

PSI3441 - Arquitetura de Sistemas Embarcados

Relatório Exercício Prático 06

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1) Utilizar um timer periódico para, por interrupção, disparar a conversão AD por hardware. Usar a interrupção de fim de conversão para acender os LEDs como feito no exercício 7. De maneira semelhante ao exercício 5 anterior, precisamos configurar o ADC, o Timer e os LEDs. Os códigos gerados estão abaixo:

```
1 /* #####
2 **      Filename      : main.c
3 **      Project       : ex_5_3
4 **      Processor     : MKL25Z128VLK4
5 **      Version       : Driver 01.01
6 **      Compiler      : GNU C Compiler
7 **      Date/Time     : 2022-07-07, 01:35, # CodeGen: 0
8 **      Abstract      :
9 **      Main module.
10 **      This module contains user's application code.
11 **      Settings      :
12 **      Contents      :
13 **      No public methods
14 **
15 ** #####*/
16 /*!
17 ** @file main.c
18 ** @version 01.01
19 ** @brief
20 **      Main module.
21 **      This module contains user's application code.
22 */
23 /*!
24 ** @addtogroup main_module main module documentation
25 ** @{
26 */
27 /* MODULE main */
28
29
30 /* Including needed modules to compile this module/procedure */
31 #include "Cpu.h"
32 #include "Events.h"
33 #include "TII1.h"
34 #include "TUI1.h"
35 #include "Bit1_Green_LED.h"
36 #include "Bit1oLdd1.h"
37 #include "Bit2_Blue_LED.h"
38 #include "Bit1oLdd2.h"
39 #include "AD1.h"
40 #include "AdcLdd1.h"
41 /* Including shared modules, which are used for whole project */
42 #include "PE_Types.h"
43 #include "PE_Error.h"
44 #include "PE_Const.h"
45 #include "IO_Map.h"
46
47 uint16_t adc_value;
48
49 /* User includes (#include below this line is not maintained by Processor Expert) */
50
51 /*lint -save -e970 Disable MISRA rule (6.3) checking. */
52 int main(void)
53 /*lint -restore Enable MISRA rule (6.3) checking. */
54 {
55     /* Write your local variable definition here */
56
57     /**** Processor Expert internal initialization. DON'T REMOVE THIS CODE!!! ****/
58     PE_low_level_init();
59     /**** End of Processor Expert internal initialization.          ****/
60
61     /* Write your code here */
62     Bit1_Green_LED_SetVal();
63
64     /**** Don't write any code pass this line, or it will be deleted during code generation. ****/
65     /**** RTOS startup code. Macro PEX_RTOS_START is defined by the RTOS component. DON'T MODIFY THIS CODE!!! ****/
66     #ifdef PEX_RTOS_START
67         PEX_RTOS_START(); /* Startup of the selected RTOS. Macro is defined by the RTOS component. */
68     #endif
69     /**** End of RTOS startup code. ****/
70     /**** Processor Expert end of main routine. DON'T MODIFY THIS CODE!!! ****/
71     for(;;){}
72     /**** Processor Expert end of main routine. DON'T WRITE CODE BELOW!!! ****/
73 } /**** End of main routine. DO NOT MODIFY THIS TEXT!!! ****/
74
75 /* END main */
76 /*!
77 ** @}
78 */
79 /*
80 ** #####
81 **
82 **      This file was created by Processor Expert 10.3 [05.09]
83 **      for the Freescale Kinetis series of microcontrollers.
84 **
85 ** #####
86 */
87
```

