconds between interrupts
26  * @param fpInterrupt_handler Timer interrupt handler routine address pointer
27  */
28 void pit_start_timer_interrupt(unsigned short usTimer_numb, unsigned int
    uiTimer_period_us, void (*fpInterrupt_handler)(void));
29
30 /**
31  * Stop interruptions for given timer, unchained mode.
32  *
33  * @param usTimer_numb The number for the desired timer (0,1)
34  */
35 void pit_stop_timer_interrupt(unsigned short usTimer_numb);
36
37 /**
38  * Mark interruption as handled for the given timer, this should be called by timer
39  * interruption handlers once they are finished.
40  *
41  * @param usTimer_numb The number for the desired timer (0,1)
```



```

42  */
43  void pit_mark_interrupt_handled(unsigned short usTimer_numb);
44
45  /**
46   * Pit interruption handler. Checks what timer caused the interruption and call the
47   * correct timer interruption handler.
48   */
49  void PIT_IRQHandler(void);
50
51  /**
52   * Disables PIT interruptions temporarily
53   */
54  void pit_mask_interrupts();
55
56  /**
57   * Re-enables PIT interruptions
58   */
59  void pit_unmask_interrupts();
60  #endif /* SOURCES_PIT_PIT_HAL_H_ */

```

7.21 ../Sources/print_scan.c

```
1  /*****
2  * File:      print_scan.c
3  * Purpose: Implementation of debug_printf(), debug_scanf() functions.
4  *
5  * This is a modified version of the file printf.c, which was distributed
6  * by Motorola as part of the M5407C3B00T.zip package used to initialize
7  * the M5407C3 evaluation board.
8  *
9  * Copyright:
10 *      1999-2000 MOTOROLA, INC. All Rights Reserved.
11 * You are hereby granted a copyright license to use, modify, and
12 * distribute the SOFTWARE so long as this entire notice is
13 * retained without alteration in any modified and/or redistributed
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15 * as such. No licenses are granted by implication, estoppel or
16 * otherwise under any patents or trademarks of Motorola, Inc. This
17 * software is provided on an "AS IS" basis and without warranty.
18 *
19 * To the maximum extent permitted by applicable law, MOTOROLA
20 * DISCLAIMS ALL WARRANTIES WHETHER EXPRESS OR IMPLIED, INCLUDING
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22 * PURPOSE AND ANY WARRANTY AGAINST INFRINGEMENT WITH REGARD TO THE
23 * SOFTWARE (INCLUDING ANY MODIFIED VERSIONS THEREOF) AND ANY
24 * ACCOMPANYING WRITTEN MATERIALS.
25 *
26 * To the maximum extent permitted by applicable law, IN NO EVENT
27 * SHALL MOTOROLA BE LIABLE FOR ANY DAMAGES WHATSOEVER (INCLUDING
28 * WITHOUT LIMITATION, DAMAGES FOR LOSS OF BUSINESS PROFITS, BUSINESS
29 * INTERRUPTION, LOSS OF BUSINESS INFORMATION, OR OTHER PECUNIARY
30 * LOSS) ARISING OF THE USE OR INABILITY TO USE THE SOFTWARE.
31 *
32 * Motorola assumes no responsibility for the maintenance and support
33 * of this software
34 *****/
35
36 #include "print_scan.h"
37 #include <stdio.h>
38 #include <stdlib.h>
39 #include <ctype.h>
40 #include <stdint.h>
41 #include <stdbool.h>
42 // Keil: suppress ellipsis warning in va_arg usage below
```

```

43 #if defined(__CC_ARM)
44 #pragma diag_suppress 1256
45 #endif
46
47 #define FLAGS_MINUS      (0x01)
48 #define FLAGS_PLUS      (0x02)
49 #define FLAGS_SPACE     (0x04)
50 #define FLAGS_ZERO      (0x08)
51 #define FLAGS_POUND     (0x10)
52
53 #define IS_FLAG_MINUS(a)  (a & FLAGS_MINUS)
54 #define IS_FLAG_PLUS(a)  (a & FLAGS_PLUS)
55 #define IS_FLAG_SPACE(a) (a & FLAGS_SPACE)
56 #define IS_FLAG_ZERO(a)  (a & FLAGS_ZERO)
57 #define IS_FLAG_POUND(a) (a & FLAGS_POUND)
58
59 #define LENMOD_h         (0x01)
60 #define LENMOD_l         (0x02)
61 #define LENMOD_L         (0x04)
62 #define LENMOD_hh        (0x08)
63 #define LENMOD_ll        (0x10)
64
65 #define IS_LENMOD_h(a)   (a & LENMOD_h)
66 #define IS_LENMOD_hh(a)  (a & LENMOD_hh)
67 #define IS_LENMOD_l(a)   (a & LENMOD_l)
68 #define IS_LENMOD_ll(a)  (a & LENMOD_ll)
69 #define IS_LENMOD_L(a)   (a & LENMOD_L)
70
71 #define SCAN_SUPPRESS           0x2
72
73 #define SCAN_DEST_MASK          0x7c
74 #define SCAN_DEST_CHAR          0x4
75 #define SCAN_DEST_STRING        0x8
76 #define SCAN_DEST_SET           0x10
77 #define SCAN_DEST_INT           0x20
78 #define SCAN_DEST_FLOAT         0x30
79
80 #define SCAN_LENGTH_MASK        0x1f00
81 #define SCAN_LENGTH_CHAR        0x100
82 #define SCAN_LENGTH_SHORT_INT   0x200
83 #define SCAN_LENGTH_LONG_INT    0x400
84 #define SCAN_LENGTH_LONG_LONG_INT 0x800
85 #define SCAN_LENGTH_LONG_DOUBLE 0x1000
86

```

```

87 #define SCAN_TYPE_SIGNED          0x2000
88
89 /*!
90  * @brief Scanline function which ignores white spaces.
91  *
92  * @param[in] s The address of the string pointer to update.
93  *
94  * @return String without white spaces.
95  */
96 static uint32_t scan_ignore_white_space(const char **s);
97
98 #if defined(SCANF_FLOAT_ENABLE)
99 static double fnum = 0.0;
100 #endif
101
102 /*!
103  * @brief Converts a radix number to a string and return its length.
104  *
105  * @param[in] numstr    Converted string of the number.
106  * @param[in] nump      Pointer to the number.
107  * @param[in] neg       Polarity of the number.
108  * @param[in] radix     The radix to be converted to.
109  * @param[in] use_caps  Used to identify %x/X output format.
110  *
111  * @return Length of the converted string.
112  */
113 static int32_t mknumstr (char *numstr, void *nump, int32_t neg, int32_t radix, bool
    use_caps);
114
115 #if defined(PRINTF_FLOAT_ENABLE)
116 /*!
117  * @brief Converts a floating radix number to a string and return its length.
118  *
119  * @param[in] numstr    Converted string of the number.
120  * @param[in] nump      Pointer to the number.
121  * @param[in] radix     The radix to be converted to.
122  * @param[in] precision_width  Specify the precision width.
123  *
124  * @return Length of the converted string.
125  */
126 static int32_t mkfloatnumstr (char *numstr, void *nump, int32_t radix, uint32_t
    precision_width);
127 #endif
128

```

```

129
130 static void fput_pad(int32_t c, int32_t curlen, int32_t field_width, int32_t *count,
    PUTCHAR_FUNC func_ptr, void *farg, int *max_count);
131
132 double modf(double input_dbl, double *intpart_ptr);
133
134 #if !defined(PRINT_MAX_COUNT)
135 #define n_putchar(func, chacter, p, count)      func(chacter, p)
136 #else
137 static int n_putchar(PUTCHAR_FUNC func_ptr, int chacter, void *p, int *max_count)
138 {
139     int result = 0;
140     if (*max_count)
141     {
142         result = func_ptr(chacter, p);
143         (*max_count)--;
144     }
145     return result;
146 }
147 #endif
148
149 /*FUNCTION*****
150 *
151 * Function Name : _doprint
152 * Description   : This function outputs its parameters according to a
153 * formatted string. I/O is performed by calling given function pointer
154 * using following (*func_ptr)(c,farg);
155 *
156 *END*****
157 int _doprint(void *farg, PUTCHAR_FUNC func_ptr, int max_count, char *fmt, va_list ap)
158 {
159     /* va_list ap; */
160     char *p;
161     int32_t c;
162
163     char vstr[33];
164     char *vstrp;
165     int32_t vlen;
166
167     int32_t done;
168     int32_t count = 0;
169     int temp_count = max_count;
170
171

```

```

172     uint32_t flags_used;
173     uint32_t field_width;
174
175     int32_t ival;
176     int32_t schar, dschar;
177     int32_t *ivalp;
178     char *sval;
179     int32_t cval;
180     uint32_t uval;
181     bool use_caps;
182     uint32_t precision_width;
183     //uint32_t length_modifier = 0;
184 #if defined(PRINTF_FLOAT_ENABLE)
185     double fval;
186 #endif
187
188     if (max_count == -1)
189     {
190         max_count = INT32_MAX - 1;
191     }
192
193     /*
194     * Start parsing apart the format string and display appropriate
195     * formats and data.
196     */
197     for (p = (char *)fmt; (c = *p) != 0; p++)
198     {
199         /*
200         * All formats begin with a '%' marker. Special chars like
201         * '\n' or '\t' are normally converted to the appropriate
202         * character by the __compiler__. Thus, no need for this
203         * routine to account for the '\' character.
204         */
205         if (c != '%')
206         {
207             n_putchar(func_ptr, c, farg, &max_count);
208
209             count++;
210
211             /*
212             * By using 'continue', the next iteration of the loop
213             * is used, skipping the code that follows.
214             */
215             continue;

```

```

216     }
217
218     /*
219      * First check for specification modifier flags.
220      */
221     use_caps = true;
222     flags_used = 0;
223     done = false;
224     while (!done)
225     {
226         switch (/* c = */ **p)
227         {
228             case '-':
229                 flags_used |= FLAGS_MINUS;
230                 break;
231             case '+':
232                 flags_used |= FLAGS_PLUS;
233                 break;
234             case ' ':
235                 flags_used |= FLAGS_SPACE;
236                 break;
237             case '0':
238                 flags_used |= FLAGS_ZERO;
239                 break;
240             case '#':
241                 flags_used |= FLAGS_POUND;
242                 break;
243             default:
244                 /* we've gone one char too far */
245                 --p;
246                 done = true;
247                 break;
248         }
249     }
250
251     /*
252      * Next check for minimum field width.
253      */
254     field_width = 0;
255     done = false;
256     while (!done)
257     {
258         switch (c = **p)
259         {

```

```

260         case '0':
261         case '1':
262         case '2':
263         case '3':
264         case '4':
265         case '5':
266         case '6':
267         case '7':
268         case '8':
269         case '9':
270             field_width = (field_width * 10) + (c - '0');
271             break;
272         default:
273             /* we've gone one char too far */
274             --p;
275             done = true;
276             break;
277     }
278 }
279
280 /*
281  * Next check for the width and precision field separator.
282  */
283 precision_width = 6;
284 if (/* (c = ++p) */ ++p == ',')
285 {
286     /* precision_used = true; */
287
288     /*
289      * Must get precision field width, if present.
290      */
291     precision_width = 0;
292     done = false;
293     while (!done)
294     {
295         switch (c = ++p)
296         {
297             case '0':
298             case '1':
299             case '2':
300             case '3':
301             case '4':
302             case '5':
303             case '6':

```



```

304         case '7':
305         case '8':
306         case '9':
307             precision_width = (precision_width * 10) + (c - '0');
308             break;
309         default:
310             /* we've gone one char too far */
311             --p;
312             done = true;
313             break;
314     }
315 }
316 }
317 else
318 {
319     /* we've gone one char too far */
320     --p;
321 }
322
323 /*
324  * Check for the length modifier.
325  */
326 /* length_modifier = 0; */
327 switch (/* c = */ *++p)
328 {
329     case 'h':
330         if (*++p != 'h')
331         {
332             --p;
333         }
334         /* length_modifier |= LENMOD_h; */
335         break;
336     case 'l':
337         if (*++p != 'l')
338         {
339             --p;
340         }
341         /* length_modifier |= LENMOD_l; */
342         break;
343     case 'L':
344         /* length_modifier |= LENMOD_L; */
345         break;
346     default:
347         /* we've gone one char too far */

```

```

348         --p;
349         break;
350     }
351
352     /*
353     * Now we're ready to examine the format.
354     */
355     switch (c = *++p)
356     {
357         case 'd':
358         case 'i':
359             ival = (int32_t)va_arg(ap, int32_t);
360             vlen = mknumstr(vstr,&ival,true,10,use_caps);
361             vstrp = &vstr[vlen];
362
363             if (ival < 0)
364             {
365                 schar = '-';
366                 ++vlen;
367             }
368             else
369             {
370                 if (IS_FLAG_PLUS(flags_used))
371                 {
372                     schar = '+';
373                     ++vlen;
374                 }
375                 else
376                 {
377                     if (IS_FLAG_SPACE(flags_used))
378                     {
379                         schar = ' ';
380                         ++vlen;
381                     }
382                     else
383                     {
384                         schar = 0;
385                     }
386                 }
387             }
388             dschar = false;
389
390             /*
391             * do the ZERO pad.

```

```

392         */
393     if (IS_FLAG_ZERO(flags_used))
394     {
395         if (schar)
396         {
397             n_putchar(func_ptr, schar, farg, &max_count);
398             count++;
399         }
400         dschar = true;
401
402         fput_pad('0', vlen, field_width, &count, func_ptr, farg,
&max_count);
403         vlen = field_width;
404     }
405     else
406     {
407         if (!IS_FLAG_MINUS(flags_used))
408         {
409             fput_pad(' ', vlen, field_width, &count, func_ptr, farg,
&max_count);
410
411             if (schar)
412             {
413                 n_putchar(func_ptr, schar, farg, &max_count);
414                 count++;
415             }
416             dschar = true;
417         }
418
419         /* the string was built in reverse order, now display in */
420         /* correct order */
421         if ((!dschar) && schar)
422         {
423             n_putchar(func_ptr, schar, farg, &max_count);
424             count++;
425         }
426         goto cont_xd;
427 #if defined(PRINTF_FLOAT_ENABLE)
428         case 'f':
429         case 'F':
430             fval = (double)va_arg(ap, double);
431             vlen = mkfloatnumstr(vstr,&fval,10, precision_width);
432             vstrp = &vstr[vlen];
433

```

```

434         if (fval < 0)
435         {
436             schar = '-';
437             ++vlen;
438         }
439     else
440     {
441         if (IS_FLAG_PLUS(flags_used))
442         {
443             schar = '+';
444             ++vlen;
445         }
446         else
447         {
448             if (IS_FLAG_SPACE(flags_used))
449             {
450                 schar = ' ';
451                 ++vlen;
452             }
453             else
454             {
455                 schar = 0;
456             }
457         }
458     }
459     dschar = false;
460     if (IS_FLAG_ZERO(flags_used))
461     {
462         if (schar)
463         {
464             n_putchar(func_ptr, schar, farg, &max_count);
465             count++;
466         }
467         dschar = true;
468         fput_pad('0', vlen, field_width, &count, func_ptr, farg,
469 &max_count);
470         vlen = field_width;
471     }
472     else
473     {
474         if (!IS_FLAG_MINUS(flags_used))
475         {
476             fput_pad(' ', vlen, field_width, &count, func_ptr, farg,
477 &max_count);

```

```

476         if (schar)
477         {
478             n_putchar(func_ptr, schar, farg, &max_count);
479             count++;
480         }
481         dschar = true;
482     }
483 }
484 if (!dschar && schar)
485 {
486     n_putchar(func_ptr, schar, farg, &max_count);
487     count++;
488 }
489 goto cont_xd;
490 #endif
491 case 'x':
492     use_caps = false;
493 case 'X':
494     uval = (uint32_t)va_arg(ap, uint32_t);
495     vlen = mknumstr(vstr,&uval,false,16,use_caps);
496     vstrp = &vstr[vlen];
497
498     dschar = false;
499     if (IS_FLAG_ZERO(flags_used))
500     {
501         if (IS_FLAG_POUND(flags_used))
502         {
503             n_putchar(func_ptr, '0', farg, &max_count);
504             n_putchar(func_ptr, (use_caps ? 'X' : 'x'), farg, &max_count);
505             count += 2;
506             /*vlen += 2;*/
507             dschar = true;
508         }
509         fput_pad('0', vlen, field_width, &count, func_ptr, farg,
510 &max_count);
511         vlen = field_width;
512     }
513     else
514     {
515         if (!IS_FLAG_MINUS(flags_used))
516         {
517             if (IS_FLAG_POUND(flags_used))
518             {
519                 vlen += 2;

```

```

519         }
520         fput_pad(' ', vlen, field_width, &count, func_ptr, farg,
&max_count);
521         if (IS_FLAG_POUND(flags_used))
522         {
523             n_putchar(func_ptr, '0', farg, &max_count);
524             n_putchar(func_ptr, (use_caps ? 'X' : 'x'), farg,
&max_count);
525             count += 2;
526
527             dschar = true;
528         }
529     }
530 }
531
532 if ((IS_FLAG_POUND(flags_used)) && (!dschar))
533 {
534     n_putchar(func_ptr, '0', farg, &max_count);
535     n_putchar(func_ptr, (use_caps ? 'X' : 'x'), farg, &max_count);
536     count += 2;
537     vlen += 2;
538 }
539 goto cont_xd;
540
541 case 'o':
542     uval = (uint32_t)va_arg(ap, uint32_t);
543     vlen = mknumstr(vstr,&uval,false,8,use_caps);
544     goto cont_u;
545 case 'b':
546     uval = (uint32_t)va_arg(ap, uint32_t);
547     vlen = mknumstr(vstr,&uval,false,2,use_caps);
548     goto cont_u;
549 case 'p':
550     uval = (uint32_t)va_arg(ap, uint32_t);
551     uval = (uint32_t)va_arg(ap, void *);
552     vlen = mknumstr(vstr,&uval,false,16,use_caps);
553     goto cont_u;
554 case 'u':
555     uval = (uint32_t)va_arg(ap, uint32_t);
556     vlen = mknumstr(vstr,&uval,false,10,use_caps);
557
558 cont_u:
559     vstrp = &vstr[vlen];
560

```

```

561         if (IS_FLAG_ZERO(flags_used))
562         {
563             fput_pad('0', vlen, field_width, &count, func_ptr, farg,
&max_count);
564             vlen = field_width;
565         }
566         else
567         {
568             if (!IS_FLAG_MINUS(flags_used))
569             {
570                 fput_pad(' ', vlen, field_width, &count, func_ptr, farg,
&max_count);
571             }
572         }
573
574         cont_xd:
575         while (*vstrp)
576         {
577             n_putchar(func_ptr, *vstrp--, farg, &max_count);
578             count++;
579         }
580
581         if (IS_FLAG_MINUS(flags_used))
582         {
583             fput_pad(' ', vlen, field_width, &count, func_ptr, farg,
&max_count);
584         }
585         break;
586
587         case 'c':
588             cval = (char)va_arg(ap, uint32_t);
589             n_putchar(func_ptr, cval, farg, &max_count);
590             count++;
591             break;
592         case 's':
593             sval = (char *)va_arg(ap, char *);
594             if (sval)
595             {
596                 vlen = strlen(sval);
597                 if (!IS_FLAG_MINUS(flags_used))
598                 {
599                     fput_pad(' ', vlen, field_width, &count, func_ptr, farg,
&max_count);
600                 }

```

```

601         while (*sval)
602         {
603             n_putchar(func_ptr, *sval++, farg, &max_count);
604             count++;
605         }
606         if (IS_FLAG_MINUS(flags_used))
607         {
608             fput_pad(' ', vlen, field_width, &count, func_ptr, farg,
&max_count);
609         }
610     }
611     break;
612 case 'n':
613     ivalp = (int32_t *)va_arg(ap, int32_t *);
614     *ivalp = count;
615     break;
616 default:
617     n_putchar(func_ptr, c, farg, &max_count);
618     count++;
619     break;
620 }
621 }
622
623 if (max_count)
624 {
625     return count;
626 }
627 else
628 {
629     return temp_count;
630 }
631 }
632
633 /*FUNCTION*****
634 *
635 * Function Name : _sputc
636 * Description   : Writes the character into the string located by the string
637 * pointer and updates the string pointer.
638 *
639 *END*****
640 int _sputc(int c, void * input_string)
641 {
642     char **string_ptr = (char **)input_string;
643

```



```

644     *(*string_ptr)++ = (char)c;
645     return c;
646 }
647
648 /*FUNCTION*****
649 *
650 * Function Name : mknumstr
651 * Description   : Converts a radix number to a string and return its length.
652 *
653 *END*****/
654 static int32_t mknumstr (char *numstr, void *nump, int32_t neg, int32_t radix, bool
        use_caps)
655 {
656     int32_t a,b,c;
657     uint32_t ua,ub,uc;
658
659     int32_t nlen;
660     char *nstrp;
661
662     nlen = 0;
663     nstrp = numstr;
664     *nstrp++ = '\0';
665
666     if (neg)
667     {
668         a = *(int32_t *)nump;
669         if (a == 0)
670         {
671             *nstrp = '0';
672             ++nlen;
673             goto done;
674         }
675         while (a != 0)
676         {
677             b = (int32_t)a / (int32_t)radix;
678             c = (int32_t)a - ((int32_t)b * (int32_t)radix);
679             if (c < 0)
680             {
681                 c = ~c + 1 + '0';
682             }
683             else
684             {
685                 c = c + '0';
686             }

```

```

687         a = b;
688         *nstrp++ = (char)c;
689         ++nlen;
690     }
691 }
692 else
693 {
694     ua = *(uint32_t *)nump;
695     if (ua == 0)
696     {
697         *nstrp = '0';
698         ++nlen;
699         goto done;
700     }
701     while (ua != 0)
702     {
703         ub = (uint32_t)ua / (uint32_t)radix;
704         uc = (uint32_t)ua - ((uint32_t)ub * (uint32_t)radix);
705         if (uc < 10)
706         {
707             uc = uc + '0';
708         }
709         else
710         {
711             uc = uc - 10 + (use_caps ? 'A' : 'a');
712         }
713         ua = ub;
714         *nstrp++ = (char)uc;
715         ++nlen;
716     }
717 }
718 done:
719 return nlen;
720 }
721
722 #if defined(PRINTF_FLOAT_ENABLE)
723 /*FUNCTION*****
724 *
725 * Function Name : mkfloatnumstr
726 * Description   : Converts a floating radix number to a string and return
727 * its length, user can specify output precision width.
728 *
729 *END*****

```

```

730 static int32_t mkfloatnumstr (char *numstr, void *nump, int32_t radix, uint32_t
    precision_width)
731 {
732     int32_t a,b,c,i;
733     double fa,fb;
734     double r, fractpart, intpart;
735
736     int32_t nlen;
737     char *nstrp;
738     nlen = 0;
739     nstrp = numstr;
740     *nstrp++ = '\0';
741     r = *(double *)nump;
742     if (r == 0)
743     {
744         *nstrp = '0';
745         ++nlen;
746         goto done;
747     }
748     fractpart = modf((double)r , (double *)&intpart);
749     /* Process fractional part */
750     for (i = 0; i < precision_width; i++)
751     {
752         fractpart *= radix;
753     }
754     //a = (int32_t)floor(fractpart + (double)0.5);
755     fa = fractpart + (double)0.5;
756     for (i = 0; i < precision_width; i++)
757     {
758         fb = fa / (int32_t)radix;
759         c = (int32_t)(fa - (uint64_t)fb * (int32_t)radix);
760         if (c < 0)
761         {
762             c = ~c + 1 + '0';
763         }else
764         {
765             c = c + '0';
766         }
767         fa = fb;
768         *nstrp++ = (char)c;
769         ++nlen;
770     }
771     *nstrp++ = (char)'.';
772     ++nlen;

```