Código do arquivo main.c

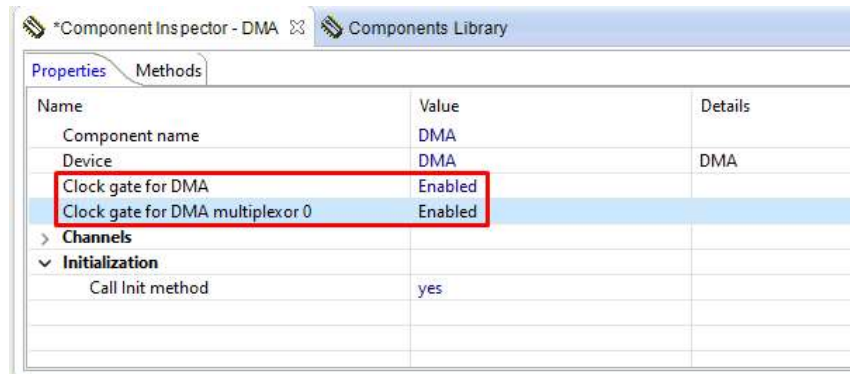
```

1 /* #####
2 **      Filename      : main.c
3 **      Project       : ex_5_3
4 **      Processor     : MKL25Z128VLK4
5 **      Version       : Driver 01.01
6 **      Compiler      : GNU C Compiler
7 **      Date/Time     : 2022-07-07, 01:35, # CodeGen: 0
8 **      Abstract      :
9 **      Main module.
10 **      This module contains user's application code.
11 **      Settings      :
12 **      Contents      :
13 **      No public methods
14 **
15 ** #####*/
16 /*!
17 ** @file main.c
18 ** @version 01.01
19 ** @brief
20 **      Main module.
21 **      This module contains user's application code.
22 */
23 /*!
24 ** @addtogroup main_module main module documentation
25 ** @{
26 */
27 /* MODULE main */
28
29
30 /* Including needed modules to compile this module/procedure */
31 #include "Cpu.h"
32 #include "Events.h"
33 #include "TII.h"
34 #include "TUI.h"
35 #include "Bit1_Green_LED.h"
36 #include "BitIoLdd1.h"
37 #include "Bit2_Blue_LED.h"
38 #include "BitIoLdd2.h"
39 #include "AD1.h"
40 #include "AdcLdd1.h"
41 /* Including shared modules, which are used for whole project */
42 #include "PE_Types.h"
43 #include "PE_Error.h"
44 #include "PE_Const.h"
45 #include "IO_Map.h"
46
47 uint16_t adc_value;
48
49 /* User includes (#include below this line is not maintained by Processor Expert) */
50
51 /*lint -save -e970 Disable MISRA rule (6.3) checking. */
52 int main(void)
53 /*lint -restore Enable MISRA rule (6.3) checking. */
54 {
55     /* Write your local variable definition here */
56
57     /*** Processor Expert internal initialization. DON'T REMOVE THIS CODE!!! ***/
58     PE_low_level_init();
59     /*** End of Processor Expert internal initialization. ***/
60
61     /* Write your code here */
62     Bit1_Green_LED_SetVal();
63
64     /*** Don't write any code pass this line, or it will be deleted during code generation. ***/
65     /*** RTOS startup code. Macro PEX_RTOS_START is defined by the RTOS component. DON'T MODIFY THIS CODE!!! ***/
66     #ifdef PEX_RTOS_START
67         PEX_RTOS_START(); /* Startup of the selected RTOS. Macro is defined by the RTOS component. */
68     #endif
69     /*** End of RTOS startup code. ***/
70     /*** Processor Expert end of main routine. DON'T MODIFY THIS CODE!!! ***/
71     for(;;){}
72     /*** Processor Expert end of main routine. DON'T WRITE CODE BELOW!!! ***/
73 } /*** End of main routine. DO NOT MODIFY THIS TEXT!!! ***/
74
75 /* END main */
76 /*!
77 ** @}
78 */
79 /*
80 ** #####
81 **
82 **      This file was created by Processor Expert 10.3 [05.09]
83 **      for the Freescale Kinetis series of microcontrollers.
84 **
85 ** #####
86 */
87

```

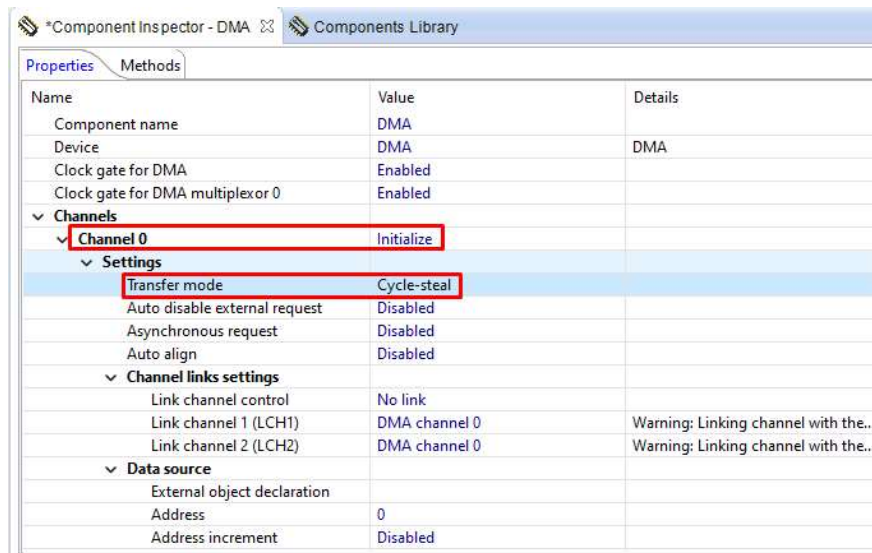
2) utilize DMA para gravar os dados na memória.