```

773     a = (int32_t)intpart;
774     while (a != 0)
775     {
776         b = (int32_t)a / (int32_t)radix;
777         c = (int32_t)a - ((int32_t)b * (int32_t)radix);
778         if (c < 0)
779         {
780             c = ~c + 1 + '0';
781         }else
782         {
783             c = c + '0';
784         }
785         a = b;
786         *nstrp++ = (char)c;
787         ++nlen;
788     }
789     done:
790     return nlen;
791 }
792 #endif
793
794 static void fput_pad(int32_t c, int32_t curlen, int32_t field_width, int32_t *count,
795     PUTCHAR_FUNC func_ptr, void *farg, int *max_count)
796 {
797     int32_t i;
798
799     for (i = curlen; i < field_width; i++)
800     {
801         func_ptr((char)c, farg);
802         (*count)++;
803     }
804 }
805
806 /*FUNCTION*****
807 *
808 * Function Name : scan_prv
809 * Description   : Converts an input line of ASCII characters based upon a
810 * provided string format.
811 *
812 *END*****
813
814 int scan_prv(const char *line_ptr, char *format, va_list args_ptr)
815 {
816     uint8_t base;
817     /* Identifier for the format string */

```

```

816     char *c = format;
817     const char *s;
818     char temp;
819     /* Identifier for the input string */
820     const char *p = line_ptr;
821     /* flag telling the conversion specification */
822     uint32_t flag = 0 ;
823     /* filed width for the matching input streams */
824     uint32_t field_width;
825     /* how many arguments are assigned except the suppress */
826     uint32_t nassigned = 0;
827     /* how many characters are read from the input streams */
828     uint32_t n_decode = 0;
829
830     int32_t val;
831     char *buf;
832     int8_t neg;
833
834     /* return EOF error before any conversion */
835     if (*p == '\0')
836     {
837         return EOF;
838     }
839
840     /* decode directives */
841     while ((*c) && (*p))
842     {
843         /* ignore all white-spaces in the format strings */
844         if (scan_ignore_white_space((const char **)&c))
845         {
846             n_decode += scan_ignore_white_space(&p);
847         }
848         else if (*c != '%')
849         {
850             /* Ordinary characters */
851             c++;
852 ordinary:    if (*p == *c)
853             {
854                 n_decode++;
855                 p++;
856                 c++;
857             }
858             else
859             {

```

```

860         /* Match failure. Misalignment with C99, the unmatched
861         * characters need to be pushed back to stream. However
862         * , it is deserted now. */
863         break;
864     }
865 }
866 else
867 {
868     /* conversion specification */
869     c++;
870     if (*c == '%')
871     {
872         goto ordinary;
873     }
874
875     /* Reset */
876     flag = 0;
877     field_width = 0;
878     base = 0;
879
880     /* Loop to get full conversion specification */
881     while ((*c) && (!(flag & SCAN_DEST_MASK)))
882     {
883         switch (*c)
884         {
885             case '*':
886                 if (flag & SCAN_SUPPRESS)
887                 {
888                     /* Match failure*/
889                     return nassigned;
890                 }
891                 flag |= SCAN_SUPPRESS;
892                 c++;
893                 break;
894             case 'h':
895                 if (flag & SCAN_LENGTH_MASK)
896                 {
897                     /* Match failure*/
898                     return nassigned;
899                 }
900                 flag |= SCAN_LENGTH_SHORT_INT;
901
902                 if (c[1] == 'h')
903                 {

```

```

904         flag |= SCAN_LENGTH_CHAR;
905         c++;
906     }
907     c++;
908     break;
909 case 'l':
910     if (flag & SCAN_LENGTH_MASK)
911     {
912         /* Match failure*/
913         return nassigned;
914     }
915     flag |= SCAN_LENGTH_LONG_INT;
916
917     if (c[1] == 'l')
918     {
919         flag |= SCAN_LENGTH_LONG_LONG_INT;
920         c++;
921     }
922     c++;
923     break;
924 #if defined(ADVANCE)
925 case 'j':
926     if (flag & SCAN_LENGTH_MASK)
927     {
928         /* Match failure*/
929         return nassigned;
930     }
931     flag |= SCAN_LENGTH_INTMAX;
932     c++
933 case 'z':
934     if (flag & SCAN_LENGTH_MASK)
935     {
936         /* Match failure*/
937         return nassigned;
938     }
939     flag |= SCAN_LENGTH_SIZE_T;
940     c++;
941     break;
942 case 't':
943     if (flag & SCAN_LENGTH_MASK)
944     {
945         /* Match failure*/
946         return nassigned;
947     }

```

```

948         flag |= SCAN_LENGTH_PTRDIFF_T;
949         c++;
950         break;
951 #endif
952 #if defined(SCANF_FLOAT_ENABLE)
953     case 'L':
954         if (flag & SCAN_LENGTH_MASK)
955         {
956             /* Match failure*/
957             return nassigned;
958         }
959         flag |= SCAN_LENGTH_LONG_DOUBLE;
960         c++;
961         break;
962 #endif
963     case '0':
964     case '1':
965     case '2':
966     case '3':
967     case '4':
968     case '5':
969     case '6':
970     case '7':
971     case '8':
972     case '9':
973         if (field_width)
974         {
975             /* Match failure*/
976             return nassigned;
977         }
978         do {
979             field_width = field_width * 10 + *c - '0';
980             c++;
981         } while ((*c >= '0') && (*c <= '9'));
982         break;
983     case 'd':
984         flag |= SCAN_TYPE_SIGNED;
985     case 'u':
986         base = 10;
987         flag |= SCAN_DEST_INT;
988         c++;
989         break;
990     case 'o':
991         base = 8;

```



```

992         flag |= SCAN_DEST_INT;
993         c++;
994         break;
995     case 'x':
996     case 'X':
997         base = 16;
998         flag |= SCAN_DEST_INT;
999         c++;
1000        break;
1001    case 'i':
1002        base = 0;
1003        flag |= SCAN_DEST_INT;
1004        c++;
1005        break;
1006    #if defined(SCANF_FLOAT_ENABLE)
1007        case 'a':
1008        case 'A':
1009        case 'e':
1010        case 'E':
1011        case 'f':
1012        case 'F':
1013        case 'g':
1014        case 'G':
1015            flag |= SCAN_DEST_FLOAT;
1016            c++;
1017            break;
1018    #endif
1019    case 'c':
1020        flag |= SCAN_DEST_CHAR;
1021        if (!field_width)
1022        {
1023            field_width = 1;
1024        }
1025        c++;
1026        break;
1027    case 's':
1028        flag |= SCAN_DEST_STRING;
1029        c++;
1030        break;
1031    #if defined(ADVANCE) /* [x]*/
1032    case '[':
1033        flag |= SCAN_DEST_SET;
1034        /*Add Set functionality */
1035        break;

```

```

1036 #endif
1037         default:
1038 #if defined(SCAN_DEBUG)
1039         printf("Unrecognized expression specifier: %c format: %s,
            number is: %d\r\n", c, format, nassigned);
1040 #endif
1041         return nassigned;
1042     }
1043 }
1044
1045 if (!(flag & SCAN_DEST_MASK))
1046 {
1047     /* Format strings are exhausted */
1048     return nassigned;
1049 }
1050
1051 if (!field_width)
1052 {
1053     /* Larget then length of a line */
1054     field_width = 99;
1055 }
1056
1057 /* Matching strings in input streams and assign to argument */
1058 switch (flag & SCAN_DEST_MASK)
1059 {
1060     case SCAN_DEST_CHAR:
1061         s = (const char *)p;
1062         buf = va_arg(args_ptr, char *);
1063         while ((field_width--) && (*p))
1064         {
1065             if (!(flag & SCAN_SUPPRESS))
1066             {
1067                 *buf++ = *p++;
1068             }
1069             else
1070             {
1071                 p++;
1072             }
1073             n_decode++;
1074         }
1075
1076         if (((!(flag)) & SCAN_SUPPRESS) && (s != p))
1077         {
1078             nassigned++;

```

```

1079     }
1080     break;
1081     case SCAN_DEST_STRING:
1082         n_decode += scan_ignore_white_space(&p);
1083         s = p;
1084         buf = va_arg(args_ptr, char *);
1085         while ((field_width--) && (*p != '\0') && (*p != ' ') &&
1086             (*p != '\t') && (*p != '\n') && (*p != '\r') && (*p !=
1087             '\v') && (*p != '\f'))
1088         {
1089             if (flag & SCAN_SUPPRESS)
1090             {
1091                 p++;
1092             }
1093             else
1094             {
1095                 *buf++ = *p++;
1096             }
1097             n_decode++;
1098         }
1099         if ((!(flag & SCAN_SUPPRESS)) && (s != p))
1100         {
1101             /* Add NULL to end of string */
1102             *buf = '\0';
1103             nassigned++;
1104         }
1105         break;
1106     case SCAN_DEST_INT:
1107         n_decode += scan_ignore_white_space(&p);
1108         s = p;
1109         val = 0;
1110         /*TODO: scope is not teststed */
1111         if ((base == 0) || (base == 16))
1112         {
1113             if ((s[0] == '0') && ((s[1] == 'x') || (s[1] == 'X')))
1114             {
1115                 base = 16;
1116                 if (field_width >= 1)
1117                 {
1118                     p += 2;
1119                     n_decode += 2;
1120                     field_width -= 2;
1121                 }

```

```

1122     }
1123 }
1124
1125 if (base == 0)
1126 {
1127     if (s[0] == '0')
1128     {
1129         base = 8;
1130     }
1131     else
1132     {
1133         base = 10;
1134     }
1135 }
1136
1137 neg = 1;
1138 switch (*p)
1139 {
1140     case '-':
1141         neg = -1;
1142         n_decode++;
1143         p++;
1144         field_width--;
1145         break;
1146     case '+':
1147         neg = 1;
1148         n_decode++;
1149         p++;
1150         field_width--;
1151         break;
1152     default:
1153         break;
1154 }
1155
1156 while ((*p) && (field_width--))
1157 {
1158     if ((*p <= '9') && (*p >= '0'))
1159     {
1160         temp = *p - '0';
1161     }
1162     else if ((*p <= 'f') && (*p >= 'a'))
1163     {
1164         temp = *p - 'a' + 10;
1165     }

```



```

1207         else
1208         {
1209             *va_arg(args_ptr, unsigned short *) = (unsigned
short)val;
1210         }
1211         break;
1212     case SCAN_LENGTH_LONG_INT:
1213         if (flag & SCAN_TYPE_SIGNED)
1214         {
1215             *va_arg(args_ptr, signed long int *) = (signed
long int)val;
1216         }
1217         else
1218         {
1219             *va_arg(args_ptr, unsigned long int *) = (unsigned
long int)val;
1220         }
1221         break;
1222     case SCAN_LENGTH_LONG_LONG_INT:
1223         if (flag & SCAN_TYPE_SIGNED)
1224         {
1225             *va_arg(args_ptr, signed long long int *) =
(signed long long int)val;
1226         }
1227         else
1228         {
1229             *va_arg(args_ptr, unsigned long long int *) =
(unsigned long long int)val;
1230         }
1231         break;
1232     default:
1233         /* The default type is the type int */
1234         if (flag & SCAN_TYPE_SIGNED)
1235         {
1236             *va_arg(args_ptr, signed int *) = (signed int)val;
1237         }
1238         else
1239         {
1240             *va_arg(args_ptr, unsigned int *) = (unsigned
int)val;
1241         }
1242         break;
1243     }
1244     nassigned++;

```

```

1245         }
1246         break;
1247 #if defined(SCANF_FLOAT_ENABLE)
1248     case SCAN_DEST_FLOAT:
1249         n_decode += scan_ignore_white_space(&p);
1250         fnum = strtod(p, (char **)&s);
1251
1252         if ((fnum == HUGE_VAL) || (fnum == -HUGE_VAL))
1253         {
1254             break;
1255         }
1256
1257         n_decode += (int)(s) - (int)(p);
1258         p = s;
1259         if (!(flag & SCAN_SUPPRESS))
1260         {
1261             if (flag & SCAN_LENGTH_LONG_DOUBLE)
1262             {
1263                 *va_arg(args_ptr, double *) = fnum;
1264             }
1265             else
1266             {
1267                 *va_arg(args_ptr, float *) = (float)fnum;
1268             }
1269             nassigned++;
1270         }
1271         break;
1272 #endif
1273 #if defined(ADVANCE)
1274     case SCAN_DEST_SET:
1275         break;
1276 #endif
1277     default:
1278 #if defined(SCAN_DEBUG)
1279         printf("ERROR: File %s line: %d\r\n", __FILE__, __LINE__);
1280 #endif
1281         return nassigned;
1282     }
1283 }
1284 }
1285 return nassigned;
1286 }
1287
1288 /*FUNCTION*****

```

```

1289  *
1290  * Function Name : scan_ignore_white_space
1291  * Description   : Scanline function which ignores white spaces.
1292  *
1293  *END*****
1294  static uint32_t scan_ignore_white_space(const char **s)
1295  {
1296      uint8_t count = 0;
1297      uint8_t c;
1298
1299      c = **s;
1300      while ((c == ' ') || (c == '\t') || (c == '\n') || (c == '\r') || (c == '\v') ||
1301              (c == '\f'))
1302      {
1303          count++;
1304          (*s)++;
1305          c = **s;
1306      }
1307      return count;
1308  }

```

7.22 ../Sources/print_scan.h

```
1  /*
2  * Copyright (c) 2013 - 2014, Freescale Semiconductor, Inc.
3  * All rights reserved.
4  *
5  * Redistribution and use in source and binary forms, with or without modification,
6  * are permitted provided that the following conditions are met:
7  *
8  * o Redistributions of source code must retain the above copyright notice, this list
9  *   of conditions and the following disclaimer.
10 *
11 * o Redistributions in binary form must reproduce the above copyright notice, this
12 *   list of conditions and the following disclaimer in the documentation and/or
13 *   other materials provided with the distribution.
14 *
15 * o Neither the name of Freescale Semiconductor, Inc. nor the names of its
16 *   contributors may be used to endorse or promote products derived from this
17 *   software without specific prior written permission.
18 *
19 * THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND
20 * ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED
21 * WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE
22 * DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR
23 * ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES
24 * (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES;
25 * LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON
26 * ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
27 * (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS
28 * SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
29 */
30 #ifndef __print_scan_h__
31 #define __print_scan_h__
32
33 #include <stdio.h>
34 #include <stdarg.h>
35 #include <stdint.h>
36 #include <stdbool.h>
37 #include <string.h>
38
39 // #define PRINTF_FLOAT_ENABLE    1
40 // #define PRINT_MAX_COUNT        1
41 // #define SCANF_FLOAT_ENABLE     1
42
```

```

43 #ifndef HUGE_VAL
44 #define HUGE_VAL          (99.e99)///wrong value
45 #endif
46
47 typedef int (*PUTCHAR_FUNC)(int a, void *b);
48
49 /*!
50 * @brief This function outputs its parameters according to a formatted string.
51 *
52 * @note I/O is performed by calling given function pointer using following
53 * (*func_ptr)(c,farg);
54 *
55 * @param[in] farg      Argument to func_ptr.
56 * @param[in] func_ptr  Function to put character out.
57 * @param[in] max_count Maximum character count for snprintf and vsnprintf.
58 * Default value is 0 (unlimited size).
59 * @param[in] fmt_ptr   Format string for printf.
60 * @param[in] args_ptr  Arguments to printf.
61 *
62 * @return Number of characters
63 * @return EOF (End Of File found.)
64 */
65 int _doprint(void *farg, PUTCHAR_FUNC func_ptr, int max_count, char *fmt, va_list ap);
66
67 /*!
68 * @brief Writes the character into the string located by the string pointer and
69 * updates the string pointer.
70 *
71 * @param[in]      c          The character to put into the string.
72 * @param[in, out] input_string This is an updated pointer to a string pointer.
73 *
74 * @return Character written into string.
75 */
76 int _sputc(int c, void * input_string);
77
78 /*!
79 * @brief Converts an input line of ASCII characters based upon a provided
80 * string format.
81 *
82 * @param[in] line_ptr The input line of ASCII data.
83 * @param[in] format   Format first points to the format string.
84 * @param[in] args_ptr The list of parameters.
85 *
86 * @return Number of input items converted and assigned.

```

```
87  * @return IO_EOF - When line_ptr is empty string "".
88  */
89  int scan_prv(const char *line_ptr, char *format, va_list args_ptr);
90
91  #endif
```

7.23 ../Sources/Protocolo/cmdmachine_hal.c

```
1  /* ***** */
2  /* File name:      cmdmachine_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                interfaces for protocol command machine */
5  /* Author name:    ddello */
6  /* Creation date:   27abr2016 */
7  /* Revision date:   13mai2016 */
8  /* ***** */
9  #include <string.h>
10 #include <stdio.h>
11 #include "cmdmachine_hal.h"
12 #include "LedSwi/ledswi_hal.h"
13 #include "Buzzer/buzzer_hal.h"
14 #include "SevenSeg/sevensseg_hal.h"
15 #include "LCD/lcd_hal.h"
16 #include "Util/util.h"
17 #include "Cooler/cooler_hal.h"
18 #include "TempSensor/tempSensor_hal.h"
19
20 #define ERR_STR "ERR\n"
21 #define ACK_STR "ACK\n"
22
23 #define STATE_IDLE 0
24 #define STATE_LED_CMD 1
25 #define STATE_BUZZER_CMD 2
26 #define STATE_SWITCH_CMD 3
27 #define STATE_SEVENSEG_CMD 4
28 #define STATE_LCD_CMD 5
29 #define STATE_COOLER_CMD 6
30 #define STATE_TEMP_CMD 7
31 #define STATE_ERR 99
32
33 static int iState = STATE_IDLE;
34
35 //=====
36 // IDLE STATE MACHINE
37 //=====
38 /**
39  * Handles parsing while in IDLE state and checks for transitions
40  *
41  * @param cpCmdBuffer The start of the command string to parse
42  * @param uiSize The size of the command string
```

```

43  * @param cpCmdRes Buffer for concatenating the command response
44  *
45  * @return The number of characters parsed while in the IDLE state
46  */
47  unsigned int handleIdle(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
48      unsigned int uiCounter = 0;
49      while(uiCounter < uiSize && iState == STATE_IDLE){
50          switch(cpCmdBuffer[uiCounter++){
51              case 'L':
52                  iState = STATE_LED_CMD;
53                  break;
54              case 'S':
55                  iState = STATE_SWITCH_CMD;
56                  break;
57              case 'B':
58                  iState = STATE_BUZZER_CMD;
59                  break;
60              case 'D':
61                  iState = STATE_SEVENSEG_CMD;
62                  break;
63              case 'P':
64                  iState = STATE_LCD_CMD;
65                  break;
66              case 'C':
67                  iState = STATE_COOLER_CMD;
68                  break;
69              case 'T':
70                  iState = STATE_TEMP_CMD;
71                  break;
72              case ' ':
73              case '\t':
74              case '\r':
75              case '\n':
76              case '\0':
77                  break;
78              default:
79                  iState = STATE_ERR;
80          }
81      }
82      return uiCounter;
83  }
84
85  // =====
86  // LED CMD STATE MACHINE

```

```

87 //=====
88 /**
89  * Parses character ledNumberReference into a led number
90  *
91  * @param ccLedInput Character between '1' and '4' referring to the desired
92  *         led number
93  *
94  * @return Led number reference (number between 1 and 4) or -1 in case of invalid
95  *         input
96  */
97 ledswi_pin_type_e parseLedNum(char cLedInput){
98     switch(cLedInput){
99         case '1':
100             return LS_1;
101         case '2':
102             return LS_2;
103         case '3':
104             return LS_3;
105         case '4':
106             return LS_4;
107         default:
108             iState = STATE_ERR;
109             return UNKNOWN;
110     }
111 }
112
113 /**
114  * Handles parsing while in LED_COMMAND state and checks for transitions
115  *
116  * @param cpCmdBuffer The start of the command string to parse
117  * @param uiSize The size of the command string
118  * @param cpCmdRes Buffer for concatenating the command response
119  *
120  * @return The number of characters parsed while in the LED_COMMAND state
121  */
122 unsigned int handleLed(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
123     unsigned int uiCounter = 0;
124     ledswi_pin_type_e eLedNum = UNKNOWN;
125     void (*fpLedFunction)(ledswi_pin_type_e);
126     while(uiCounter < uiSize && iState == STATE_LED_CMD){
127         switch(cpCmdBuffer[uiCounter++){
128             case 'C':
129                 eLedNum = parseLedNum(cpCmdBuffer[uiCounter++]);
130                 fpLedFunction = &ledswi_clearLed;

```

```

131         break;
132     case 'S':
133         eLedNum = parseLedNum(cpCmdBuffer[uiCounter++]);
134         fpLedFunction = &ledswi_setLed;
135         break;
136     case 'R':
137         eLedNum = parseLedNum(cpCmdBuffer[uiCounter++]);
138         if(eLedNum != UNKNOWN){
139             strcat(cpCmdRes, ACK_STR);
140             ledswi_setLed(eLedNum);
141             if(ledswi_getLedStatus(eLedNum) == LED_ON){
142                 strcat(cpCmdRes, "O\n");
143             }else{
144                 strcat(cpCmdRes, "C\n");
145             }
146             iState = STATE_IDLE;
147         }else{
148             iState = STATE_ERR;
149         }
150         return uiCounter;
151         break;
152     default:
153         iState = STATE_ERR;
154     }
155 }
156 if(eLedNum != UNKNOWN){
157     strcat(cpCmdRes, ACK_STR);
158     ledswi_initLed(eLedNum);
159     (*fpLedFunction)(eLedNum);
160     iState = STATE_IDLE;
161 }else{
162     iState = STATE_ERR;
163 }
164 return uiCounter;
165 }
166 //=====
167 // SWITCH CMD STATE MACHINE
168 //=====
169 /**
170  * Handles parsing while in SWITCH_COMMAND state and checks for transitions
171  *
172  * @param cpCmdBuffer The start of the command string to parse
173  * @param uiSize The size of the command string
174  * @param cpCmdRes Buffer for concatenating the command response

```