Para o DMA, vamos criar um componente Init_DMA e realizar as configurações conforme a imagem abaixo:



Configuração do Init_DMA

Em seguida, inicializamos o canal 0:



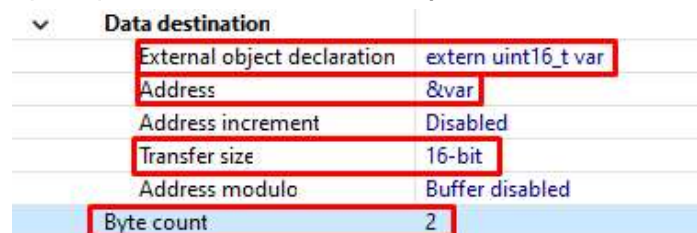
Inicialização do canal 0

Realizamos as configurações para Data source



Configuração do data source

Depois, as configurações para Data destination e Byte count:



Configuração do data destination

Fazemos também a configuração do DMA:

▼ Pins/Signals		
▼ DMA MUX settings		
Channel state	Enabled	
> Channel periodic trigger	Disabled	
Channel request	Software_DMA_Request	Software_DMA_Request
Channel request signal	ADC0_DMA_Request	

Configuração DMA

▼	Interrupts		
▼	DMA transfer done interrupt		
	Interrupt	INT_DMA0	INT_DMA0
	Interrupt request	Enabled	
	Interrupt priority	0 (Highest)	
	ISR Name	DMA done	DMA_done
	DMA transfer interrupt	Enabled	

Configuração DMA

Por fim, basta realizar algumas alterações no `main.c`, `events.c` e `DMA.c` conforme mostrado a seguir:

```

1  /* *****
2  **      filename      : main.c
3  **      Project       : ex_3.3
4  **      Processor     : MK22Z128PQ4
5  **      Version       : Driver 01.01
6  **      Compiler      : GNU C Compiler
7  **      Date/Time    : 2022-07-07, 01:35, # CodeGen: 0
8  **      Abstract     :
9  **      Main module.
10 **      This module contains user's application code.
11 **      Settings     :
12 **      Contents     :
13 **      No public methods
14 **
15 ** *****
16 */
17
18 /* @file main.c
19 ** @version 01.01
20 ** @brief
21 **      Main module.
22 **      This module contains user's application code.
23 */
24
25 /* @addtogroup main_module main module documentation
26 ** @
27 */
28
29 /* MODULE main */
30
31 /* Including needed modules to compile this module/procedure */
32 #include "Cpu.h"
33 #include "Events.h"
34 #include "TTL.h"
35 #include "TTL.h"
36 #include "Bt11_Green_LED.h"
37 #include "Bt11_Green_LED.h"
38 #include "Bt12_Blue_LED.h"
39 #include "Bt12_Blue_LED.h"
40 #include "AD1.h"
41 #include "AD1.h"
42 #include "DMA.h"
43
44 /* Including shared modules, which are used for whole project */
45 #include "PE_Types.h"
46 #include "PE_Error.h"
47 #include "PE_Const.h"
48 #include "IO_Map.h"
49
50 #include "uart16_t.h"
51
52 /* User includes (#include below this line is not maintained by Processor Expert) */
53
54 #ifndef __disable_misra__
55 #define __disable_misra__ 0
56 #endif
57
58 /* User includes (#include below this line is not maintained by Processor Expert) */
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60 #ifndef __disable_misra__
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412 /* User includes (#include below this line is not maintained by Processor Expert) */
413
414 #ifndef __disable_misra__
415 #define __disable_misra__ 0
416 #endif
417
```