```

175  *
176  * @return The number of characters parsed while in the SWITCH_COMMAND state
177  */
178  unsigned int handleSwitch(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
179      unsigned int uiCounter = 0;
180      ledswi_pin_type_e eSwiNum = UNKNOWN;
181      while(uiCounter < uiSize && iState == STATE_SWITCH_CMD){
182          switch(cpCmdBuffer[uiCounter++){
183              case '1':
184                  eSwiNum = LS_1;
185                  break;
186              case '2':
187                  eSwiNum = LS_2;
188                  break;
189              case '3':
190                  eSwiNum = LS_3;
191                  break;
192              case '4':
193                  eSwiNum = LS_4;
194                  break;
195              default:
196                  eSwiNum = UNKNOWN;
197                  break;
198          }
199          if(eSwiNum != UNKNOWN){
200              strcat(cpCmdRes, ACK_STR);
201              ledswi_initSwitch(eSwiNum);
202              if(ledswi_getSwitchStatus(eSwiNum) == SWITCH_ON){
203                  strcat(cpCmdRes, "0\n");
204              }else{
205                  strcat(cpCmdRes, "C\n");
206              }
207              iState = STATE_IDLE;
208          }else{
209              iState = STATE_ERR;
210          }
211      }
212      return uiCounter;
213  }
214
215
216  //=====
217  // BUZZER CMD STATE MACHINE
218  //=====

```



```

219 /**
220  * Parses Buzzer command milliseconds input into integer
221  *
222  * @param cpCmdBuffer The start of the Buzzer command milliseconds input string
223  *
224  * @return The parsed number of milliseconds contained in the start of the command
225  *         string or -1 in case of parsing failure
226  */
227 int getBuzzMs(char *cpCmdBuffer){
228     int iMs = -1;
229     if(!sscanf(cpCmdBuffer, "%3d", &iMs)){
230         iMs = -1;
231     }
232     return iMs;
233 }
234
235 /**
236  * Handles parsing while in BUZZER_COMMAND state and checks for transitions
237  *
238  * @param cpCmdBuffer The start of the command string to parse
239  * @param uiSize The size of the command string
240  * @param cpCmdRes Buffer for concatenating the command response
241  *
242  * @return The number of characters parsed while in the BUZZER_COMMAND state
243  */
244 int handleBuzzer(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
245     unsigned int uiCounter = 0;
246     int iBuzzMs = -1;
247     if(uiCounter < uiSize){
248         iBuzzMs = getBuzzMs(cpCmdBuffer);
249     }
250     if(iBuzzMs >= 0){
251         strcat(cpCmdRes, ACK_STR);
252         buzzer_initPeriodic(440, iBuzzMs);    //440Hz
253         iState = STATE_IDLE;
254         //Exactly how many characters where read.
255         while(uiCounter < 3 && uiCounter < uiSize && cpCmdBuffer[uiCounter] >= '0' &&
            cpCmdBuffer[uiCounter] <= '9'){
256             uiCounter++;
257         }
258     }else{
259         iState = STATE_ERR;
260     }
261     return uiCounter;

```

```

262 }
263
264
265 //=====
266 // Seven Segment CMD STATE MACHINE
267 //=====
268 /**
269  * Parses SevenSeg command hexadecimal input into integer
270  *
271  * @param cpCmdBuffer The start of the Buzzer command hexadecimal input string
272  *
273  * @return The parsed number contained in the start of the command
274  *         string or -1 in case of parsing failure
275  */
276 int getSevenSegHex(char *cpCmdBuffer){
277     int iCommand = -1;
278     if(!sscanf(cpCmdBuffer, "%4x", &iCommand)){
279         iCommand = -1;
280     }
281     return iCommand;
282 }
283
284 /**
285  * Handles parsing while in SEVSEG_COMMAND state and checks for transitions
286  *
287  * @param cpCmdBuffer The start of the command string to parse
288  * @param uiSize The size of the command string
289  * @param cpCmdRes Buffer for concatenating the command response
290  *
291  * @return The number of characters parsed while in the SEVSEG_COMMAND state
292  */
293 int handleSevenSeg(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
294     unsigned int uiCounter = 0;
295     int iHex = -1;
296     if(uiCounter < uiSize){
297         iHex = getSevenSegHex(cpCmdBuffer);
298     }
299     if(iHex >= 0){
300         strcat(cpCmdRes, ACK_STR);
301         sevenseg_printHex(iHex);
302         iState = STATE_IDLE;
303         //Exactly how many characters where read.
304         while(uiCounter < 4 && uiCounter < uiSize && ((cpCmdBuffer[uiCounter] >= '0' &&
            cpCmdBuffer[uiCounter] <= '9') || (cpCmdBuffer[uiCounter] >= 'A' &&

```

```

        cpCmdBuffer[uiCounter] <= 'F')) ){
305     uiCounter++;
306 }
307 }else{
308     iState = STATE_ERR;
309 }
310 return uiCounter;
311 }
312
313 //=====
314 // Cooler CMD STATE MACHINE
315 //=====
316 /**
317  * Parses Cooler command hexadecimal input into integer
318  *
319  * @param cpCmdBuffer The start of the Buzzer command hexadecimal input string
320  *
321  * @return The parsed number contained in the start of the command
322  *         string or -1 in case of parsing failure
323  */
324 int getCoolerHex(char *cpCmdBuffer){
325     int iCommand = -1;
326     if(!sscanf(cpCmdBuffer, "%4x", &iCommand)){
327         iCommand = -1;
328     }
329     return iCommand;
330 }
331
332 /**
333  * Handles parsing while in COOLER_CMD state and checks for transitions
334  *
335  * @param cpCmdBuffer The start of the command string to parse
336  * @param uiSize The size of the command string
337  * @param cpCmdRes Buffer for concatenating the command response
338  *
339  * @return The number of characters parsed while in the COOLER_COMMAND state
340  */
341 int handleCooler(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
342     unsigned int uiCounter = 0;
343     int iHex = -1;
344     if(uiCounter < uiSize){
345         iHex = getCoolerHex(cpCmdBuffer);
346     }
347     if(iHex >= 0){

```

```

348     strcat(cpCmdRes, ACK_STR);
349     cooler_setVelocity(iHex);
350     iState = STATE_IDLE;
351     //Exactly how many characters where read.
352     while(uiCounter < 4 && uiCounter < uiSize && ((cpCmdBuffer[uiCounter] >= '0' &&
        cpCmdBuffer[uiCounter] <= '9') || (cpCmdBuffer[uiCounter] >= 'A' &&
        cpCmdBuffer[uiCounter] <= 'F')) ){
353         uiCounter++;
354     }
355 }else{
356     iState = STATE_ERR;
357 }
358 return uiCounter;
359 }
360
361 //=====
362 // TEMP CMD STATE MACHINE
363 //=====
364 /**
365  * Handles parsing while in TEMP_COMMAND state and checks for transitions
366  *
367  * @param cpCmdBuffer The start of the command string to parse
368  * @param uiSize The size of the command string
369  * @param cpCmdRes Buffer for concatenating the command response
370  *
371  * @return The number of characters parsed while in the TEMP_COMMAND state
372  */
373 int handleTemp(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
374     char iPrintBuff[30];
375     strcat(cpCmdRes, ACK_STR);
376     sprintf(iPrintBuff, "%d", tempSensor_getLastConversionRawResult());
377     strcat(cpCmdRes, iPrintBuff);
378     iState = STATE_IDLE;
379     return 0;
380 }
381
382 //=====
383 // LCD CMD STATE MACHINE
384 //=====
385 /**
386  * Handles parsing while in LCD_COMMAND state and checks for transitions
387  *
388  * @param cpCmdBuffer The start of the command string to parse
389  * @param uiSize The size of the command string

```

```

390  * @param cpCmdRes Buffer for concatenating the command response
391  *
392  * @return The number of characters parsed while in the LCD_COMMAND state
393  */
394  int handleLCD(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
395      unsigned int uiCounter = 0;
396      char iPrintBuff[30];
397      if(uiCounter < uiSize){
398          sscanf(cpCmdBuffer, "%30s", iPrintBuff);
399          uiCounter += strlen(iPrintBuff);
400          strcat(cpCmdRes, ACK_STR);
401          lcd_printString(iPrintBuff);
402          iState = STATE_IDLE;
403      }else{
404          iState = STATE_ERR;
405      }
406      return uiCounter;
407  }
408
409  //=====
410  // ERROR STATE MACHINE
411  //=====
412  /**
413   * Handles parsing while in ERR state and checks for transitions
414   *
415   * @param cpCmdBuffer The start of the command string to parse
416   * @param uiSize The size of the command string
417   * @param cpCmdRes Buffer for concatenating the command response
418   *
419   * @return The number of characters parsed while in the ERR state
420   */
421  int handleError(char *cpCmdBuffer, unsigned int uiSize, char* cpCmdRes){
422      int uiCounter = 0;
423      while(uiCounter < uiSize && iState == STATE_ERR){
424          switch(cpCmdBuffer[uiCounter++){
425              case ' ':
426              case '\t':
427              case '\r':
428              case '\n':
429              case '\0':
430                  iState = STATE_IDLE;
431                  break;
432              default:
433                  break;

```

```

434     }
435 }
436 strcat(cpCmdRes, ERR_STR);
437 return uiCounter;
438 }
439
440
441 /**
442  * Interpret all commands in the given command buffer.
443  * Will trigger the command execution and format an output string for printing
444  * Ignores blanks (\r,\n, ,\t,\0) between commands.
445  *
446  * For each valid command, the string ACK will be concatenated to the response string
447  * followed by a line-break and the command response (if any).
448  *
449  * If invalid command syntax is found ERR will be concatenated to the response string
450  * and all the characters before the next blank (\r,\n, ,\t,\0) will be ignored.
451  *
452  * @param cpCmdBuffer Pointer to command buffer
453  * @param uiSize Size of the command buffer
454  * @param cpCmdRes Pointer for response string.
455  *
456  * @after cpCmdRes with the response string for this cmdBuffer,
457  * this will contain a ACK for each valid command in the cmdBuffer
458  * followed by a line break and the command output (if any).
459  * If an invalid command syntax is found the output string will contain
460  * an ERR\n for that command and all characters before the next blank
461  * (\r,\n, ,\t,\0) will be ignored.
462  */
463 void cmdmachine_interpretCmdBuffer(char *cpCmdBuffer, unsigned int uiSize, char*
    cpCmdRes){
464     iState = STATE_IDLE;
465     *cpCmdRes = '\0'; //Start response as an empty string.
466     unsigned int uiCounter = 0;
467     while(uiCounter < uiSize){
468         switch(iState){
469             case STATE_IDLE:
470                 uiCounter += handleIdle(&cpCmdBuffer[uiCounter], uiSize - uiCounter, cpCmdRes);
471                 break;
472             case STATE_LED_CMD:
473                 uiCounter += handleLed(&cpCmdBuffer[uiCounter], uiSize - uiCounter, cpCmdRes);
474                 break;
475             case STATE_SWITCH_CMD:

```

```

476         uiCounter += handleSwitch(&cpCmdBuffer[uiCounter], uiSize - uiCounter,
cpCmdRes);
477         break;
478     case STATE_BUZZER_CMD:
479         uiCounter += handleBuzzer(&cpCmdBuffer[uiCounter], uiSize - uiCounter,
cpCmdRes);
480         break;
481     case STATE_SEVENSEG_CMD:
482         uiCounter += handleSevenSeg(&cpCmdBuffer[uiCounter], uiSize - uiCounter,
cpCmdRes);
483         break;
484     case STATE_LCD_CMD:
485         uiCounter += handleLCD(&cpCmdBuffer[uiCounter], uiSize - uiCounter, cpCmdRes);
486         break;
487     case STATE_COOLER_CMD:
488         uiCounter += handleCooler(&cpCmdBuffer[uiCounter], uiSize - uiCounter,
cpCmdRes);
489         break;
490     case STATE_TEMP_CMD:
491         uiCounter += handleTemp(&cpCmdBuffer[uiCounter], uiSize - uiCounter, cpCmdRes);
492         break;
493     case STATE_ERR:
494         uiCounter += handleError(&cpCmdBuffer[uiCounter], uiSize - uiCounter,
cpCmdRes);
495         break;
496     }
497 }
498 }

```

7.24 ../Sources/Protocolo/cmdmachine_hal.h

```
1  /* ***** */
2  /* File name:      cmdmachine_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for protocol command machine */
5  /* Author name:    ddello */
6  /* Creation date:   27abr2016 */
7  /* Revision date:   27abr2016 */
8  /* ***** */
9
10 #ifndef SOURCES_CMDMACHINE_HAL_H_
11 #define SOURCES_CMDMACHINE_HAL_H_
12
13 /**
14  * Interpret all commands in the given command buffer.
15  * Will trigger the command execution and format an output string for printing
16  * Ignores blanks (\r,\n, ,\t,\0) between commands.
17  *
18  * For each valid command, the string ACK will be concatenated to the response string
19  * followed by a line-break and the command response (if any).
20  *
21  * If invalid command syntax is found ERR will be concatenated to the response string
22  * and all the characters before the next blank (\r,\n, ,\t,\0) will be ignored.
23  *
24  * @param cpCmdBuffer Pointer to command buffer
25  * @param uiSize Size of the command buffer
26  * @param cpCmdRes Pointer for response string.
27  *
28  * @after cpCmdRes with the response string for this cmdBuffer,
29  *        this will contain a ACK for each valid command in the cmdBuffer
30  *        followed by a line break and the command output (if any).
31  *        If an invalid command syntax is found the output string will contain
32  *        an ERR\n for that command and all characters before the next blank
33  *        (\r,\n, ,\t,\0) will be ignored.
34  */
35 void cmdmachine_interpretCmdBuffer(char *cpCmdBuffer, unsigned int uiSize, char*
    cpCmdRes);
36
37 #endif /* SOURCES_CMDMACHINE_HAL_H_ */
```

7.25 ../Sources/Serial/serial_hal.c

```
1  /* ***** */
2  /* File name:      serial_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                interfaces for serial communication */
5  /* Author name:    ddello */
6  /* Creation date:   27abr2016 */
7  /* Revision date:   27abr2016 */
8  /* ***** */
9
10 #include "serial_hal.h"
11 #include "KL25Z/es670_peripheral_board.h"
12 #include "fsl_clock_manager.h"
13 #include "fsl_debug_console.h"
14
15
16 /* The UART to use for debug messages */
17 #ifndef BOARD_DEBUG_UART_INSTANCE
18     #define BOARD_DEBUG_UART_INSTANCE    0
19     #define BOARD_DEBUG_UART_BASEADDR    UART0
20 #endif
21 #ifndef BOARD_DEBUG_UART_BAUD
22     #define BOARD_DEBUG_UART_BAUD        9600
23 #endif
24
25
26 /**
27  * Initialize the serial device configuration
28  */
29 void serial_initUart(void){
30     /* LPSCI0 */
31     /* UART0_RX */
32     PORT_PCR_REG(PORTA , 1) = PORT_PCR_MUX(2U);
33     /* UART0_TX */
34     PORT_PCR_REG(PORTA , 2) = PORT_PCR_MUX(2U);
35
36
37     /* Select different clock source for LPSCI */
38     CLOCK_SYS_SetLpSciSrc(BOARD_DEBUG_UART_INSTANCE , kClockLpSciSrcPll1Sel);
39
40     /* init the debug console */
41     DbgConsole_Init(BOARD_DEBUG_UART_INSTANCE , BOARD_DEBUG_UART_BAUD ,
42                     kDebugConsoleLPSCI);
```

```

42 }
43
44
45 /**
46  * Write buffer content to serial port
47  *
48  * @param cpBuffer Pointer to the start of the buffer
49  * @param uiSize Number of characters to write
50  */
51 void serial_sendBuffer(char *cpBuffer, unsigned int uiSize){
52     while(uiSize--){
53         while (!UART0_BRD_S1_TDRE(UART0)){
54             //Wait for room in the transmission buffer
55         }
56         UART0_D = (*cpBuffer++);
57     }
58 }
59
60
61 /**
62  * Receive content from serial port to buffer.
63  *
64  * This function will read until one of {\n, \0} is found
65  *
66  * @param cpBuffer Pointer to the start of the buffer
67  * @param uiSize Maximum number of characters to be read from serial port
68  *
69  * @return The number of characters actually read if the successful,
70  *         -1 in case of buffer overRun
71  */
72 int serial_recieveBuffer(char *cpBuffer, unsigned int uiSize){
73     int ret = 0;
74     while(uiSize--){
75         while(!UART0_BRD_S1_RDRF(UART0)){
76             //Wait for transmission buffer to be filled
77         }
78         *cpBuffer = UART0_D;
79         ret++;
80         //In case of a buffer overRun
81         if(UART0_BRD_S1_OR(UART0)){
82             //Clear OR flag so we can continue to receive
83             UART0_BWR_S1_OR(UART0,1U);
84             return -1;
85         }

```

```
86
87     switch(*cpBuffer){
88         case '\n':
89         case '\r':
90             *(++cpBuffer) = '\0';
91         case '\0':
92             return ret;
93         default:
94             cpBuffer++;
95     }
96 }
97 *cpBuffer = '\0';
98 return ret;
99 }
```

7.26 ../Sources/Serial/serial_hal.h

```
1  /* ***** */
2  /* File name:      serial_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for serial communication */
5  /* Author name:     ddello */
6  /* Creation date:    27abr2016 */
7  /* Revision date:    27abr2016 */
8  /* ***** */
9
10 #ifndef SOURCES_SERIAL_HAL_H_
11 #define SOURCES_SERIAL_HAL_H_
12
13 /**
14  * Initialize the serial device configuration
15  */
16 void serial_initUart(void);
17
18
19 /**
20  * Write buffer content to serial port
21  *
22  * @param cpBuffer Pointer to the start of the buffer
23  * @param uiSize Number of characters to write
24  */
25 void serial_sendBuffer(char *cpBuffer, unsigned int uiSize);
26
27
28 /**
29  * Receive content from serial port to buffer.
30  *
31  * This function will read until one of {\n, \0} is found
32  *
33  * @param cpBuffer Pointer to the start of the buffer
34  * @param uiSize Maximum number of characters to be read from serial port
35  *
36  * @return The number of characters actually read if the successful,
37  *         -1 in case of buffer overRun
38  */
39 int serial_recieveBuffer(char *cpBuffer, unsigned int uiSize);
40
41 #endif /* SOURCES_SERIAL_HAL_H_ */
```

7.27 ../Sources/SevenSeg/sevenseg_hal.c

```
1  /* ***** */
2  /* File name:      sevenseg_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                for handling SEVEN SEGMENT DISPLAY */
5  /*                from the peripheral board */
6  /* Author name:    ddello */
7  /* Creation date:   18mar2016 */
8  /* Revision date:   13abr2016 */
9  /* ***** */
10
11 #include "GPIO/gpio_hal.h"
12 #include "sevenseg_hal.h"
13 #include "math.h"
14 #include "KL25Z/es670_peripheral_board.h"
15 #include "PIT/pit_hal.h"
16
17 #define SEV_SEG_SEGMENT_MASK GPIO_HIGH << SEGA_PIN | GPIO_HIGH << SEGB_PIN | GPIO_HIGH
18     << SEGC_PIN | GPIO_HIGH << SEGD_PIN | GPIO_HIGH << SEGE_PIN | GPIO_HIGH << SEGF_PIN
19     | GPIO_HIGH << SEGG_PIN | GPIO_HIGH << SEGDP_PIN
20 #define SEV_SEG_DISP_MASK GPIO_HIGH << SEG_DISP1_PIN | GPIO_HIGH << SEG_DISP2_PIN |
21     GPIO_HIGH << SEG_DISP3_PIN | GPIO_HIGH << SEG_DISP4_PIN
22
23 #define SEVEN_SEG_PIT_PERIOD 3125 /*3.125ms*/
24
25 static unsigned short usIsHex = 0;
26 static unsigned int uiPrintVal = 0;
27
28 static seven_segment_seg_type_e epSeg_Matrix[MAX_DISP_NUMBER][MAX_SEGMENT_NUMBER+1];
29
30 /**
31  * Interrupt handler for updating in display configuration
32  */
33 void _sevenseg_interrupt_handler(void){
34     static seven_segment_disp_type_e epDisplays[] = {DISP_1, DISP_2, DISP_3, DISP_4};
35     static volatile unsigned short usCur_disp = 0;
36     sevenseg_setSegs(epSeg_Matrix[usCur_disp]);
37     sevenseg_setDisp(epDisplays[usCur_disp]);
38     usCur_disp = (usCur_disp+1)%MAX_DISP_NUMBER;
39     pit_mark_interrupt_handled(SEV_SEG_PIT_TIMER_NUMB);
40 }
41
42 /**
43  * Initialize the seven segment display
44  */
```

```

40 */
41 void sevenseg_init(void){
42     GPIO_UNGATE_PORT(SEV_SEG_PORT_ID);
43
44     // Init the Seven Segment segment control pins as OUTPUT
45     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGA_PIN, GPIO_OUTPUT);
46     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGB_PIN, GPIO_OUTPUT);
47     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGC_PIN, GPIO_OUTPUT);
48     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGD_PIN, GPIO_OUTPUT);
49     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGE_PIN, GPIO_OUTPUT);
50     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGF_PIN, GPIO_OUTPUT);
51     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGG_PIN, GPIO_OUTPUT);
52     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEGDP_PIN, GPIO_OUTPUT);
53     // Init the Seven Segment segment display pins as OUTPUT
54     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEG_DISP1_PIN, GPIO_OUTPUT);
55     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEG_DISP2_PIN, GPIO_OUTPUT);
56     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEG_DISP3_PIN, GPIO_OUTPUT);
57     GPIO_INIT_PIN(SEV_SEG_PORT_ID, SEG_DISP4_PIN, GPIO_OUTPUT);
58
59     sevenseg_printDec(0);
60     //Init pit interrupts
61     pit_enable();
62     //Init timer 0
63     pit_start_timer_interrupt(SEV_SEG_PIT_TIMER_NUMB, SEVEN_SEG_PIT_PERIOD,
64                             &_sevenseg_interrupt_handler);
65 }
66
67 /**
68  * Sets only the selected segments as high. Setting the others as low
69  * @param epDet_segments = Array with the segments that should be set as on (Last
70     element should be SEG_END)
71 */
72 void sevenseg_setSegs(seven_segment_seg_type_e* epSet_segments){
73     //Clear all segments.
74     GPIO_WRITE_MASK(SEV_SEG_PORT_ID, SEV_SEG_SEGMENT_MASK, GPIO_LOW);
75     //Set the selected segments to high
76     for(unsigned short usCounter = 0; epSet_segments[usCounter] != SEG_END; usCounter++){
77         GPIO_WRITE_PIN(SEV_SEG_PORT_ID, epSet_segments[usCounter], GPIO_HIGH);
78     }
79 }
80 /**
81  * Shows the value written in the segment pins to the

```

```

82  *   given display after clearing the others
83  *   @param eDisplay the display to initialize.
84  */
85  void sevenseg_setDisp(seven_segment_disp_type_e eDisplay){
86      //Clear all displays
87      GPIO_WRITE_MASK(SEV_SEG_PORT_ID, SEV_SEG_DISP_MASK, GPIO_LOW);
88      //Activate the selected display
89      GPIO_WRITE_PIN(SEV_SEG_PORT_ID, eDisplay, GPIO_HIGH);
90  }
91
92  /**
93   * Shows the passed value in hexadecimal format in the seven segment display.
94   * @param uiHex the value to be printed
95   */
96  void sevenseg_printHex(unsigned int uiHex){
97      for(unsigned short usCur_disp = 0; usCur_disp < MAX_DISP_NUMBER; usCur_disp++){
98          sevenseg_hex2segArray(uiHex/pow(16,MAX_DISP_NUMBER-1-usCur_disp),
99                               epSeg_Matrix[usCur_disp]);
100      }
101
102  /**
103   * Shows the passed value in decimal format in the seven segment display.
104   * @param uiDec the value to be printed
105   */
106  void sevenseg_printDec(unsigned int uiDec){
107      for(unsigned short usCur_disp = 0; usCur_disp < MAX_DISP_NUMBER; usCur_disp++){
108          sevenseg_dec2segArray(uiDec/pow(10,MAX_DISP_NUMBER-1-usCur_disp),
109                               epSeg_Matrix[usCur_disp]);
110      }
111
112  /**
113   * Converts the less significative decimal digit of the argument into it's seven
114   * segment display configuration
115   * @param usDec the value to be converted (-1 if none should be displayed)
116   * @param epRet address for results (should be a allocated array of minimal 9 elements)
117   *
118   * @return epRet
119   */
120  seven_segment_seg_type_e* sevenseg_dec2segArray(unsigned short usDec,
121                                                  seven_segment_seg_type_e* epRet){
122      if(usDec < 0){
123          epRet[0] = SEG_END;

```