Código do arquivo main.c

```

1 /* #####
2 ** Filename   : Events.c
3 ** Project    : ex_5_3
4 ** Processor  : MKL25Z128VLK4
5 ** Component  : Events
6 ** Version    : Driver 01.00
7 ** Compiler   : GNU C Compiler
8 ** Date/Time  : 2022-07-07, 01:35, # CodeGen: 0
9 ** Abstract   :
10 ** This is user's event module.
11 ** Put your event handler code here.
12 ** Settings   :
13 ** Contents   :
14 **     Cpu_OnNMIINT ~ void Cpu_OnNMIINT(void);
15 **
16 ** #####/
17 /*!
18 ** @file Events.c
19 ** @version 01.00
20 ** @brief
21 **     This is user's event module.
22 **     Put your event handler code here.
23 **/
24 /*!
25 ** @addtogroup Events_module Events module documentation
26 ** @{
27 **/
28 /* MODULE Events */
29
30 #include "Cpu.h"
31 #include "Events.h"
32
33 #ifdef __cplusplus
34 extern "C" {
35 #endif
36
37 extern uint16_t adc_value;
38
39 /* User includes (#include below this line is not maintained by Processor Expert) */
40
41 /*
42 **
43 ** Event      : Cpu_OnNMIINT (module Events)
44 **
45 ** Component  : Cpu [MKL25Z128LK4]
46 **/
47 /*!
48 ** @brief
49 **     This event is called when the Non maskable interrupt had
50 **     occurred. This event is automatically enabled when the [NMI
51 **     interrupt] property is set to 'Enabled'.
52 **/
53 /* #####
54 void Cpu_OnNMIINT(void)
55 {
56     /* Write your code here ... */
57 }
58
59 /*
60 **
61 ** Event      : T11_OnInterrupt (module Events)
62 **
63 ** Component  : T11 [TimerInt_LDD]
64 **/
65 /*!
66 ** @brief
67 **     Called if periodic event occur. Component and OnInterrupt
68 **     event must be enabled. See [SetEventMask] and [GetEventMask]
69 **     methods. This event is available only if a [Interrupt
70 **     service/event] is enabled.
71 **
72 ** @param
73 **     UserDataPtr ~ Pointer to the user or
74 **                 RIOS specific data. The pointer passed as
75 **                 the parameter of Init method.
76 **/
77 void T11_OnInterrupt(LDD_UserData *UserDataPtr)
78 {
79     AD1_Measure(0);
80 }
81
82 /*
83 **
84 ** Event      : AD1_OnEnd (module Events)
85 **
86 ** Component  : AD1 [ADC]
87 ** Description :
88 **     This event is called after the measurement (which consists
89 **     of <1 or more conversions>) is/are finished.
90 **     The event is available only when the <Interrupt
91 **     service/event> property is enabled.
92 ** Parameters : None
93 ** Returns    : Nothing
94 **/
95
96 void AD1_OnEnd(void)
97 {
98 }
99
100
101 /*
102 **
103 ** Event      : AD1_OnCalibrationEnd (module Events)
104 **
105 ** Component  : AD1 [ADC]
106 ** Description :
107 **     This event is called when the calibration has been finished.
108 **     User should check if the calibration pass or fail by
109 **     Calibration status method. This event is enabled only if
110 **     the <Interrupt service/event> property is enabled.
111 ** Parameters : None
112 ** Returns    : Nothing
113 **/
114
115 void AD1_OnCalibrationEnd(void)
116 {
117     /* Write your code here ... */
118 }
119
120 PE_ISR(DMA_done)
121 {
122     DMA_DSRB |= DMA_DSR_BCR_DONE_MASK; // Clear Done Flag
123     DMA_DSR_BCRB |= DMA_DSR_BCRB(2); // Set byte count register
124 }
125
126 /* END Events */
127
128 #ifdef __cplusplus
129 } /* extern "C" */
130 #endif
131
132 /*!
133 ** @}
134 **/
135 /*
136 ** #####
137 **
138 ** This file was created by Processor Expert 10.3 [05.09]
139 ** for the Freescale Kinetis series of microcontrollers.
140 **
141 ** #####
142 **/
143

```

Código do arquivo events.c

[illegible]

Código do arquivo DMA.c

Link com o código dos arquivos do projeto:

https://github.com/kevinkirsten/psi3441-arquitetura-de-sistemas-embarcados/tree/main/exercicio_pratico_06