```

123     return epRet;
124 }
125 epRet[0] = SEG_A;
126 epRet[1] = SEG_B;
127 epRet[2] = SEG_C;
128 epRet[3] = SEG_D;
129 epRet[4] = SEG_E;
130 epRet[5] = SEG_F;
131 epRet[6] = SEG_G;
132 epRet[7] = SEG_END;
133 switch(usDec%10){
134 case 0:
135     //{SEG_A,SEG_B,SEG_C,SEG_D,SEG_G,SEG_E,SEG_F,SEG_END};
136     epRet[6] = SEG_END;
137     break;
138 case 1:
139     //{SEG_B,SEG_C,SEG_END};
140     epRet[0] = SEG_B;
141     epRet[1] = SEG_C;
142     epRet[2] = SEG_END;
143     break;
144 case 2:
145     //{SEG_A,SEG_B,SEG_G,SEG_D,SEG_E,SEG_END};
146     epRet[2] = SEG_G;
147     epRet[5] = SEG_END;
148     break;
149 case 3:
150     //{SEG_A,SEG_B,SEG_C,SEG_D,SEG_G,SEG_END}
151     epRet[4] = SEG_G;
152     epRet[5] = SEG_END;
153     break;
154 case 4:
155     //{SEG_G, SEG_B,SEG_C,SEG_F, SEG_END}
156     epRet[0] = SEG_G;
157     epRet[3] = SEG_F;
158     epRet[4] = SEG_END;
159     break;
160 case 5:
161     //{SEG_A,SEG_G,SEG_C,SEG_D,SEG_F,SEG_END}
162     epRet[1] = SEG_G;
163     epRet[4] = SEG_F;
164     epRet[5] = SEG_END;
165     break;
166 case 6:

```



```

167     //{SEG_A,SEG_G,SEG_C,SEG_D,SEG_E,SEG_F,SEG_END}
168     epRet[1] = SEG_G;
169     epRet[6] = SEG_END;
170     break;
171 case 7:
172     //{SEG_A,SEG_B,SEG_C,SEG_END}
173     epRet[3] = SEG_END;
174     break;
175 case 8:
176     //{SEG_A,SEG_B,SEG_C,SEG_D,SEG_E,SEG_F,SEG_G,SEG_END}
177     break;
178 case 9:
179     //{SEG_A,SEG_B,SEG_C,SEG_F,SEG_G,SEG_END}
180     epRet[3] = SEG_F;
181     epRet[4] = SEG_G;
182     epRet[5] = SEG_END;
183     break;
184 }
185 return epRet;
186 }
187
188 /**
189  * Converts the less significative hexadecimal digit of the argument into it's seven
190  * segment display configuration
191  * @param usHex the value to be converted (-1 if none should be displayed)
192  * @param epRet address for results (should be a allocated array of minimal 9 elements)
193  *
194  * @return epRet
195  */
196 seven_segment_seg_type_e* sevenseg_hex2segArray(unsigned short usHex,
197     seven_segment_seg_type_e* epRet){
198     if(usHex < 0){
199         epRet[0] = SEG_END;
200         return epRet;
201     }
202     epRet[0] = SEG_A;
203     epRet[1] = SEG_B;
204     epRet[2] = SEG_C;
205     epRet[3] = SEG_D;
206     epRet[4] = SEG_E;
207     epRet[5] = SEG_F;
208     epRet[6] = SEG_G;
209     epRet[7] = SEG_END;
210     switch(usHex%16){

```

```

210     case 0:
211     case 1:
212     case 2:
213     case 3:
214     case 4:
215     case 5:
216     case 6:
217     case 7:
218     case 8:
219     case 9:
220         return sevenseg_dec2segArray(usHex%16, epRet);
221         break;
222     case 10: //A
223         //{SEG_A,SEG_B,SEG_C,SEG_G,SEG_E,SEG_F,SEG_END}
224         epRet[3] = SEG_G;
225         epRet[6] = SEG_END;
226         break;
227     case 11: //B (b)
228         //{SEG_G,SEG_F,SEG_C,SEG_D,SEG_E,SEG_END}
229         epRet[0] = SEG_G;
230         epRet[1] = SEG_F;
231         epRet[5] = SEG_END;
232         break;
233     case 12: //C
234         //{SEG_A,SEG_E,SEG_F,SEG_D,SEG_END}
235         epRet[1] = SEG_E;
236         epRet[2] = SEG_F;
237         epRet[4] = SEG_END;
238         break;
239     case 13: //D (d)
240         //{SEG_G,SEG_B,SEG_C,SEG_D,SEG_E,SEG_END}
241         epRet[0] = SEG_G;
242         epRet[5] = SEG_END;
243         break;
244     case 14: //E
245         //{SEG_A,SEG_G,SEG_F,SEG_D,SEG_E,SEG_END}
246         epRet[1] = SEG_G;
247         epRet[2] = SEG_F;
248         epRet[5] = SEG_END;
249         break;
250     case 15: //F
251         //{SEG_A,SEG_E,SEG_F,SEG_G,SEG_END}
252         epRet[1] = SEG_E;
253         epRet[2] = SEG_F;

```

```
254         epRet[3] = SEG_G;
255         epRet[4] = SEG_END;
256         break;
257     }
258     return epRet;
259 }
```

7.28 ../Sources/SevenSeg/sevensseg_hal.h

```
1  /* ***** */
2  /* File name:      sevensseg_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for handling SEVEN SEGMENT DISPLAY */
5  /*                from the peripheral board */
6  /* Author name:    ddello */
7  /* Creation date:   18mar2016 */
8  /* Revision date:   13abr2016 */
9  /* ***** */
10
11 #ifndef SOURCES_SEVEN_SEGMENT_HAL_H_
12 #define SOURCES_SEVEN_SEGMENT_HAL_H_
13
14 #include "KL25Z/es670_peripheral_board.h"
15
16 #define MAX_SEGMENT_NUMBER 8
17 #define MAX_DISP_NUMBER 4
18
19
20 typedef enum
21 {
22     SEG_A = SEGA_PIN,
23     SEG_B = SEGB_PIN,
24     SEG_C = SEGC_PIN,
25     SEG_D = SEGD_PIN,
26     SEG_E = SEGE_PIN,
27     SEG_F = SEGF_PIN,
28     SEG_G = SEGG_PIN,
29     SEG_DP = SEGDP_PIN,
30     SEG_END = -1
31 } seven_segment_seg_type_e;
32
33 typedef enum
34 {
35     DISP_1 = SEG_DISP1_PIN,
36     DISP_2 = SEG_DISP2_PIN,
37     DISP_3 = SEG_DISP3_PIN,
38     DISP_4 = SEG_DISP4_PIN,
39 } seven_segment_disp_type_e;
40
41 /**
42 * Initialize the seven segment display
```

```

43 */
44 void sevenseg_init(void);
45
46 /**
47  * Sets only the selected segments as high. Setting the others as low
48  * @param epDet_segments = Array with the segments that should be set as on (Last
49    element should be SEG_END)
50  */
51 void sevenseg_setSegs(seven_segment_seg_type_e* epSet_segments);
52
53 /**
54  * Shows the value written in the segment pins to the
55  * given display after clearing the others
56  * @param eDisplay the display to initialize.
57  */
58 void sevenseg_setDisp(seven_segment_disp_type_e eDisplay);
59
60 /**
61  * Shows the passed value in hexadecimal format in the seven segment display.
62  * @param uiHex the value to be printed
63  */
64 void sevenseg_printHex(unsigned int uiHex);
65
66 /**
67  * Shows the passed value in decimal format in the seven segment display.
68  * @param uiDec the value to be printed
69  */
70 void sevenseg_printDec(unsigned int uiDec);
71
72 /**
73  * Converts the less significative decimal digit of the argument into it's seven
74  * segment display configuration
75  * @param usDec the value to be converted (-1 if none should be displayed)
76  * @param epRet address for results (should be a allocated array of minimal 9 elements)
77  * @return epRet
78  */
79 seven_segment_seg_type_e* sevenseg_dec2segArray(unsigned short usDec,
80    seven_segment_seg_type_e* epRet);
81
82 /**
83  * Converts the less significative hexadecimal digit of the argument into it's seven
84  * segment display configuration
85  * @param usHex the value to be converted (-1 if none should be displayed)

```

```
85  * @param epRet address for results (should be a allocated array of minimal 9 elements)
86  *
87  * @return epRet
88  */
89  seven_segment_seg_type_e* sevenseg_hex2segArray(unsigned short usHex,
           seven_segment_seg_type_e* epRet);
90
91 #endif /* SOURCES_SEVEN_SEGMENT_HAL_H_ */
```

7.29 ../Sources/Tacometro/tacometro_hal.c

```
1  /* ***** */
2  /* File name:      tacometro_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                for tacometer */
5  /* Author name:    ddello */
6  /* Creation date:   13maio2016 */
7  /* Revision date:   13maio2016 */
8  /* ***** */
9  #include "tacometro_hal.h"
10 #include "KL25Z/es670_peripheral_board.h"
11
12 #define TACOMETRO_SCALER 7
13
14 /**
15  * Initialize the tacometer module
16  */
17 void tacometro_init(void){
18     /* Init tacometer pin */
19     SIM_SCGC5 |= SIM_SCGC5_PORTE(1u);
20     PORT_PCR_REG(TACOMETRO_PORT_BASE_PNT , TACOMETRO_PIN) =
        PORT_PCR_MUX(TACOMETRO_PIN_ALT);
21
22     /* INIT TPM */
23     //Init TPM Clock source as OSCERCLOCK
24     SIM_WR_SOPT2_TPMSRC(SIM,0x2);
25     //TPM0 ClockIn0
26     SIM_WR_SOPT4_TPM0CLKSEL(SIM, 0x0);
27     //Enable clock to TPM0
28     SIM_SCGC6 |= SIM_SCGC6_TPM0(0x1);
29     //Select External Clock Source for TPM module
30     TPM_WR_SC_CMOD(TACOMETRO_TPM_BASE, 0x2);
31     //Prescale 1:1
32     TPM_WR_SC_PS(TACOMETRO_TPM_BASE, 0x0);
33     //Init mod as maximum value
34     TPM_WR_MOD(TACOMETRO_TPM_BASE, 0xFFFF);
35 }
36
37
38 /**
39  * @param uiPeriod Time ellapsed since last getSpeedCall in ms
40  *
41  * @return current tacometer speed in rps
```

```
42  */
43  unsigned int tacometro_getSpeed(unsigned int uiPeriod){
44      unsigned int ret = TPM_RD_CNT(TACOMETRO_TPM_BASE)/TACOMETRO_SCALER*1000/uiPeriod;
45      TPM_WR_CNT(TACOMETRO_TPM_BASE, 0x0);  /*Reset counter */
46      return ret;
47  }
```

7.30 ../Sources/Tacometro/tacometro_hal.h

```
1  /* ***** */
2  /* File name:      tacometro_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for tacometer */
5  /* Author name:    ddello */
6  /* Creation date:   13maio2016 */
7  /* Revision date:   13maio2016 */
8  /* ***** */
9
10 #ifndef SOURCES_TACOMETRO_HAL_H_
11 #define SOURCES_TACOMETRO_HAL_H_
12
13 /**
14  * Initialize the tacometer module
15  */
16 void tacometro_init(void);
17
18
19 /**
20  * @param uiPeriod Time ellapsed since last getSpeedCall in ms
21  *
22  * @return current tacometer speed in rps
23  */
24 unsigned int tacometro_getSpeed(unsigned int uiPeriod);
25
26 #endif /* SOURCES_TACOMETRO_HAL_H_ */
```

7.31 ../Sources/TempSensor/tempSensor_hal.c

```
1  /* ***** */
2  /* File name:      tempSesnor_hal.c */
3  /* File description: File containing the functions/methods */
4  /*                for temperature sensor */
5  /* Author name:    ddello */
6  /* Creation date:   16jun2016 */
7  /* Revision date:   16jun2016 */
8  /* ***** */
9
10 #include "tempSensor_hal.h"
11 #include "ADC/adc.h"
12
13 #define TEMP_ADC_TRANSF_EQ_PARAM_A 0.4073
14 #define TEMP_ADC_TRANSF_EQ_PARAM_B -123.75
15
16 static uint16_t rawReading = 0;
17
18 /**
19  * Init temperature sensor
20  */
21 void tempSensor_init(){
22     adc_initADCModule();
23 }
24
25 /**
26  * Updates temperature sensor readings and starts a new conversion
27  */
28 void tempSensor_executeTask(){
29     if(tempSensor_isConversionFinished()){
30         rawReading = adc_getConversionValue();
31     }
32     adc_initConversion();
33 }
34
35 /**
36  * Checks if last triggered conversion is finished
37  *
38  * @return 1 if conversion is complete, 0 otherwise
39  */
40 short tempSensor_isConversionFinished(){
41     return adc_isAdcDone();
42 }
```

```

43
44 /**
45  * @return Raw result from last successful conversion
46  */
47 uint16_t tempSensor_getLastConversionRawResult(){
48     return rawReading;
49 }
50
51 /**
52  * @return Last read temperature (in Celcius Degrees)
53  */
54 int tempSensor_getLastConversionTemperature(){
55     return TEMP_ADC_TRANSF_EQ_PARAM_A * tempSensor_getLastConversionRawResult() +
        TEMP_ADC_TRANSF_EQ_PARAM_B;
56 }

```

7.32 ../Sources/TempSensor/tempSensor_hal.h

```
1  /* ***** */
2  /* File name:      tempSesnor_hal.h */
3  /* File description: Header file containing the functions/methods */
4  /*                for temperature sensor */
5  /* Author name:    ddello */
6  /* Creation date:   16jun2016 */
7  /* Revision date:   16jun2016 */
8  /* ***** */
9
10 #include <stdint.h>
11
12 /**
13  * Init temperature sensor
14  */
15 void tempSensor_init();
16
17 /**
18  * Updates temperature sensor readings and starts a new conversion
19  */
20 void tempSensor_executeTask();
21
22 /**
23  * Checks if last triggered conversion is finished
24  *
25  * @return 1 if conversion is complete, 0 otherwise
26  */
27 short tempSensor_isConversionFinished();
28
29 /**
30  * @return Raw result from last successful conversion
31  */
32 uint16_t tempSensor_getLastConversionRawResult();
33
34 /**
35  * @return Last read temperature (in Celcius Degrees)
36  */
37 int tempSensor_getLastConversionTemperature();
```

7.33 ../Sources/Util/tc_hal.c

```
1  /* File name:          tc_hal.c                                */
2  /* File description: This file has a couple of useful functions to */
3  /*                    timer and counter hardware abstraction layer */
4  /*                                                            */
5  /* Author name:        dloubach                                */
6  /* Creation date:      23out2015                               */
7  /* Revision date:      25fev2016                               */
8  /* ***** */
9
10 #include "tc_hal.h"
11
12 /* system includes */
13 #include "fsl_lptmr_driver.h"
14
15 #include "fsl_clock_manager.h"
16 #include "fsl_port_hal.h"
17 #include "fsl_gpio_hal.h"
18
19
20 /* LPTMR configurations */
21 lptmr_user_config_t lptmrConfig =
22 {
23     .timerMode          = kLptmrTimerModeTimeCounter,
24     .freeRunningEnable  = false,
25     .prescalerEnable    = true,
26     .prescalerClockSource = kClockLptmrSrcLpoClk,
27     .prescalerValue     = kLptmrPrescalerDivide2,
28     .isInterruptEnabled = true,
29 };
30
31 /* LPTMR driver state information */
32 lptmr_state_t lptmrState;
33
34
35 /* LPTMR IRQ handler that would cover the same name's APIs in startup code */
36 /* Do not edit this part */
37 void LPTMR0_IRQHandler(void)
38 {
39     LPTMR_DRV_IRQHandler(0U);
40 }
41
42
```

```

43
44 /* dummy code for hardware debug purpose */
45 void tc_testDelaySetup(void)
46 {
47     CLOCK_SYS_EnablePortClock(PORTE_IDX);
48     PORT_HAL_SetMuxMode(PORTE, 0u, kPortMuxAsGpio);
49     GPIO_HAL_SetPinDir(PTE, 0u, kGpioDigitalOutput);
50     GPIO_HAL_ClearPinOutput(PTE, 0u);
51 }
52 /* dummy code for hardware debug purpose */
53 void tc_TestDelay(void)
54 {
55     static char cTest = 0;
56
57     if(!cTest)
58         GPIO_HAL_ClearPinOutput(PTE, 0u);
59     else
60         GPIO_HAL_SetPinOutput(PTE, 0u);
61
62     cTest ^= 1u;
63 }
64 /* dummy code for hardware debug purpose */
65 void tc_lptmrCallback(void)
66 {
67     tc_TestDelay();
68 }
69
70
71 /* ***** */
72 /* Method name:          tc_installLptmr          */
73 /* Method description:  Low power timer 0          */
74 /*                      initialization and start    */
75 /* Input params:         uiTimeInUs:              */
76 /*                      time in micro seconds      */
77 /*                      tUserCallback              */
78 /*                      function pointer to be called*/
79 /*                      when counter achieves      */
80 /*                      uiTimeInUs                */
81 /* Output params:       n/a                      */
82 /* ***** */
83 void tc_installLptmr0(uint32_t uiTimeInUs, lptmr_callback_t tUserCallback)
84 {
85     /* Initialize LPTMR */
86     LPTMR_DRV_Init(LPTMR0_IDX, &lptmrState, &lptmrConfig);

```

```
87
88     /* Set timer period for TMR_PERIOD mili seconds */
89     LPTMR_DRV_SetTimerPeriodUs(LPTMR0_IDX, uiTimeInUs);
90
91     /* Install interrupt call back function for LPTMR */
92     LPTMR_DRV_InstallCallback(LPTMR0_IDX, tUserCallback);
93
94     /* Start LPTMR */
95     LPTMR_DRV_Start(LPTMR0_IDX);
96 }
```

7.34 ../Sources/Util/tc_hal.h

```
1  /* ***** */
2  /* File name:      tc_hal.c */
3  /* File description: Header file containing the functions/methods */
4  /*                interfaces for handling timers and counter */
5  /*                from the FRDM-KL25Z board */
6  /* Author name:    dloubach */
7  /* Creation date:   23out2015 */
8  /* Revision date:   25fev2016 s */
9  /* ***** */
10
11 #ifndef SOURCES_TC_HAL_H_
12 #define SOURCES_TC_HAL_H_
13
14 #include "fsl_lptmr_driver.h"
15
16 /* ***** */
17 /* Method name:      tc_installLptmr */
18 /* Method description: Low power timer 0 */
19 /*                initialization and start */
20 /* Input params:      uiTimeInUs: */
21 /*                time in micro seconds */
22 /*                tUserCallback */
23 /*                function pointer to be called */
24 /*                when counter achieves */
25 /*                uiTimeInUs */
26 /* Output params:     n/a */
27 /* ***** */
28 void tc_installLptmr0(uint32_t uiTimeInUs, lptmr_callback_t tUserCallback);
29
30
31 #endif /* SOURCES_TC_HAL_H_ */
```

7.35 ../Sources/Util/util.c

```
1  /* ***** */
2  /* File name:      util.c */
3  /* File description: This file has a couple of useful functions to */
4  /*                make programming more productive */
5  /* */
6  /*                Remarks: The soft delays consider */
7  /*                core clock @ 40MHz */
8  /*                bus clock @ 20MHz */
9  /* */
10 /* Author name:     dloubach */
11 /* Creation date:    09jan2015 */
12 /* Revision date:    13abr2016 */
13 /* ***** */
14
15 #include "util.h"
16
17 /**
18  * generates ~ 088 micro sec
19  */
20 void util_genDelay088us(void)
21 {
22     char i;
23     for(i=0; i<120; i++)
24     {
25         __asm("NOP");
26         __asm("NOP");
27         __asm("NOP");
28         __asm("NOP");
29         __asm("NOP");
30         __asm("NOP");
31         __asm("NOP");
32         __asm("NOP");
33         __asm("NOP");
34         __asm("NOP");
35         __asm("NOP");
36         __asm("NOP");
37         __asm("NOP");
38         __asm("NOP");
39         __asm("NOP");
40     }
41 }
42
```

```

43
44
45 /**
46  * generates ~ 250 micro sec
47  */
48 void util_genDelay250us(void)
49 {
50     char i;
51     for(i=0; i<120; i++)
52     {
53         __asm("NOP");
54         __asm("NOP");
55         __asm("NOP");
56         __asm("NOP");
57         __asm("NOP");
58         __asm("NOP");
59         __asm("NOP");
60         __asm("NOP");
61         __asm("NOP");
62         __asm("NOP");
63     }
64     util_genDelay088us();
65     util_genDelay088us();
66 }
67
68
69
70 /**
71  * generates ~ 1 mili sec
72  */
73 void util_genDelay1ms(void)
74 {
75     util_genDelay250us();
76     util_genDelay250us();
77     util_genDelay250us();
78     util_genDelay250us();
79 }
80
81
82 /**
83  * generates ~ 10 mili sec
84  */
85 void util_genDelay10ms(void)
86 {

```

```
87     util_genDelay1ms();
88     util_genDelay1ms();
89     util_genDelay1ms();
90     util_genDelay1ms();
91     util_genDelay1ms();
92     util_genDelay1ms();
93     util_genDelay1ms();
94     util_genDelay1ms();
95     util_genDelay1ms();
96     util_genDelay1ms();
97 }
```

7.36 ../Sources/Util/util.h

```
1  /* ***** */
2  /* File name:      util.h */
3  /* File description: Header file containing the function/methods */
4  /*                prototypes of util.c */
5  /*                Those delays were tested under the following: */
6  /*                core clock @ 40MHz */
7  /*                bus clock @ 20MHz */
8  /* Author name:    dloubach */
9  /* Creation date:   09jan2015 */
10 /* Revision date:   13abr2016 */
11 /* ***** */
12
13 #ifndef UTIL_H
14 #define UTIL_H
15
16 /**
17  * generates ~ 088 micro sec
18  */
19 void util_genDelay088us(void);
20
21
22 /**
23  * generates ~ 250 micro sec
24  */
25 void util_genDelay250us(void);
26
27
28 /**
29  * generates ~ 1 mili sec
30  */
31 void util_genDelay1ms(void);
32
33
34 /**
35  * generates ~ 10 mili sec
36  */
37 void util_genDelay10ms(void);
38
39
40 #endif /* UTIL_H */
```
